International Journal on New Trends in Education and Their Implications
October 2013 Volume: 4 Issue: 4 Article: 07 ISSN 1309-6249

# AN EXPLORATION OF UNDERGRADUATE ENGINEERING, EDUCATION, ART'S AND SCIENCES STUDENTS' CHEMISTRY LABORATORY ANXIETY LEVELS

Dilek KARIŞAN
Middle East Technical University
Faculty of Education
Department of Elementary Education
Ankara, TURKEY

Assoc. Prof. Dr. Ozgul YILMAZ-TUZUN
Middle East Technical University
Faculty of Education
Department of Elementary Education
Ankara, TURKEY

## ABSTRACT

This study examined the difference among undergraduate engineering, education, and arts and sciences students' chemistry laboratory anxiety levels and aimed to describe the causes of these differences. Chemistry Laboratory Anxiety Instrument (CLAI), developed by Bowen (1999) and adapted into Turkish by Azizoğlu and Uzuntiryaki (2006), was used as the data source. There are four dimensions of the scale which are: using equipment and working with chemicals, working with other students, collecting data, having adequate time. 295 college students were participated in the study. Participants consist of three different faculty students (engineering, art-science, and education faculty). SPSS and AMOS statistics programs were used to analyze students' anxiety levels. MANOVA was performed to explore the relation between gender, faculty and chemistry anxieties (i.e using chemicals, peer work, data collection, and time management) of undergraduate students. Results of the study have shown that gender has no significant effect on students' chemistry laboratory anxiety levels. However, there is a significant difference among different faculty students' anxiety levels. These variations were tried to be explained by conducting semi-structured interviews with lowest and highest anxious students.

**Key Words:** Anxiety, Chemistry laboratory anxiety, Undergraduate students.

## INTRODUCTION

In last few decades, there is consensus on that personal and motivational variables have an impact on learning (Gaudry & Spielberger, 1971). Anxiety is one of these variables that have positive or negative effects on learning. Number of publications on this issue has continued to accelerate since the second half of the 20$^{th}$ century (Spielberger, 1972). Anxiety is given importance in the literature because it is usually experienced by the entire society. Huge numbers of people are suffered by inappropriate and excessive anxiety (Rachman, 2004). Anxiety can be defined as the tense, unsettling anticipation of a threatening but ambiguous event (Rachman, 2004). Not only psychologists but also educators are concerned with this problem. Educators are interested in the effects of anxiety on the learning process.

Over the last few decades, a significant amount of the research has been conducted on the effects of anxiety on learning and retention (Gaudry & Spielberger; 1971). Education literature highlights many types of anxiety. Math, test, science and laboratory anxiety are usually investigated types of anxiety among the researchers. Science anxiety is a debilitating interaction of emotion of fear, and tension during the interaction with science concepts. Science anxious students felt relaxes in their non-science programs, including their mathematics courses (Mallow, 1994). Science anxiety indicated as a career filter; students avoids from entering certain fields as they have fear of participation in the prerequisite science courses (Udo, Ramsey, and Mallow, 2004).

Students' perceptions about science were related with their attitudes towards laboratory (Havdala & Ashkenazi; 2007). On the other hand, enhancing science courses with laboratory activities increase students' attitudes success and interests towards these courses (Aydoğdu, 2000). Researchers and policy-makers worldwide have consensus on the value of laboratory work (Woolnough & Alsop 1985). However, the effectiveness of the laboratory works are being debated (Tobin, Tippins & Gallard 1995). Laboratory activities are organized in order to reach science learning outcomes. These learning outcomes or objectives can be classified into two main groups: content and process. The former are concerned with the learning of scientific facts, concept, relationship; the latter are concerned with the learning of scientific enquiry process such as how to use a laboratory instrument, duration of a task (time), people with whom the student interacts, how to carry out a standard procedure etc. (Miller, Tiberghien, & Le Marechal, 2002). It is of utmost importance to recognize that affective variables, such as anxiety, affect learning and performance in laboratory situations (Bowen, 1999). General chemistry course and chemistry laboratory course are usually experienced by entire science major departments (e.g. engineering, biology, chemistry, physics, education, molecular biology-genetic etc.). Therefore, reducing stress in laboratory conditions may improve learning of complex laboratory and problem-solving skills (Bowen, 1999). The purpose of this study is to compare undergraduate chemistry and elementary education students' chemistry anxiety levels with those undergraduate students majoring in degrees from engineering and arts and sciences using CLAI item survey. Our main goal was to see if there is a statistically significant difference among students chemistry anxiety level. Udo, Ramsey, and Mallow (2004) indicate that science anxiety and science enrollments are assertively affected by role models (i.e. teachers). Thus, we claim that there is a strong correlation between teachers' characteristics and students' science anxiety and their science enrollment. To compare education students' anxiety scores with their counterparts in engineering and arts and sciences is worth to analyze since all students from three different colleges take chemistry courses and chemistry laboratories in the same manner during their undergraduate curriculum, but they feel different levels of anxiety. Education students' anxiety scores were taken into the center as education students are future teachers who will teach special science topics to the next generation. Present study also attempts to explain the causes of chemistry laboratory anxiety.

Following research questions will guide the present study.
Is there a statistically significant difference between undergraduate female and male engineering, education, and arts and sciences students' chemistry laboratory anxiety levels?

Is there a statistically significant difference among the engineering, education, and arts and sciences students' chemistry laboratory anxiety levels?

If there is a statistically significant difference among the engineering, education, and arts and sciences students' chemistry laboratory anxiety levels, how can these differences be explained?

## Theoretical framework

College students' chemistry anxiety or chemistry laboratory anxiety has been studied by many researchers (Erökten, 2010; Jegede, 2007; McCarthy and Widanski, 2009). It is commonly emphasized in the literature that female students reflect more chemistry anxiety than male students. Students past experiences are thought as predictor for chemistry laboratory anxiety. In the recent study,not only anxiety but also causes of anxiety are valued by the researchers (Jegede, 2007; Tai, & Sadler, 2007). Chemistry experiments are generally performed by using experiment handbook or laboratory manual. Whether it is written in the manual or not, students have to participate actively in the experiment. This active participation process includes planning, designing, analyzing, interpretation and application by individually or sometimes collaboratively (Hofstein & Lunetta, 1982). Students have to interact with chemicals in Chemistry laboratory. As well cognitive domain, the affective domain,is also an important factor in education process (Azizoğlu & Uzuntiryaki, 2006). Anxiety is one of the major affective variables that affect learning. Researchers conducted several research to analyze students' reactions to the chemistry laboratory.

McCarthy and Widanski (2009) studied with 264 undergraduate students. Participants were asked to complete a survey that consisted of a series of demographic questions and the Derived Chemistry Anxiety Rating Scale.

The rating scale is made up of three subscales: learning-chemistry anxiety, chemistry-evaluation anxiety, and handling-chemicals anxiety. The F test results for chemistry-evaluation anxiety were significant; females reported higher levels of evaluation anxiety than males. The F test results for learning-chemistry anxiety and handling chemicals were not significant between different genders. The F test results for learning-chemistry anxiety and chemistry evaluation were significant, with participants who had never had chemistry; these students reported higher levels of this type of anxiety. The F test results for handling-chemicals anxiety were not significant. Females reported more evaluation anxiety than males did. This may be due to socialization. Females are often led to believe that science is the domain of males.

Anxiety is generally accepted as having negative effect on learning. Students' chemistry lab anxiety is utmost necessary. The interaction of anxiety with other affective variables such as attitude, self-efficacy etc. is also highlighted in the literature. Kurbanoglu and Akim (2010) conducted a study with 395 first year major undergraduates. Students were randomly selected from four universities' general chemistry and general chemistry laboratory classes. They used the same scale (CLAI) with the present study in order to measure laboratory anxiety. They aimed to examine the relationship among chemistry laboratory anxiety, chemistry attitudes and self-efficacy. Results of this study indicate that the self -efficacy has predicted chemistry laboratory anxiety in a negative way. Anxious students who hold high anxiety about chemistry laboratory generally feel incapable of doing laboratory activities. Therefore, self-efficacy is thought as a negative predictor of chemistry laboratory anxiety. Results also highlighted that chemistry laboratory anxiety was predicted by chemistry attitudes, negatively.

As previously indicated, not only anxiety but also causes of the excessive amount of anxiety is given importance in the literature. Jegede (2007) aimed to find out students' anxiety towards the learning of chemistry, classify the factors that cause the anxiety, examine the gender differences towards the learning of chemistry. He conducted a study with 300 secondary school grade students. The findings of the study highlighted that all of the students have high anxiety towards the learning of chemistry. Female students reported higher levels of anxiety than male. He reviewed the basis of students' anxiety as broad coverage of the syllabus, low awareness of career opportunities, their teacher and his teaching methods and lack of teaching aids. Well-qualified chemistry teachers and well-equipped chemistry laboratories are suggested to decrease students' chemistry laboratory anxieties. He also alerts that numbers of chemistry teachers are also limited in secondary schools. This is indicated as another factor that causes anxiety.

Tai, Sadler, & Loehr (2005) aimed to investigate the effects of high school chemistry experiences on students' the college chemistry success. They conducted the study with 1531 students who were taking introductory college chemistry courses for science and engineering majors at 12 different U.S. colleges and universities. Most notably, results of this study are that repeating chemistry labs for understanding was associated with higher student grades, however,when lab procedure is overemphasized students lab grades get lower. Results suggest that the high school teachers' and students' previous experiences have positive or negative effect on college students' future performance.

The current study also aims to compare three faculties' results in chemistry laboratory anxiety. The focus of the present study is to examine the difference among students of three different faculties' chemistry laboratory anxiety levels and find out the possible reasons for these differences.

## METHOD

### Sample

The purpose of the study is to investigate chemistry laboratory anxiety differences among three different faculties (i.e. engineering, art-science, and education faculty) in Ankara Therefore, the target population of this study is all engineering, art-science, and education faculty students in Ankara; however, it is not possible to reach all of these students. For this reason, Two-hundred and ninety-five college students of eight different departments at METU are defined as the accessible population. The sample from this accessible population is determined by using purposive sampling method. Participants were students from three different faculties (i.e.

engineering, art-science, and education faculty). The primary reason for selecting these faculties can be explained as general chemistry course,and general chemistry laboratory are common courses for all faculties. The distribution of art and science faculty included chemistry, molecular biology – genetics, and biology (25 %) departments. The distribution of education faculty involved elementary science education (ESE), and chemistry education (31 %), departments. Remaining of the participants were engineering students involved electronic, mechanic, civil engineering (44%) departments. General chemistry course and general chemistry laboratory are common for all departments. Students of chemistry engineering, chemistry education and elementary science education departments were taking similar chemistry courses at their first and second years. These courses consist of general chemistry, analytical chemistry, organic chemistry, inorganic chemistry, in addition to these courses students, were respected to take related laboratories such as; general chemistry laboratory, inorganic chemistry, organic chemistry laboratory, and analytical chemistry laboratory during their undergraduate education. ESE departments' curriculum is differed from other departments for one laboratory course. Sophomore ESE students covers analytical and inorganic chemistry experiments together in one laboratory course. The majority of participants were 23 years old and younger, with 43% between 18–20 years old, 50% in the range of 20-23 years old, and 7% in the range of 24-25 years old.

### Instrumentation

In order to determine anxiety levels, that students have in college chemistry laboratories Chemistry Laboratory Anxiety Instrument (CLAI) was used. The instrument was designed by Bowen (1999) and adapted into Turkish by Azizoğlu & Uzuntiryaki (2006). The scale consisted of 20 items rated on a Likert-type scale. Respondents were asked to respond to each item using a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Fifteen of the twenty items were positive statements (supports anxiety), however, remaining five items were negative statements regarding anxiety. 15 positive statements were rated as 5,4,3,2,1 from strongly agree to disagree on the contrary, remaining 5 negative statements were rated as 1,2,3,4,5. The original scale measures the following dimensions of chemistry laboratory anxiety: working with chemicals, using equipment and procedures, collecting data, working with other students, having sufficient time. Azizoğlu & Uzuntiryaki (2006) found four dimensions in their adapted version of this scale which are: using equipment and working with chemicals, working with other students, collecting data, having sufficient time.

### Procedure

The study was conducted in the fall semester of 2011-2012 academic year. Timeline for the data collection is divided into three part; applying CLAI, analysing data, conducting interviews. Data collection procedure took five week. The general characteristic of the participants is their being taken chemistry laboratory. All of them had already taken the chemistry laboratory course or were just attending the course in that semester. Permission for participation of students was obtained from departments, and all students were volunteers. The scale was applied to the students in the classrooms. Before the application, all participants were told about the purposes of the study. Pearson correlation coefficient and structural equation modeling were utilized to determine the relationships between the dimensions of chemistry laboratory anxiety.

The scale was applied by the course instructors. It took about ten minutes for participants to respond all questions. Demographic items contained in the questionnaire asked participants about their age, gender, grade, department, and GPA. Initial data consists of 340 students' responding to the questionnaire. However, 35 of these 340 students were student at psychology departments, which is out of our target participants, and 10 of the students rated as 3 (uncertain) for all questions, therefore, we exclude these 45 participants from our data. Semi-structured interviews were used as the data source to explore the differences among students' anxiety levels and causes of these differences. 2 students who have lowest anxiety score and 2 students who have greatest anxiety score were interviewed. Interviews were audio recorded and were transcribed verbatim.

### Interviews

Combining quantitative and qualitative methods enhance the comprehensibility and usefulness of results (Tobin, & Fraser; 1998). After analyzing quantitative data, we collected qualitative data based mainly on student interviews. Duit and Confrey (1996) propose that, interviews should be used to suggest complete picture of students reasoning patterns. Interview questions were written in open ended and non-biased question forms enables students' to be free while responding the questions. Semi-structured interviews were conducted among students who took lowest and highest score from CLAI. Four students, two of them have lowest and two of them have highest anxiety score, participated in the interviews. Students in each group were of different genders and departments. Interviews took 20 to 40 minutes.

### Data Analysis

SPSS 18 statistic program was used to explain the descriptive and inferential statistics. There are four dimensions of the scale. These dimensions were also analyzed with Confirmatory factor analysis by using the analysis of moment structures (AMOS) version 4 (Arbuckle and Wothke 1999) statistical software packages.

## RESULTS

### Validity Evidence

In an effort to confirm the factor structure of the scores obtained from the 20-item CLAI, Confirmatory factor analysis was employed using the analysis of moment structures (AMOS) version 4 (Arbuckle and Wothke 1999) statistical software packages. The maximum likelihood estimation method was used. As can be observed from the figure 1, four dimensions of the CLAI (using chemicals, peer work, data collection, and time management) were allowed to correlate to each other. Figure 1 demonstrates the model specification and the parameter estimates. In order to evaluate the fit between the hypothesized model and the data multiple goodness-of-fit tests were used. These are Normed Fit Index (NFI; Bentler and Bonett 1980), the Comparative Fit Index (CFI; Bentler 1990), and the Root Mean Square Error Approximation (RMSEA; Steiger and Lind 1980).

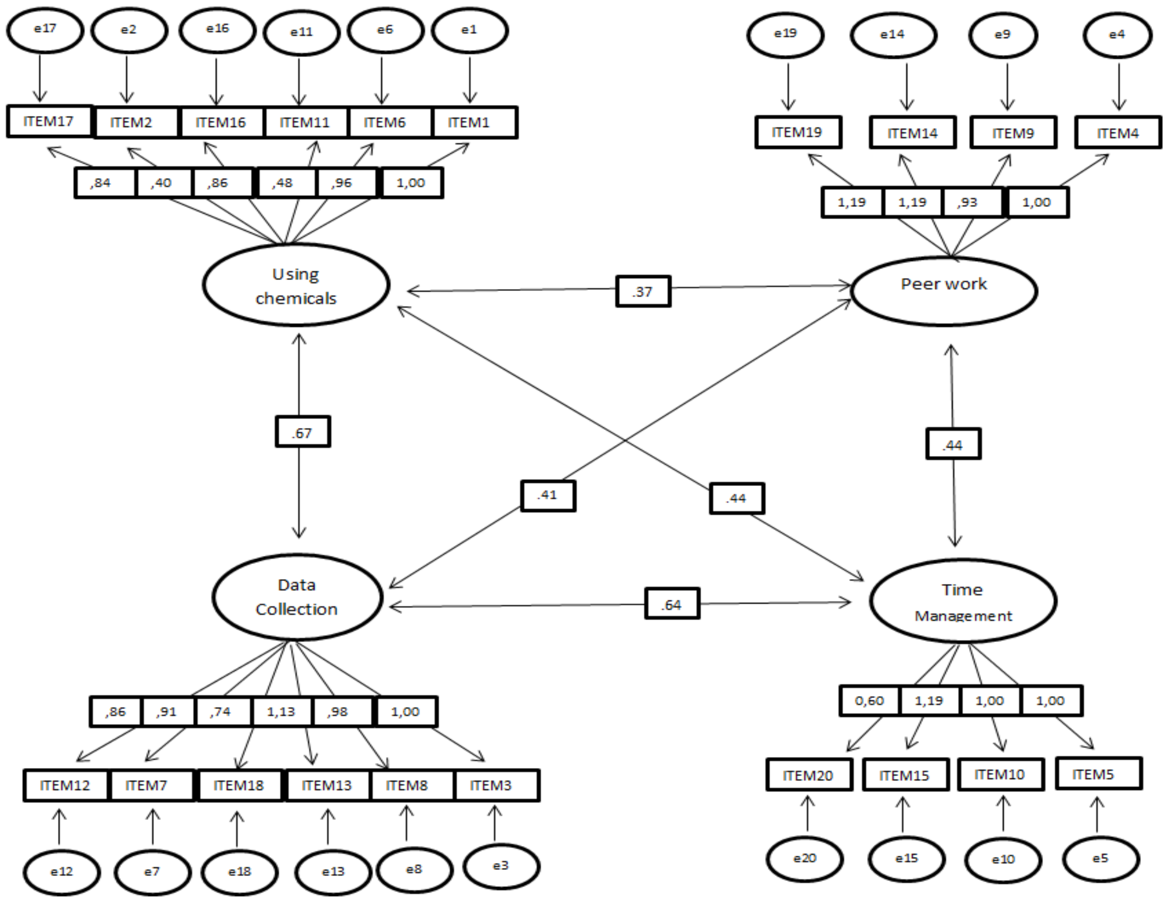


Figure 1: Standardized coefficients for the four-factor model of undergraduate chemistry laboratory anxiety scale. Normed FIT Index = .841; Comparative Fit Index = .890; Root Mean Square Error Approximation: 0.08.,

Results from the CFA suggested that the four-factor structure do not fit well to the sample data with all fit indices (NFI = .841; CFI = 0.890). An NFI and CFI greater than 0.90 indicates a good fit to the data (Kline 1998). So, our model indicates a close fit. Browne and Cudeck (1993) reported that the RMSEA of about 0.05 indicates a close fit of the model and 0.08 represents a reasonable error of approximation. For this study, RMSEA= 0.79, which indicated a reasonable fit. It is proposed that, RMSEA greater than 0.10, not using the model. There were no specification errors nor were any additional alterations of the model specified.

A one-way multivariate analysis of variance (MANOVA) was conducted to determine the effect of four dimensions of CLAI (UC, PW, TM, DC) on the two dependent variables, the gender and faculty CLAI scores. A one-way manova revealed non significant difference found among the four dimensions of CLAI on the dependent measures (Wilks ’ Lambda = .974, F (8, 572) = .941, p =.482, η2 = .013), thus hypothesis 1 was confirmed. The multivariate η2 of .013 would be interpreted as a small effect with respect to Cohen ’s (1988) standards.

*Null hypothesis 1*: There is no significant difference between chemistry laboratory anxiety scores of females and males.

A one-way manova revealed a non-significant difference found among gender (F (4,286)=1.998, p=.095; Wilks’ Lambda=.973; η2=.027). Therefore, it was stated that there was no statistically significant difference between males and females regarding the combined dependent variables. The multivariate η2 of .027 would be interpreted as a small effect with respect to Cohen ’s (1988) standards. When the results for the dependent variables were considered separately, gender has still no significant difference on dependent variables at Bonferroni adjusted alpha level of .125.

*Null hypothesis 2*: There is no statistical difference among engineering, arts and sciences, and education students’ chemistry laboratory anxiety scores.

The results revealed that the null hypothesis were rejected (F (8,572)=2.628, p=.008; Wilks’ Lambda=.930; η2=.035). Therefore, it was stated that there was statistically significant difference among engineering, arts and sciences and education students’ chemistry laboratory anxiety scores considering the combined dependent variables. The multivariate η2 of .035 would be interpreted as a small effect with respect to Cohen ’s (1988) standards.

### Students Interviews

We conducted semi-structured interviews with arts and science students and education students in order to find out where the difference lies between these students’ anxiety scores, which factors makes the difference and etc. Interview questions were organized by taking into consideration of four dimension of CLAI (i.e using chemicals, peer work, time management, and data collection). Students’ academic backgrounds (Anatolian high school, teacher education high school (öğretmen lisesi), or science high school (fen lisesi)) and their science experiences had been asked at the beginning of the interviews. Although all types of high school have the same curriculum in Turkey, the use of the curriculum varies from school to school. I thought that the school type and educational students’ background may influence their anxiety scores.

Researchers first asked the interviewees to read the interview results section of the present study to check whether the results were consistent with their explanations or not. Following sections includes student interviews, direct quotation from their explanation regarding chemistry laboratory method. Students’ general complains about chemistry laboratory are broad coverage of the laboratory manual, lack of laboratory experiences in high school, lack of physical conditions, a limited number of laboratory assistant, having laboratory accident (e.g gas explosion) in the past.

To begins with broad coverage of the laboratory manual; both of the groups (low anxious and high anxious student) complained about the excess amount of experiments in the laboratory manual. Some of the experiments require two or more day to complete, so these experiments were omitted from the course content.

There were lots of scientific information in the manual,and some of the experiments were too long to be complete in laboratory hours. Some of the information and experiments were not useful for us. When we completed the laboratory and look at back, we cannot be able to use any of those experiments. I still do not understand why there was the excess number of experiments in manuals. I just confused which experiment will be performed in the laboratory which one of them will be omitted. Our manual was like a thick book. It is impossible to cover all the experiments in one semester. I think these manuals are too broad to be used as the lab manual. Some of the experiments require two or three day, we omitted them. (low anxious student-1)

Students past laboratory experiences affect their laboratory anxiety scores. If students had a chance to do experiments in elementary science or high school science, they generally report less anxiety in laboratory. If they did not perform any experiment in the laboratory before coming to undergraduate education,this makes them nervous in the laboratory. Both of the groups reported the importance of high school or elementary school laboratory experience on their laboratory anxiety. High anxious students reported that their lack of past experience on laboratory makes them nervous. On the contrary; one of the low anxious students attributes her feeling comfortable while using chemicals to her elementary school experience.

My elementary teacher was very ambitious to do experiments. I had used to participate actively in the experiments since my elementary years. I learn by seeing, in the laboratory;I do experiment; I took a sample; I collect data, I record my observation's etc. these experiment process were very helpful for me. I prefer being in a laboratory and doing experiments rather than being in a classroom and listening to the teacher. (low anxious student-2).

Lack of past experiences and having a laboratory accident is reported as causes of chemistry laboratory anxiety. I always feel anxious in the chemistry laboratory. Using chemicals make me nervous. Experiment is unnecessary. We did not do any experiment in high school; my chemistry teacher was an experienced teacher she teaches the chemistry topics to us by lecturing. I learned lots of things from her. If the laboratory is so necessary,I think she would use it. Maybe, I don't know. I am pretty sure that, chemicals are dangerous. In the chemistry laboratory, I am always afraid of having an accident. Previous year, one of graduate students had a gas explosion in the laboratory. Her face burned. I am not sure; we must be careful. (high anxious student-1).

Physical conditions of a laboratory are listed as another factor that causes anxiety or reduces it. If there is enough material to perform an experiment and if there are safety rules, precautions in the laboratory this makes students more comfortable during the laboratory.

There are always enough materials to perform an experiment. There are three or four students in each group. These groups work at one side of the bench; a second group works at the other side of the bench. These groups work separately, but they can interact with each other if they need. There is a shelve on the middle of the bench. we use these shelves during the experiment. we put our sample on it etc. Each lab has a bath in case of emergency (burn or being exposed to acids). There is also eyewash near the benches. Such items decrease my anxiety. Actually, we always wear laboratory glasses (Low anxious student-1).

Limited number of laboratory assistant is pointed as anxiety cause;
We formed experiment groups there was maximum four students in the groups. One assistant was responsible for three or four group. This is not enough I think. There are some experiments that we cannot understand at which moment we will add something. For example,we have to add something in a mixture before the color change occurs sometimes we missed the point when we called the assistant s/he was dealing with other groups. When we pass the proper time, we have to re-perform the experiment from the beginning. This is time consuming. Number of assistant should be increased in chemistry laboratories (high anxious student- 2).

## CONCLUSION AND DISCUSSION

The chemistry laboratory anxiety scale with four dimensions was applied to engineering, arts and sciences and education students in order to measure their chemistry laboratory anxiety levels. The aim of the study was twofold; first one is to determine the difference among engineering, arts and sciences and education students chemistry results, and if there is a difference among students' results, to investigate where the difference lies and what can be the causes of these differences. We first looked the gender relation with chemistry anxiety levels. There is no consensus on the literature regarding gender differences and anxiety (Yaylı & Hasırcı, 2009). There is a significant number of study that found females reports more anxiety than their male partners (Udo, Ramsey, & Mallow, 2004; Jegede, 2007; Pigge & Marso, 1987). On the contrary, there are a limited number of studies that found there is no gender difference for feeling anxiety (Ghaaith, & Shaaban, 1999). Present study results revealed that there is no gender difference between female and male students' chemistry laboratory anxiety scores among four independent variables (UC, PW, TM, DC).This finding does not align with Udo et al.'s (2004) study who found that females report more anxiety than his male partners and Jegede's (2007) study, who also found that females show more fear or anxiety towards chemistry than their male counterparts.

The second focus of the study was to investigate whether there is statistically significant difference among engineering, arts and sciences, and education students' chemistry laboratory anxiety levels or not. All of the participants were science major students who have already taken science major courses (physics, chemistry, biology) and laboratories (general physics lab., chemistry lab., biology lab.). The focus of the study was to compare education students' chemistry laboratory anxiety scores with engineering, and arts and sciences students' scores. The results of the study have shown that engineering students have middle level of chemistry anxiety whereas arts and science students' have lower, and education students have higher chemistry laboratory anxiety. Teachers' science concerns or anxieties were investigated in numerous study (Fuller, 1969; Kagan, 1992; Swennen, Jörg ve Korthagen, 2004; Udo et al., 2004). These studies highlight the importance of teachers' role for transforming anxiety to their students. Semi-structured interviews shed more light on students' anxiety scores. Preservice teachers' causes of chemistry laboratory anxieties were listed as: lack of laboratory experiences in high school, lack of physical conditions, a limited number of laboratory assistant, having laboratory accident (e.g gas explosion) in the past and broad coverage of the lab manual. These findings align with Jegede's (2007) survey. He also tried to explain the causes of anxiety and listed into four categories namely; wide coverage of the syllabus, low awareness of career opportunities in the subject, lack of exposure to excursion and field trips, well equipped laboratory, as well as poor teaching methods.

In third, present study results based on students self-reports about their anxiety levels. This may be a threat to internal validity of the study. Udo et. al (2004) points out that, students may over report their anxieties. In this study, students may also be over reported their anxieties. self-report scores should be triangulated by using electromyography (EMG), a physiological measure of tension, as Alvaro (1978) and Hermes (1985) did in their studies. They both compare the science-anxiety questionnaire results and EMG measurements and reported that self-reported anxiety scores were consistent with the EMG measurements, both in preclinical and post-clinic tests, this provides an important measure of confidence in the validity of the self-reports of science anxiety. Future research should be including both of these data collection tools in order to improve validity and reliability issues. On the other hand, present study used both quantitative and qualitative research results in exploration of students' anxiety scores. Method triangulation may increase the trustworthiness of the results. Still we cannot generalize our findings because the limited number of (n= 295) participants. Future research should be conducted with the large number of students in order to generalize findings of the study. Finally, since the structural,educational modeling does not fit our sample, CFI and NNFI explained values were low, it is difficult to make any firm conclusions about the findings.

For further research; Decreasing or controlling anxiety in laboratory possibly may enhance learning of multifaceted laboratory skills. Helping students how to control their anxieties and fears related to chemistry laboratory studies can enable the development of positive self-efficacy beliefs that will lead to more positive attitudes toward chemistry.

**APPENDIX-1 Chemistry Laboratory Anxiety Instrument**

| | Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree |
|---|---|---|---|---|---|
| 1. I am anxious when I use chemicals during lab. | | | | | |
| 2. When I work in the chemistry lab, I feel at ease using the equipment. | | | | | |
| 3. When I get ready for lab, I get concerned about recording the data we will generate. | | | | | |
| 4. When I work in the chemistry lab, I feel nervous working with other students. | | | | | |
| 5. I worry about whether I have enough time to complete the lab. | | | | | |
| 6. When I get ready for chemistry lab, I get concerned about the chemicals we will use. | | | | | |
| 7. When working in the chemistry lab, I feel nervous carrying out the lab procedures. | | | | | |
| 8. I am anxious when I record data during lab. | | | | | |
| 9. I feel comfortable working with other students when I am in lab. | | | | | |
| 10. When working in the lab, I am nervous about the time it will take. | | | | | |
| 11. I am comfortable being near chemicals when I am in lab. | | | | | |
| 12. I am anxious when I carry out a lab procedure. | | | | | |
| 13. When working in the chemistry lab, I feel nervous about recording the data I will need. | | | | | |
| 14. I feel anxious when I work with other students during lab. | | | | | |
| 15. When preparing for lab, I am concerned about the time available for doing the experiment. | | | | | |
| 16. When working in the chemistry lab, I feel nervous being around the chemicals. | | | | | |
| 17. I feel anxious when I use equipment during lab. | | | | | |
| 18. When working in the chemistry lab, I feel at ease recording the necessary data. | | | | | |
| 19. When I get ready for chemistry lab, I get concerned about working with other students. | | | | | |
| 20. I am comfortable with the amount of time available for doing the lab. | | | | | |

## APPENDIX-2 Interview Questions

Name, last name? Department ? Grade level?
Which chemistry courses did you take at high school (general chemistry, organic chemistry, analytical chemistry)?
Did you have a chance to make chemistry experiments at high school?
Was there a chemistry laboratory in high school?
If yes, who was performing the experiments, you as a participant or the teacher as a demonstrator?
How many chemistry courses (general chemistry, organic chemistry, analytic chemistry, inorganic chemistry) did you take so far?
Which of those courses included laboratory activities?
Were the physical conditions of the laboratory appropriate for an an experiment (seating arrangement, heating system, cooling system, etc.)
How were your laboratory manuals? Were they helpful?
How do you perform experiments in the laboratory, as an individual or as a team?
How many research assistants guide you during the experiment?
What makes you nervous in the laboratory?
How do you feel during data collection and data recording procedures?
How do you feel while using chemicals?
Have you ever had a laboratory accident?
Do you think what kind of precautions should be taken to prevent laboratory accidents?

## BIODATA AND CONTACT ADDRESS OF AUTHORS

Dilek KARISAN is a research assistant at Middle East Technical University (METU) in Turkey. She graduated from the department of elementary science education at METU in 2008. She gets her M.S degree in 2011. She is still doing PhD at METU at the department of elementary education. She is interested with science teacher education.

Dilek KARIŞAN
Middle East Technical University
Faculty of Education
Department of Elementary Education
Ankara, TURKEY
E. Mail: dilekkarisan@gmail.com

Dr. TUZUN is Associated Professor at METU. She gets her PhD degree from Indiana University in 2004. She has been working at Metu since then. She is interested with Teacher Education, Science Education, Environmental Education, Epistemological Beliefs, Self-Efficacy, Misconception.

Assoc. Prof. Dr. Özgül YILMAZ-TÜZÜN
Middle East Technical University,
Faculty of Education,
Department of Elementary Education
Ankara, TURKEY
E. Mail: ozgul@metu.edu.tr

## REFERENCES

Alvaro, R. (1978).The Effectiveness of a Science-Therapy Program on Science-Anxious Undergraduates, *PhD dissertation*, Loyola University Chicago.

Azizoğlu, N. & Uzuntiryaki, E. (2006). Kimya laboratuarı endişe ölçeği. *Hacettepe Üniversitesi, Eğitim Fakültesi Dergisi, 30*, 55-62.

Aydoğdu, C. (2000). Kimya öğretiminde deneylerle zenginleştirilmiş öğretim ve geleneksel problem çözme etkinliklerinin kimya ders başarısı açısından karşılaştırılması. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, 19,* 29 – 31.

Bentler, P. M. (1990). Comparative fit indices in structural models. *Psychological Bulletin, 107*, 238–246.

Bentler, P. M., & Bonett, D. G. (1980). Significance tests and goodness of fit in the analysis of covariance structures. *Psychological Bulletin, 88,* 588–606.

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.

Browne, M. W., & Cudeck, R. (1993). Alternative ways of assessing model fit. In K. A. Bollen & J. S. Long (Eds.), *Testing structural equation models* (pp. 136 –162). Newbury Park, CA: Sage.

Erökten, S. (2010). The Evaluation of Chemistry Laboratory Experiences on Scıence Students' Anxiety Levels. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi. 38*, 107-114.

Fuller, F., & Bown, O. H. (1975). Becoming a teacher. In K. Ryan (Ed.), *Teacher education*. Chicago: the University of Chicago Press.

Gaudry, E. & Spielberger, C. D. (1971). *Anxiety and Educational Achievement*. John Willey & Sons Australia.

Ghaith, G., & Shaaban, K. (1999). The relationship between perceptions of teaching concerns, teacher efficacy, and selected teacher characteristics. *Teaching and Teacher Education, 15,* 487–496.

Havdala, R. & Ashkenazi, G. (2007). Coordination of Theory and Evidence: Effect of Epistemological Theories on Students' Laboratory Practice. *Journal of Research in Science Teaching, 44* (8), 1134–1159.

Hermes, J. (1985).The Comparative Effectiveness of a Science Anxiety Group and a Stress Management Program in the Treatment of Science-Anxious College Students , *PhD dissertation*, Loyola University Chicago.

Hofstein, A. & Lunetta, V. N.(1982). The role of the laboratory in science teaching: neglected aspects of research. *Review of EducationalResearch,52*(2), 201-217.

Jegede, S. A. (2007). Students' anxiety towards the learning of chemistry in some Nigerian secondary schools. *Educational Research and Review, 2* (7), 193–197.

Kagan, D.M. (1992). Professional growth among preservice and beginning teachers. *Review of Educational Research, 62*(2), 129– 169.
Kline, R. B. (1998). *Principles and practice of structural equation modeling*. New York: Guildford.

Kurbanoglu, N. I., & Akim, A. (2010). The Relationships between University Students' Chemistry Laboratory Anxiety, Attitudes, and Self-Efficacy Beliefs. *Australian Journal of Teacher Education. 35* (8). 47-59.

Mallow, J. V. (1994). Gender-related science anxiety: A first binational study. *Journal of Science Education and Technology, 3,* 227–238.

McCarthy, W. C., & Widanski, B. B. (2009). Assessment of Chemistry Anxiety in a Two- Year College. *Journal of Chemical Education. 86* (12). 1447-1449.

Millar, R., Tiberghien, A. and Le Maréchal, J. F. (2002). Varieties of labwork: a way of profiling labwork tasks. In Psillos, D. & Niedderer, H. (Eds.), *Teaching and learning in the science laboratory* (pp 9–20). Dordrecht: Kluwer.

Pigge, F. L., & Marso, R. N. (1987). Relationships between student characteristics and changes in attitudes, concerns, anxieties, and confidence about teaching during teacher preparation. *Journal of Educational Research, 81*, 109–115.

Rachman, S. (2004). *Anxiety* (2nd ed.) Psychology Press. New York. Spielberger, C. D. (1972). *Anxiety Current Trends in Theory and Research*. Academic Press. New York. London.

Steiger, J. H., & Lind, J. C. (1980). Statistically based tests for the number of common factors. Paper presented at the Psychometric Society Annual Meeting, Iowa City, IA.

Tai, R. H. & Sadler, P. M. (2007). High school chemistry instructional practices and their association with college chemistry grades. Journal of Chemical Education. 84(6), 1040 – 1046.

Tai, R. H. & Sadler, P. M., Loehr, J. F. (2005). Factors Influencing Success in Introductory College Chemistry. Journal of Research In Science Teaching 42 (9), 987–1012.

Tobin , K. , & Fraser, B . J. (1998) . Qualitative and quantitative land scapes of classroom learning environments. In B. J. Fraser & K. G. Tobin (Eds.), *International Handbook of Science Education* (pp. 623–640). Dordrecht, The Netherlands: Kluwer Academic Publishers.

Tobin, K., Tippins, D. J. and Gallard, A. J. (1995). Research on instructional Strategies for Teaching Science. In Gabel D. (Ed): *Handbook of research on science teaching and learning.* (45-93). NY: Macmillan.

Udo, M. K., Ramsey, G. P., Mallow, J. W. (2004). Science Anxiety and Gender in Students Taking General Education Science Courses. *Journal of Science Education and Technology, 13* (4).

Woolnough, B. & Allsop, T. (1985). *Practical Work in Science*. Cambridge: Cambridge University Press.

Yaylı, D., & Hasırcı, S., (2009). Hizmet Öncesi Türkçe Öğretmenlerinin Öğretmeye yönelik endişeleri. *The Journal of International Social Research, 2* (9).