STUDENTS' AFFECTIVE OUTCOMES IN THE UNDERGRADUATE CHEMISTRY LABORATORY COURSES IN LEBANON

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Abstract

The undergraduate chemistry laboratory is an ideal place for meaningful learning to occur. However, accurately characterizing students' affective experiences in the chemistry laboratory can be a very difficult task. This study focuses on students' affective outcomes (attitude and anxiety) towards Chemistry. The participants in this study are 131 undergraduate students at a private university in Beirut, Lebanon. The Chemistry Attitudes and Experiences Questionnaire (CAEQ), and the Chemistry Laboratory Anxiety Instrument (CLAI) were used to collect data. This study led to a main finding that students had "High Attitude Level" and "Moderate Anxiety Level" toward Chemistry. Recommendations for increasing students' attitudes and anxiety towards Chemistry are provided.

Keywords: Chemistry Laboratory, Undergraduate Chemistry, Laboratory, Affective outcomes, Attitude, Anxiety

Introduction

Meaningful learning requires the integration of cognitive and affective learning with the psychomotor, i.e., hands-on learning. In its simplest form, affective learning characterizes the emotional area of learning reflected by the beliefs, values, interests, and behaviors of learners (Gronlund & Brookhart, 2009). Affective learning is concerned with how learners feel while they are learning, as well as with how learning experiences are internalized so they can guide the learner's attitudes, opinions, and behavior in the future (Miller, 2005).

Affective learning outcomes are essential components of a 21st-century university education, as exemplified in statements of graduate outcomes, various accreditation standards, and employer surveys internationally. In fact, some argue that affective learning outcomes are more important for the success of graduates and the success of society than are many of the specific cognitive outcomes emphasized in current programs. With globalization putting distinctly different cultures in close contact, rapid economic expansion leading to rapid career displacement and the growth of higher education leading to more diverse student populations inhabiting our campuses, affective learning outcomes are increasingly indispensable outcomes of university education (Gano-Phillips & Friedman, 2009).

Hofstein and Lunetta (2004) suggested that the laboratory, as a unique social setting, has great potential in enhancing social interactions that can contribute positively to developing attitudes and cognitive growth.

Students' Attitudes towards Chemistry Laboratory Work

Attitude is defined as the way you think and feels about someone or something, a feeling or way of thinking that affects a person's behavior, or a way of thinking and behaving that people regard as unfriendly, rude, etc. (Merriam-Webster, 2016). A common definition has involved describing attitudes as including the three components

of cognition, affect, and behavior (Rajecki, 1990). A problem that has been raised by those studying attitudes towards science (Osborne, Simon, & Collins, 2003) is the definition of attitude itself. There seem to be many concepts that relate to attitudes that may or may not be included in their definitions; for example, feelings, motivations, enjoyment, affect, and self-esteem. Reid (2006) provides a clear definition of these components: (a) a knowledge about the object, the beliefs, ideas components (Cognitive); (b) a feeling about the object, like or dislike component (Affective); and (c) a tendency-towards-action, the objective component (Behavioral).

Students' attitude toward the learning of chemistry is a factor that has long attracted the attention of researchers, and there is a great agreement among science theorists and practitioners on the importance of students' attitudes toward chemistry lessons in school (Osborne, Simon & Collins, 2003). Koballa (1988) noted that "affective variables are as important as cognitive variables in influencing learning outcomes, career choices, and use of leisure time". The development of students' positive attitudes toward chemistry as a school subject is an important issue. Unfortunately, research has established that much of what goes on in chemistry classrooms and laboratories are not particularly attractive to students across all ages (Stark & Gray, 1999).

Enhancement of students' positive attitudes to chemistry is very important due to two main reasons. First of all, research on the link between attitudes and academic achievement revealed that these variables were closely related to each other. For example, in a meta-analysis study (Weinburgh, 1995) it was found that the correlation between attitude toward science and achievement is 0.50 for boys and 0.55 for girls, indicating that attitude can account for nearly 30% of the variance in achievement. Similarly, Freedman's (1997) study demonstrated that there was a positive correlation between attitude toward science and achievement. On the other hand, Salta and Tzougraki (2004) reported that the correlation between chemistry achievement and positive attitudes toward chemistry ranged from 0.24 to 0.41. Bennett, Rollnick, Green, and White (2001) also determined that undergraduate students who had a less positive attitude to chemistry almost invariably obtained lower examination marks (Cheung, 2009). The second reason that makes attitudes important is that attitudes predict behaviors (Glasman & Albarracín, 2006).

Development and Use of Chemistry Attitudes and Experiences Questionnaire (CAEQ)

In 2002, Coll et al. designed the Chemistry Attitudes and Experiences Questionnaire (CAEQ) to quantitatively measure a student's attitudes, self-efficacy, and experiences regarding Chemistry at the post-secondary level. The CAEQ is an instrument that investigates tertiary level learning experiences of chemistry students, along with their attitude-towards-chemistry and chemistry self-efficacy. It measures students' attitudes toward chemists, Chemistry research, Chemistry as a career choice, and their leisure interest in Chemistry. Also, the CAEQ measures self-efficacy concerning students' confidence in the lab, using formulas, writing about Chemistry, discussing Chemistry with their peers or a scientist, and thinking critically about Chemistry. Finally, the CAEQ also measures students' opinions of their experiences in lecture, lab, and tutorials.

The theoretical framework for the development of the CAEQ is based on current thinking in behavioral theory; specifically, it has been adapted from the Theory of Planned Behavior (TPB) (Figure 1). The TPB is an all-encompassing theory that maintains behavior is determined by many influences including significant individuals in one's life. According to the TPB, an individual's behavior is influenced by their attitude toward that particular behavior, their associates (peers and family) attitude toward the behavior and the individual's perceived control over the behavior (Ajzen, 1989).

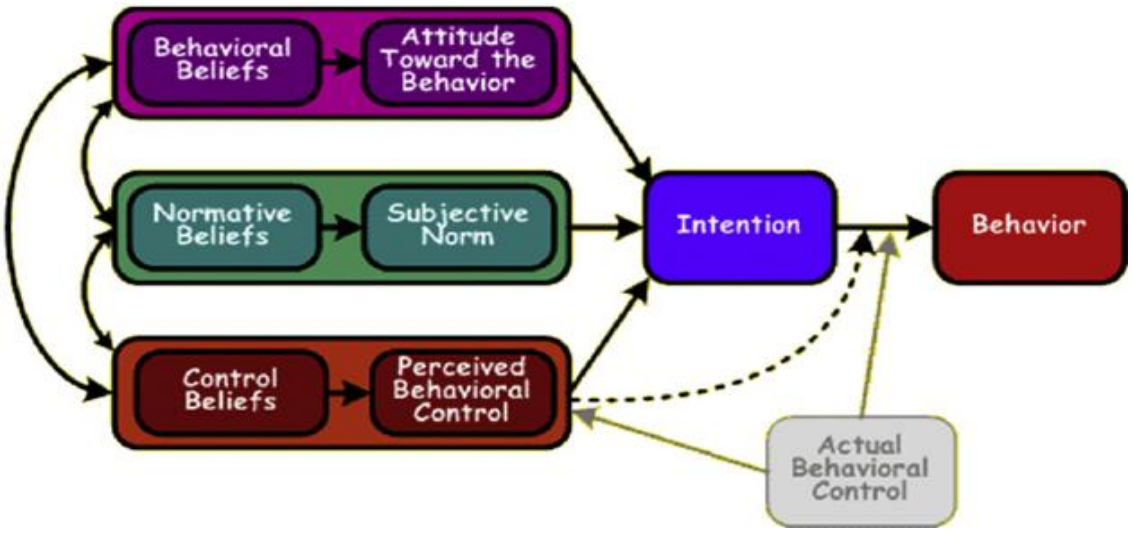

Figure 1: Theory of Planned Behavior (TPB)

The focus of the CAEQ is on the experiences of attitude towards enrolling in chemistry. The influence of associates attitude and perceived behavioral control also may influence students' attitude towards enrolling in chemistry. This influence is not addressed by the CAEQ but has been investigated previously in a qualitative study done by Dalgety et al. (2001).

The Chemistry Attitudes and Experiences Questionnaire (CAEQ) is a 76-item instrument that asks students to rate their attitudes in three key areas (learning experiences, attitude-towards-chemistry, and chemistry self-efficacy); but in this study, we are interested in only one area 'Attitude-toward-chemistry' which only contains 22 items distributed on five subscales (see Table 1).

Table 1: Descriptive Information of CAEQ

Scale	Subscale	Description of Scale	Format	Sample Items	Items #
Attitude-Toward-Chemistry	Attitude-Toward-Chemists (3 items)	Attitudinal beliefs about Chemistry practitioners	7-point Semantic Differential	Chemists are: Unfit/Athletic	1, 2, 3
	Required skills of Chemistry	The personality traits necessary for Chemistry		Chemists are: Impatient/ Patient	4, 5, 6,

22 items	(6 items)	practitioners			7, 8, 9
	Attitude-Toward-Chemistry in society (4 items)	Attitudinal beliefs about the role of Chemistry in society		Chemistry research: Harms people/ Helps people	10, 11, 12, 13
	Career interest in Chemistry (5 items)	Interest in the Chemistry discipline as a career option		Chemistry jobs: Tedious/ Exciting	14, 15, 16, 17, 18
	Leisure interest in Chemistry (4 items)	Interest in the Chemistry discipline as a leisure option		Chemistry websites: Boring/ Interesting	19, 20, 21, 22

Attitudinal responses are measured using a seven-point semantic differential scale (1=positive to 7=negative). The 'Positive attitude' scoring items were for 'Athletic', 'Patient', 'Helps people', 'Exciting', and 'Interesting', whereas items which suggested a 'Negative attitude' were: 'Unfit', 'Impatient', 'Harms people', 'Tedious', and 'Boring'.

Coll, Dalgety, and Salter (2002) described the Chemistry Attitudes and Experiences Questionnaire (CAEQ) as a tool to measure first-year university chemistry students' attitude-towards-chemistry, chemistry self-efficacy, and their learning experiences. The instrument was developed to maximize construct validity, by reference to a sound theoretical framework and evaluation of both predictive and concurrent validity. To examine the usefulness of the CAEQ, the instrument was administered at two tertiary institutions at the beginning of the academic year (n=332) and the end of the first semester (n=337). The findings suggest that the CAEQ will prove a useful tool for tertiary level educators who wish to gain an understanding of factors that influence student choice of chemistry enrolment.

Coll, Dalgety, and Jones (2003) encourage the use of real-world examples both in laboratory and lecture classes and the improved use of visual aids to engage students in the learning. Their research showed that students who were interested in the field and reported positive learning experiences continued into the second year, even if they found the material difficult. Moreover, they established the validity of the CAEQ through the use of a panel of experts (Chemistry faculty and graduate students) and a sample of undergraduate student representatives of the intended population of those who would complete the CAEQ. The experts provided their views on scales, subscales, and individual items, as well as their recommendations for which items to include in the instrument. Undergraduate students, representative of the intended population who would complete the CAEQ, provided input into clarity and readability of items through interviews. As well, an expert in the teaching of English as a Subsequent Language (ESL), students approved the readability of the instrument for ESL students.

College Students' Anxiety in the Chemistry Laboratory

Anxiety is defined as fear or nervousness about what might happen, or a feeling of wanting **to do** something very much (Merriam-Webster, 2016). Some students find chemistry classes and lab work stressful (Eddy, 2000). This anxiety has been called chemophobia. Fears commonly center on academic performance, the difficulty of learning chemical equations, and fear of getting lab chemicals on the hands. Female students were more anxious than male students. Previous exposure to learning chemistry was associated with lower anxiety.

Chemistry courses are considered as very challenging subjects for some undergraduate science students, but many students may experience anxiety and phobia towards this subject, and they may fail to perform well during their first or second academic years. It is essential to note that laboratory learning involves three outcomes, which are the following: cognitive outcomes (designing experiments), psychomotor outcomes (making observations), and affective outcomes (development of positive self-image or decreased anxiety in the laboratory environment).

Anxiety can affect a person physically or cognitively. Physically, the symptoms of anxiety are unsteady feelings, dizziness, shortness of breath, etc. Cognitively, anxiety prevents one from paying full attention, which finally obstructs the information processes, disabling the person from encoding and retrieving information appropriately (Flavell, 1987). This is supported by Littlewood (1996) who stressed the importance of emotion and internal motivation being implemented in the classroom to engage students' involvement, resolution, participation, and curiosity during the learning process.

Anxiety about chemistry laboratory influences students' performance (Eddy, 2000; Wynstra & Cummings, 1993). It has been observed that so many students fear chemistry laboratory activities, and such fear is characterized by disappointment among the students towards the subject (Jegede, 2007). According to Keeves and Morgenstern (1992), students' anxiety towards the learning of chemistry and chemistry laboratory activities makes them lose interest in that area. Moreover, the causes of chemistry laboratory anxiety are many, including past bad experiences in science classes, exposure to science anxious teachers who are teaching science in elementary and secondary schools, lack of role models, gender and racial stereotyping, and the stereotyping of scientists in the popular media. Though some degree of anxiety may be helpful in the learning process, a high level of anxiety impedes optimum performance on science learning (Udo, Ramsey, & Mallow, 2004).

Eddy (2000) examined chemistry anxiety under three dimensions as learning chemistry anxiety, chemistry evaluation anxiety, and handling chemicals anxiety. Bowen (1999), who first introduced the term chemistry laboratory anxiety, referred to chemistry laboratory anxiety from a cognitive perspective, which hinders students' performance in the chemistry laboratory, especially the understanding of chemical concepts, use of reasoning skills, and laboratory skills. He developed a chemistry laboratory anxiety scale and conceptualized it as a five-dimensional construct: (1) working with chemicals; (2) using equipment and procedures relating to chemistry; (3) collecting data; (4) working with other students; and (5) having adequate time.

Studies indicated that the students, whether males or females, urban or rural based, show great anxiety towards the learning of chemistry (Jegede, 2007). Also, relational studies demonstrated that students with high positive attitudes toward chemistry course had less anxiety toward chemistry laboratory (Kurbanoglu, Akim, & Takunyaci, 2009; Uzuntiryaki & Azizoğlu, 2004).

Different research studies have shown that anxiety is connected to students' performance and achievements. According to Öner (1990), a significant negative interaction was found between average scores of mathematics, general academic achievement, and anxiety scores to exams. Moreover, Yıldırım (2000) claimed that the academic success was predicted by loneliness and anxiety for exams. So, from both studies, it can be concluded that the academic achievement is related to some affective characteristics.

In their research, Westerback and Primavera (1992) and Eddy (2000) indicated that chemophobia does exist in the college classroom and that anxiety does affect students' performance in chemistry. Moreover, another study conducted by Terrell (2000) showed that chemistry anxiety showed significant correlation with achievement.

Moreover, Abendroth and Friedman (1983) pointed out that the college students were especially anxious about the 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, 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 showed that this treatment technique reduced students' chemistry anxiety levels.

The aim of a study done by Kurbanoglu and Akim (2010) is to examine the relationships between chemistry laboratory anxiety, chemistry attitudes, and self-efficacy. Participants were 395 university students. Participants completed the Chemistry Laboratory Anxiety Scale, the Chemistry Attitudes Scale, and the Self-Efficacy Scale. Results showed that chemistry laboratory anxiety was correlated negatively with chemistry attitudes and self-efficacy. On the other hand, chemistry attitudes were found to be positively associated with self-efficacy. The path model showed that self-efficacy predicted chemistry laboratory anxiety in a negative way. Also, self-efficacy has a direct and positive effect on chemistry attitudes which in turn affects chemistry laboratory anxiety. Finally, chemistry laboratory anxiety was explained negatively by chemistry attitudes.

The literature presents some evidence that students' attitudes toward science and their anxiety levels concerning science courses affect their learning or achievement in science (Koballa & Glynn, 2007; Osborne & Collins, 2000). The students with more positive attitude toward science or chemistry are likely to be more successful in science or chemistry lessons (McCarthy & Widanski, 2009). 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 importance and are interested in safety and risks issues more than learning in chemistry laboratory (Högström, Ottander, & Benckert, 2010). Using chemical materials and using time effectively to complete an experiment are important factors that affect students' anxiety in chemistry laboratories (Eddy, 2000). 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 with chemistry attitudes and self-efficacy. Additionally, self-efficacy predicted chemistry laboratory anxiety in a negative way.

A study was done by Melaku Masresha, Harrison and Temechegn in 2013. The study was also designed to find out students' anxiety towards the learning of chemistry, identify the factors that cause the anxiety, examine the disposition of sex towards the learning of chemistry and suggest ways to increase their taste towards the learning of the subject. Data for the study were obtained by administering a questionnaire to 300 respondents. The data obtained were analyzed using frequency counts, percentages, and stanine test. The finding of the study revealed that the students, whether male or female, urban or rural based, show great anxiety towards the learning of chemistry and that the anxiety is higher in females and rural based students than males and urban-based students. The cause of students' anxiety as revealed by the study includes redundancy of the curriculum, low awareness of career opportunities, the teachers and their teaching methods and lack of teaching aids/laboratories.

It is important to note that gender differences were also studied to test students' level of anxiety. 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 concerning chemistry evaluation. Females were more anxious about chemistry evaluation. Besides, there was a significant mean difference between college majors which are science, allied health, social science, business, education, and tech concerning learning chemistry anxiety.

According to McCarthy and Widanski (2009), 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. The decrease in these negative attitudes would lead to increased student enrollment and achievement in chemistry courses.

Development and Use of Chemistry Laboratory Anxiety Instrument (CLAI)

Laboratory learning is one of the most valued outcomes in the chemistry education community. It is important to admit that affective dimensions of learning and performance, such as anxiety, affect learning and performance in laboratory situations. For example, reducing anxiety in laboratory situations may potentially enhance the learning of complex laboratory and problem-solving skills. Instruments for measuring affective aspects of learning in laboratory situations are useful tools for the chemistry education community.

The Chemistry Laboratory Anxiety Instrument (CLAI) was designed to measure anxiety students have in college chemistry laboratory courses (Bowen, 1999). The CLAI consisted of total 20 items rated on a Likert-type scale and distributed into five scales where each scale contains four items (see Table 2). And it is important to mention that the items are placed in a cyclic arrangement (Figure 2).

Fifteen of the twenty items were positive statements which support anxiety; however, the remaining five items were negative statements. The fifteen positive statements were rated as 5, 4, 3, 2, 1 from strongly agree to strongly disagree; on the contrary, the remaining five negative statements were rated as 1, 2, 3, 4, 5. A higher score indicates higher Chemistry anxiety level. This means each response which strongly agrees with a statement of anxiety or fear concerning chemicals and chemistry was scored as 5. A high score in this subscale indicated that the respondent had a high level of anxiety and fear concerning chemicals and chemistry; whereas, a low score indicated a little anxiety or no fear concerning chemicals and chemistry.

Table 2: Descriptive Information of CLAI

Scale	Format	Sample Items	Items #
Working With Chemicals	5-point Likert (Strongly Agree/ Strongly Disagree)	I am anxious when I use chemicals during lab. [+]	1, 6, 11, 16
Using Equipment and Procedures		When working in the chemistry lab, I feel nervous carrying out the lab procedures. [+]	2, 7, 12, 17
Attitude toward-Collecting Data		When working in the chemistry lab, I feel nervous about recording the data I will need. [+]	3, 8, 13, 18
Working With Other Students		I feel anxious when I work with other students during lab. [+]	4, 9, 14, 19
Having Adequate Time		I am comfortable with the amount of time available for doing the lab. [-]	5, 10, 15, 20
CLAI has 20 items, where five items of them are negatively keyed (Items#: 2, 9, 11, 18, and 20)			

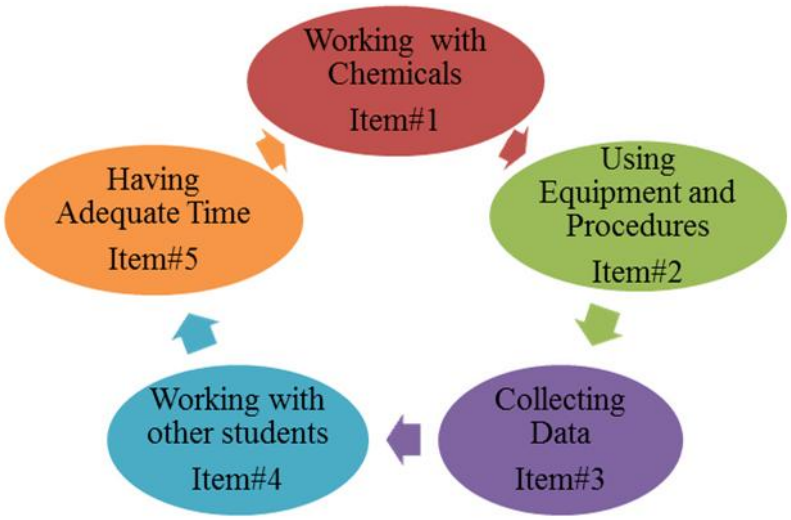

Figure 2: Cyclic arrangement of CLAI items

Purpose of the Study and Research Questions

The main purpose of this study is to gain an understanding of students' affective outcomes in the undergraduate Chemistry laboratory courses by examining the important ground including attitudes and anxiety. This study tried to answer the following questions:

1. What are the students' attitudes toward Chemistry?

2. What are the students' anxiety levels toward Chemistry?

Research Methodology

Design, Participants, and Setting

In this study, the researcher used Non-Experimental Quantitative Design. This study took place at a large private university in Beirut (Lebanon) during the Spring 2014 semester which is for four months in the Natural Sciences Department and covered a sample of six Chemistry laboratory courses. These six Chemistry laboratory courses were the only courses offered during Spring 2014.

A total of 131 undergraduate students from ten sections enrolled in the six lab courses participated in this study. The students were informed that this study had no impact on their grades and all the names of the instructors and rooms were represented by pseudonyms. Most of the respondents came from urban areas in a percentage of 89%; whereas only 10.96% of the students enrolled were from rural areas. The highest percentage of responses (86%) that completed the questionnaires was in the age range of 18-20 years, and 66% were females. Ninety percent of the respondents have completed their high school at private academic institutions, and 77% of the students were Lebanese. The majority of the students were at the junior level (48%).

Instrumentations

For this study and to answer the two research questions, the researcher used two instruments to collect data. A quantitative component was involved in this study by administrating two questionnaires listed below:

1. Chemistry Attitudes and Experiences Questionnaire (CAEQ): To assess students' attitudes towards Chemistry (Appendix A)
2. Chemistry Laboratory Anxiety Instrument (CLAI): To measure the anxiety students have in College Chemistry Laboratory courses (Appendix B)

Data Analysis

The quantitative data were analyzed by using the SPSS20 software. Descriptive statistics (mean, mode, min, max, standard deviation, CV, etc.) were calculated for the two questionnaires related to the students' affective outcomes (Attitude and Anxiety)

Data Analysis and Results

What are the students' attitudes toward Chemistry?

The data presented in Table 3 and it reports the mean, standard deviation, minimum, maximum and coefficient of variation (CV) of the sample. As shown in Table 3, attitudinal responses were measured using a seven-point semantic differential scale (1=positive to 7=negative). All the five scales showed a positive attitude towards Chemistry (all means were close to 1 which is positive this means that the lower score indicates a high positive attitude towards Chemistry). The overall average item of students' attitudes towards Chemistry was 2.63. The most positive attitudinal scale was the 'Attitude towards Chemistry in society' with an average mean of 2.07, and the least positive attitudinal scale was the 'Leisure interest in Chemistry' with an average mean of 3.32 (Figure 3). Based on the average item mean, students' attitudes towards Chemistry in ascending order were 'leisure interest in Chemistry' (mean=3.32), 'attitude towards chemists' (mean=2.693), 'career interest in Chemistry' (mean=2.666), 'skills of chemists' (mean=2.402), and 'attitude toward Chemistry in society' (mean=2.075).

Respondents agreed on that the chemists show social and environmental awareness (means= 2.47 and 1.95 respectively), are flexible in their ideas and careful about the impact of their results (means= 2.67 and 1.91 respectively), have imaginary mind (mean=2.77), friendly (mean=2.46), inquisitive (mean=2.54), patient (mean=2.06), help people (mean=1.95), improve quality of life (mean=2.10) as well as society (mean=2.20), solve problems (mean=2.05), challenging and varied career (means= 2.07 and 2.70 respectively), interesting and satisfying (means= 2.66 and 2.95 respectively), and exciting (mean=2.95). Regarding their leisure interest in chemistry, some of the respondents saw that science documentaries can be enjoyable (mean=2.94). Also, most of the participants indicated that science websites are interesting (mean=3.02). However, respondents showed that chemists are less athletic (mean=3.66), talking with each other about Chemistry is not very fascinating (mean=3.99 which is a neutral respond) and science fiction movies are not very exciting (mean=3.33).

Table 3: Descriptive Statistics of CAEQ

N= 131 students		Number of items	Mean	Std. Deviation	Min	Max	CV
Attitude toward Chemists		3	2.67	1.12	1.00	7.00	57.26%
1	1= Athletic, 7 = Unfit						
2	1= Socially aware, 7 = Socially unaware						
3	1= Environmentally aware, 7 = Environmentally unaware						
Required skills of Chemists		6	2.39	1.05	1.00	5.83	62.43%
4	1= Flexible in their ideas, 7 = Fixed in their ideas						
5	1= Care about the effects of their results, 7 = Only care about their results						
6	1= Imaginative,7 = Unimaginative						
7	1= Friendly, 7 = Unfriendly						
8	1= Inquisitive, 7 = Indifferent						

9	1= Patient, 7 = Impatient					
Attitude toward Chemistry in society	4	2.07	1.00	1.00	5.25	59.42%
10	1= Help people, 7 = Harms people					
11	1= Improves quality of life, 7= Decreases quality of life					
12	1= Solve problems, 7= Create problems					
13	1= Advance society, 7= Cause society to decline					
Career interest in Chemistry	5	2.68	1.12	1.00	6.00	55.18%
14	1=Challenging, 7= Easy					
15	1= Varied, 7= Repetitive					
16	1= Interesting, 7= Boring					
17	1= Satisfying, 7= Unsatisfying					
18	1= Exciting, 7= Tedious					
Leisure interest in Chemistry	4	3.32	1.37	1.00	7.00	53.82%
19	Science documentaries: 1= Enjoyable, 7= Boring					
20	Science websites: 1= Interesting, 7= Boring					
21	Talking to my friend about Chemistry: 1= Fascinating, 7= Dull					
22	Science fiction movies: 1= Exciting, 7= Tedious					
Attitudes Towards Chemistry	**22 Items**	**2.63 Mean**				

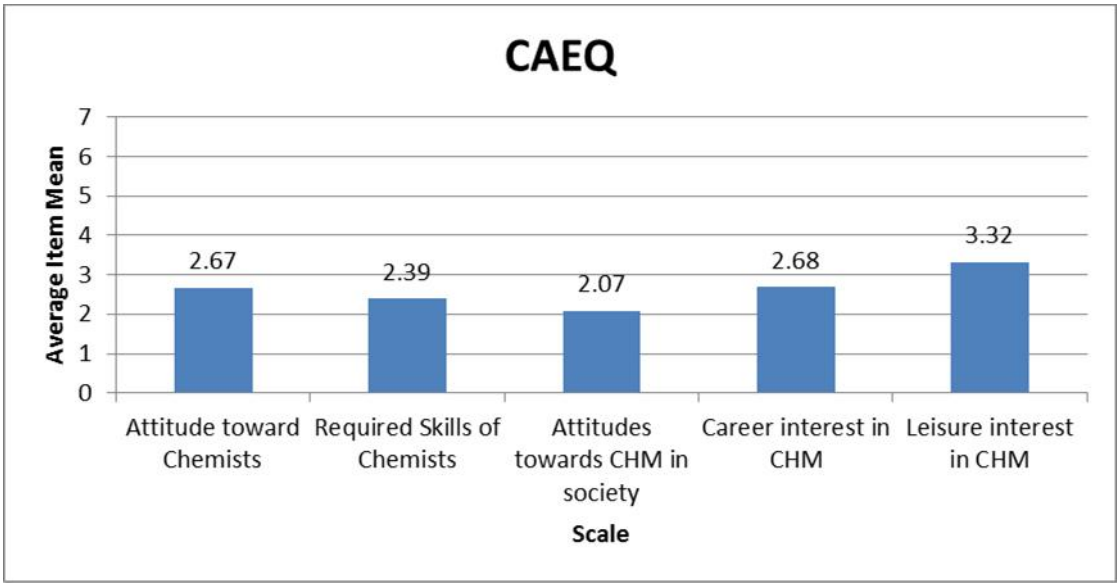

Figure 3: Simplified Plot of CAEQ

To have a clearer vision on students' attitude toward Chemistry, further analysis was done. The respondents' obtained was interpreted using the following scale with the corresponding description:

Scale	Description
1.0-2.5	Very High Attitude Level
2.6-4.0	High Attitude Level
4.1-5.5	Low Attitude Level
5.6-7.0	Very Low Attitude Level

The total mean obtained in Chemistry attitude (mean=2.63) signifies that the students have 'High Attitude Level' toward Chemistry.

What are the students' anxiety levels toward Chemistry?

The data presented in Table 4 for the present sample of 131 students, and it reports the mean, standard deviation, minimum, maximum and coefficient of variation (CV) of the sample, taking into consideration the negative items were reversed (Items#: 2, 9, 11, 18, and 20).

All the five scales showed low anxiety levels towards Chemistry (all means were below 3). The overall average item of students' anxiety towards Chemistry was 2.56 (Table 4). Based on the average item mean (Figure 4), students' anxiety towards Chemistry in descending order were "working with chemicals" (mean=2.8), "collecting data" (mean=2.71), "having adequate time" (mean=2.57), "using equipment and procedure" (mean=2.46), and "working with other students" (mean=2.27).

By looking closer to each item in CLAI, we found around four items that somehow supported anxiety with mean scores around 3. Those were: Item# 1 'I am anxious when I use chemicals during the lab' (mean=3.22), Item# 3 'When I get ready for lab, I get concerned about recording the data we will generate' (mean=3.52), Item# 6 'When I get ready for lab, I get concerned about the chemicals we will use' (mean=2.91), and Item# 10 'When working in the lab, I am nervous about the time it will take' (mean=2.91).

Table 4: Descriptive Statistics of CLAI

N= 131students		Mean	Mode	Std. Deviation	Min	Max	CV
Working with Chemicals		2.80	2.75	0.73	1.25	4.50	25.95%
1	I am anxious when I use chemicals during lab.						
6	When I get ready for chemistry lab, I get concerned about the chemicals we will use.						
11	I am comfortable being near chemicals when I am in the lab.						
16	When working in the chemistry lab, I feel nervous being around the chemicals.						
Using Equipment and Procedures		2.46	2.00	0.66	1.00	4.00	26.73%
2	When I work in the chemistry lab, I feel at ease using the equipment.						
7	When working in the chemistry lab, I feel nervous carrying out the lab procedures.						
12	I am anxious when I carry out a lab procedure.						
17	I feel anxious when I use equipment during lab.						
Collecting Data		2.71	3.00	0.72	1.00	4.50	26.57%

3	When I get ready for the lab, I get concerned about recording the data we will generate.						
8	I am anxious when I record data during lab.						
13	When working in the chemistry lab, I feel nervous about recording the data I will need.						
18	When working in the chemistry lab, I feel at ease recording the necessary data.						
Working with Other Students		2.27	2.50	0.79	1.00	4.00	34.90%
4	When I work in the chemistry lab, I feel nervous working with other students.						
9	I feel comfortable working with other students when I am in the lab.						
14	I feel anxious when I work with other students during lab.						
19	When I get ready for chemistry lab, I get concerned about working with other students.						
Having Adequate Time		2.57	2.75	0.76	1.00	4.50	29.75%
5	I worry about whether I have enough time to complete the lab.						
10	When working in the lab, I am nervous about the time it will take.						
15	When preparing for the lab, I am concerned about the time available for experimenting.						
20	I am comfortable with the amount of time available for doing the lab.						
Anxiety Towards Chemistry		**20 Items**	**2.56 Mean**				

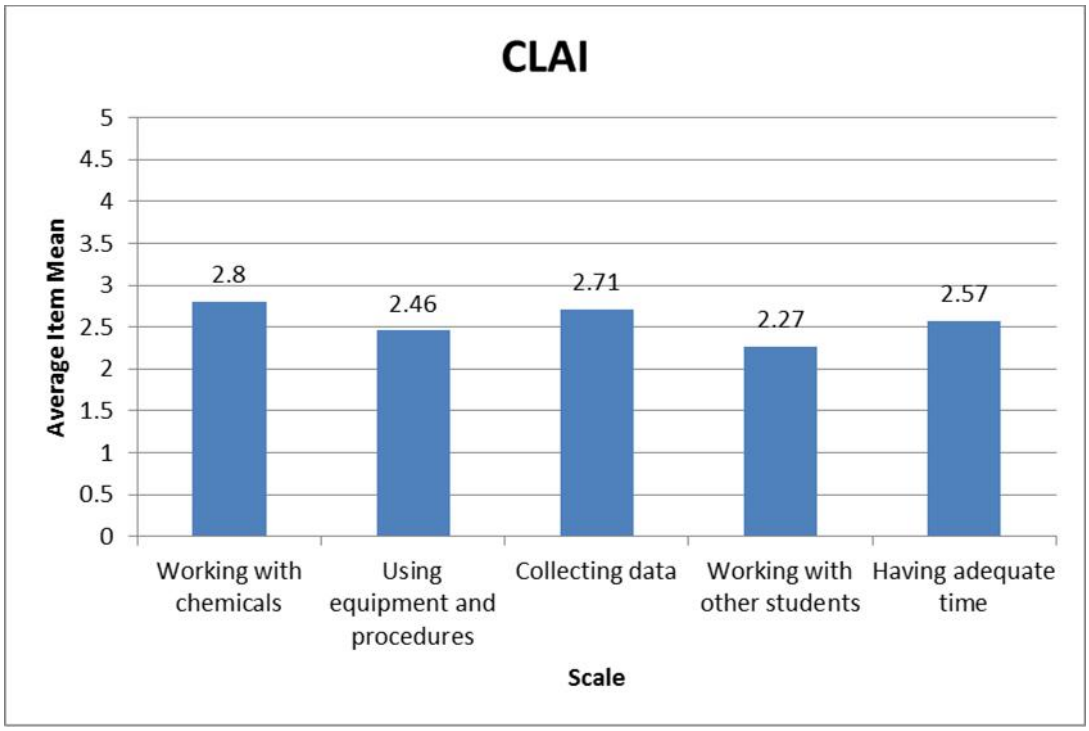

Figure 4: Simplified Plot of CLAI

To have a clearer vision of students' anxiety levels toward Chemistry, further analysis was done. The respondents' obtained was interpreted using the following scale with the corresponding description:

Scale	Description
1.00-2.33	Low Anxiety Level
2.34-3.66	Moderate Anxiety Level
3.67-5.00	High Anxiety Level

The total mean obtained in Chemistry anxiety (mean=2.56) signifies that the students had 'Moderate Anxiety Level' toward Chemistry. The moderate level of anxiety was considered normal.

Discussion of the Results and Findings

Since chemistry is a science based on experimentation, experimenting in a laboratory is an important part of chemistry learning. Besides, to develop interest, curiosity, positive attitudes toward chemistry, creativity, and problem-solving ability in science and to improve students' understanding of science concepts and scientific process, laboratories are essential (Azizoğlu & Uzuntiryaki, 2006). In the chemistry laboratory, the effects of both cognitive factors and affective factors are important, but the most important factor that affects the success of the students in the chemistry laboratory is the affective factor which is anxiety. So, it is well known that anxiety towards the learning of chemistry and chemistry laboratory activities had a strong and negative impact on the development of positive attitudes towards chemistry. In other words, negative attitudes can produce negative results in chemistry and thus creates chemistry laboratory anxiety. The relationships between chemistry laboratory anxiety and chemistry attitudes are easily understandable. That is the negative attitude towards chemistry are promoted while positive attitudes are decreased by chemistry laboratory anxiety. Therefore, affective dimensions of learning such as anxiety and attitudes are perceived as important predictors of student performance in laboratory situations (Bowen, 1999; Eddy, 2000; Wynstra & Cummings, 1993).

Many studies indicated that the students show great anxiety towards the learning of chemistry (Jegede, 2007). This contradicts the findings of our study, where we found a moderate normal anxiety level among the students in the undergraduate chemistry laboratory courses. Also, relational studies demonstrated that students with high positive attitudes toward chemistry course had less anxiety toward chemistry laboratory (Kurbanoglu, Akin, & Takunyaci, 2009; Uzuntiryaki & Azizoğlu, 2004). In our study, we also found that high positive attitude toward chemistry leads to moderate anxiety (low anxiety) level toward chemistry.

Finally, this study also didn't show that both chemistry laboratory learning environment and instructors' interpersonal behavior had an impact on the students' affective outcomes: Attitudes and Anxiety toward chemistry at the university level.

Recommendations of the Study

It is needed that the instructors be aware of the effects of anxiety on students' achievement and motivation during their training so that they make an effort to increase students' attitudes and to reduce anxiety toward chemistry through: First, setting clear goals and objectives for the tasks need to be spelled out. This will help in

aligning teaching/learning expectations of the instructor and the students so that they work towards the same goal. Second, helping students to control anxieties and fears related to chemistry laboratory studies which can facilitate the development of positive self-efficacy beliefs, which will, in turn, leads to more positive attitudes. Third, creating a safe environment in which students do not feel threatened and allow them to relax. Safety is a positive value in the laboratories- it prevents injuries, saves lives, and improves productivity and outcomes. The laboratory is a unique environment. Hazard identification, hazard assessment, and hazard management in laboratory operations are critical skills that need to be part of all undergraduate, graduate, and postdoctoral education. Therefore, instructors and students must attend safety sessions. Finally, incorporating more cooperative learning strategies may help foster a more positive attitude toward chemistry and reduce anxiety because it can provide a sense of social support for students which can decrease the feelings of isolation and the belief that everyone understands this but me, which lead to more student-student interaction. With all these efforts it can be a positive force in reducing the Chemistry anxiety. Chemistry instructors must show their students a sincere, caring attitude in the lab to help them overcome Chemistry anxiety which can lead to a more positive attitudes level toward chemistry.

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Appendix A: Chemistry Attitudes and Experiences Questionnaire (CAEQ) - ATTITUDES TOWARDS CHEMISTRY

Direction This part of the questionnaire investigates **the perceptions YOU HAVE ABOUT CHEMISTRY AND RELATED TOPICS**.

For example: If you feel chemistry is mostly about the study of natural substances and only a little bit about the study of synthetic material then you would answer the following questions as shown:

Chemistry:

Natural substances	O	■	O	O	O	O	O	Synthetic material

Please indicate what YOU think about the following									
Attitude towards Chemists									
Chemists:	Athletic	O	O	O	O	O	O	O	Unfit
	Socially aware	O	O	O	O	O	O	O	Socially unaware
	Environmentally aware	O	O	O	O	O	O	O	Environmentally unaware
Required Skills of Chemists									
Chemists:	Flexible in their ideas	O	O	O	O	O	O	O	Fixed in their ideas
	Care about the effects of their results	O	O	O	O	O	O	O	Only care about their results
	Imaginative	O	O	O	O	O	O	O	Unimaginative
	Friendly	O	O	O	O	O	O	O	Unfriendly
	Inquisitive	O	O	O	O	O	O	O	Indifferent
	Patient	O	O	O	O	O	O	O	Impatient
Attitudes towards Chemistry in Society									
Chemistry research:	Help people	O	O	O	O	O	O	O	Harms people
	Improves quality of life	O	O	O	O	O	O	O	Decreases quality of life
	Solve problems	O	O	O	O	O	O	O	Create problems

	Advance society	O	O	O	O	O	O	O	Cause society to decline
Career Interest in Chemistry									
Chemistry jobs:	Challenging	O	O	O	O	O	O	O	Easy
	Varied	O	O	O	O	O	O	O	Repetitive
	Interesting	O	O	O	O	O	O	O	Boring
	Satisfying	O	O	O	O	O	O	O	Unsatisfying
	Exciting	O	O	O	O	O	O	O	Tedious
Leisure Interest in Chemistry									
Science documentaries:	Enjoyable	O	O	O	O	O	O	O	Boring
Science websites:	Interesting	O	O	O	O	O	O	O	Boring
Talking to my friend about Chemistry:	Fascinating	O	O	O	O	O	O	O	Dull
Science fiction movies:	Exciting	O	O	O	O	O	O	O	Tedious

Appendix B: Chemistry Laboratory Anxiety Instrument (CLAI)

Direction **The purpose of this survey is to collect data on how YOU feel about various aspects of your laboratory experiences in chemistry. Circle your response according to how much you agree or disagree with the statement.**

		rongly Agree	Agree	Neither	isagree	rongly isagree
1.	I am anxious when I use chemicals during lab.	SA	A	N	D	SD
2.	When I work in the chemistry lab, I feel at ease using the equipment.	SA	A	N	D	SD
3.	When I get ready for lab, I get concerned about recording the data we will generate.	SA	A	N	D	SD
4.	When I work in the chemistry lab, I feel nervous working with other students.	SA	A	N	D	SD

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