The Relationships between University Students' Chemistry Laboratory Anxiety, Attitudes, and Self-Efficacy Beliefs

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Abstract: *The aim of this study 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 to chemistry attitudes and to 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. Results were discussed in the light of literature.*

Introduction

An essential characteristic of the effective chemistry education is to support theoretical explanations with actual practices in the laboratory. Therefore, laboratory activities have long had a unique and central role in chemistry education. Science educators have proposed that many educational benefits accrue from engaging students in chemistry laboratory activities (Lunetta, 1998). The chemistry laboratory is a unique mode of instruction and a learning environment in which the students work cooperatively and collectively in small groups to examine a scientific phenomena. When properly developed, laboratory activities have the potential to enhance students' achievement, conceptual understanding and understanding of the nature of science as well as their positive attitudes and cognitive growth (Hofstein, Levy Nahum, & Shore, 2001; Lazarowitz & Tamir, 1994). Since the atmosphere of laboratory is less formal when compared to the classroom atmosphere and presents the opportunities for more interaction between students and teacher, students and their peers; it naturally has the potential to promote positive social interactions and thus create a constructive and positive learning environment (Hofstein et al., 2001; Lazarowitz, 1991).

Since chemistry is a science based on experimentation, doing an experiment in a laboratory is an important part of chemistry learning. Besides, in order 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). However, although there a lot of important studies for improving chemistry teaching and learning, and chemistry is very important for students' academic improvement, the achievement level of students in the subject still remains low. Therefore, affective dimensions of learning such as anxiety, attitudes, and self-efficacy are perceived as important predictors of student performance in laboratory situations (Bowen, 1999).

Chemistry laboratory anxiety

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) has examined chemistry anxiety under three dimensions as learning chemistry anxiety, chemistry evaluation anxiety, and handling chemicals anxiety. On the other hand, Bowen (1999), who first introduced the term chemistry laboratory anxiety, has referred to chemistry laboratory anxiety from a cognitive perspective, which hinders students' performance in chemistry laboratory, especially on understanding of chemical concepts, use of reasoning skills, and laboratory skills. He has developed a chemistry laboratory anxiety scale and conceptualized it as a five dimensional construct:

- Working with chemicals,
- Using equipment and procedures relating to chemistry,
- Collecting data,
- Working with other students, and
- Having adequate time.

Studies generally indicated that the students, whether male or female, 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, Akin, & Takunyaci, 2009; Uzuntiryaki & Azizoğlu, 2004).

Chemistry Attitudes

Students' attitude toward the learning of chemistry is a factor that has long attracted 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" (p. 115). 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 is 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 discovered 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).

Self-efficacy

Self-efficacy, a person's beliefs concerning his or her ability to perform successfully on a given task, is a major determinant of whether a person will attempt a given task or not, how much effort will be expended, and how much persistence will be displayed while pursuing the task in the face of obstacles. According to self-efficacy theory, perceived self-efficacy influences and is in turn influenced by, thought patterns, affective arousal, and choice behavior as well as task performance (Bandura, 1986). Self-efficacy beliefs affect academic performance by influencing a number of behavioural and psychological variables. Bandura (1986) asserted that self-efficacy beliefs of students are often better predictors of the academic successes than they are objective assessments of their abilities. In parallel with this suggestion, most researchers (Hampton & Mason 2003; Multon Brown, & Lent, 1991; Pajares & Miller 1994; Shell, Murphy, & Bruning, 1995) have confirmed the relationship between self-efficacy and student achievement. This is because these beliefs mediate the effects of prior achievement, knowledge, and skills on subsequent achievement (Schunk, 1985). This makes self-efficacy a major focus for science educators who desire to increase student accomplishment and engagement in science. Studies have demonstrated that science self-efficacy is associated with science achievement and science-related choices across grade levels (Britner, 2008). At the college level, science self-efficacy predicts achievement (Andrew, 1998), persistence in science-related majors and career-choices (Dalgety & Coll, 2006; Gwilliam & Betz, 2001). Among high school students, science self-efficacy is a better predictor of achievement and engagement with science-related activities than gender, ethnicity, and parental background (Kupermintz, 2002; Lau & Roeser, 2002; Lodewyk & Winne, 2005).

Self-efficacy researchers typically assume that students' belief in their ability to succeed in chemistry tasks, courses, or activities, or their sense of self-efficacy, has a powerful impact on their choices of science-related activities, the effort they expend on those activities, the perseverance they show when encountering difficulties, and the ultimate success they experience (Bandura, 1997; Britner & Pajares, 2001; Zeldin & Pajares, 2000). For example, in schools, students with high self-efficacy tend to choose more challenging tasks, show more effort, and do not give up easily, which explains why students of similar ability can have different academic performance (Pajares 1997). Students who have a strong belief that they can succeed in chemistry-related tasks and activities will be more likely to select such tasks and activities, and work hard to complete them successfully (Britner & Pajares, 2006). Alternatively, students who do not believe that they can succeed in chemistry-related activities will avoid them if they can and will put forth minimal effort if they cannot. When confronted with the typical challenges that science involves, they will be more likely to give up and to experience the stresses and anxieties that help ensure the erosion of their efforts (Britner & Pajares, 2006). Thus, self-efficacy is proposed to be an important factor influencing attitudes toward chemistry and chemistry laboratory anxiety.

The present study: Although studies typically have focused on science and chemistry anxiety (Eddy, 2000; Laukenmann et al., 2003), chemistry laboratory anxiety has received relatively little attention in the science education literature. For this reason, the present research aims at examining the relationships between chemistry laboratory anxiety, chemistry attitudes, and self-efficacy. In this study it was hypothesized that chemistry laboratory anxiety would be associated negatively with chemistry attitudes and with self-efficacy. It was also hypothesized that self-efficacy would be related positively to chemistry attitudes.

Method

Participants

A total of 395 first year major undergraduates were randomly selected from four universities' general chemistry and general chemistry laboratory classes taught in the first semester of the 2008-2009 academic years in the Faculty of Science. Of the participants 236 (60%) were female and 159 (40%) were male. Their ages ranged from 17 to 24 years and the mean age of the participants was 20.9 years.

Measures

Chemistry Laboratory Anxiety Scale (CLAI, Bowen, 1999: This scale is a 20-item self-report measurement. Each item was rated on a 5-point Likert type scale (from 1=strongly disagree to 5=strongly agree). Higher scores indicate higher chemistry laboratory anxiety. The Turkish adaptation of this scale had been done by Azizoğlu and Uzuntiryaki (2006). The internal consistency reliability coefficient of the Turkish form was .86.

The Chemistry Attitudes Scale (Geban, Ertepınar, Yılmaz, Altın, & Şahbaz, 1994): This scale contains 15 items; 5 of them negatively keyed **(**items 3, 6**,** 9, 13 and 14). Example, during chemistry lessons, I am bored (negatively-keyed), I like chemistry course more than the others (positively-keyed). Each item was rated on a 5-point Likert type scale (from 1=strongly disagree to 5=strongly agree). Higher scores indicate higher positive attitudes towards chemistry. The internal consistency reliability coefficient of the scale was .83.

Self-efficacy Scale: Self-efficacy was measured by using the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich, Smith, Garcia, & McKeachie, 1991). The Turkish adaptation of this scale had been done by Büyüköztürk, Akgün, Özkahveci, and Demirel (2004). The self-efficacy subscale consists of eight items and each item was rated on a 7-point scale (1=not at all true for me to 7= very true for me). The internal consistency alpha coefficient of the Turkish form was calculated as .86.

Procedure

Permission for participation of students was obtained from related chief departments and students voluntarily participated in research. Completion of the scales was anonymous and there was a guarantee of confidentiality. The scales were administered to the students in groups in the classrooms. Prior to administration of scales, all participants were told about the purposes of the study. In this research, Pearson correlation coefficient and structural equation modeling was utilized to determine the relationships between the dimensions of self-compassion and submissive behavior. These analyses were carried out via LISREL 8.54 (Joreskog & Sorbom, 1996) and SPSS 11.5.

Results

Descriptive Data and Inter-correlations

Table 1 shows the means, standard deviations, inter-correlations, and internal consistency coefficients of the variables used.

Variables	1	2	3
1. Self-efficacy	1.00		
2. Chemistry attitudes	.34**	1.00	
3. Chemistry laboratory anxiety	-.23**	-.42**	1.00
Mean	41,08	35,30	51,77
Standard deviation	8,39	8,90	13,60
Alpha	.89	.86	.90
***p* < .01			

Table 1: Descriptive Statistics, Alphas, and Inter-correlations of the Variables

When Table 1 is examined, it is seen that there are significant correlations between self-efficacy, chemistry attitudes, and chemistry laboratory anxiety. Chemistry laboratory anxiety related negatively to chemistry attitudes ($r = -.42$) and to self-efficacy ($r = -.23$). On the other hand chemistry attitudes were found positively associated with self-efficacy ($r = .34$).

Structural Equation Modeling

The hypothesized model was examined via structural equation modeling (SEM). Figure 1 presents the results of SEM analysis, using maximum likelihood estimations. The model fitted well (χ^2=3.69, p=.29741, GFI=1.00, AGFI=.98, CFI=1.00, NFI=.98, RFI=.97, IFI=1.00, and RMSEA =.024) and also accounted for 22% of the chemistry laboratory anxiety and 11% of the chemistry attitudes variances.

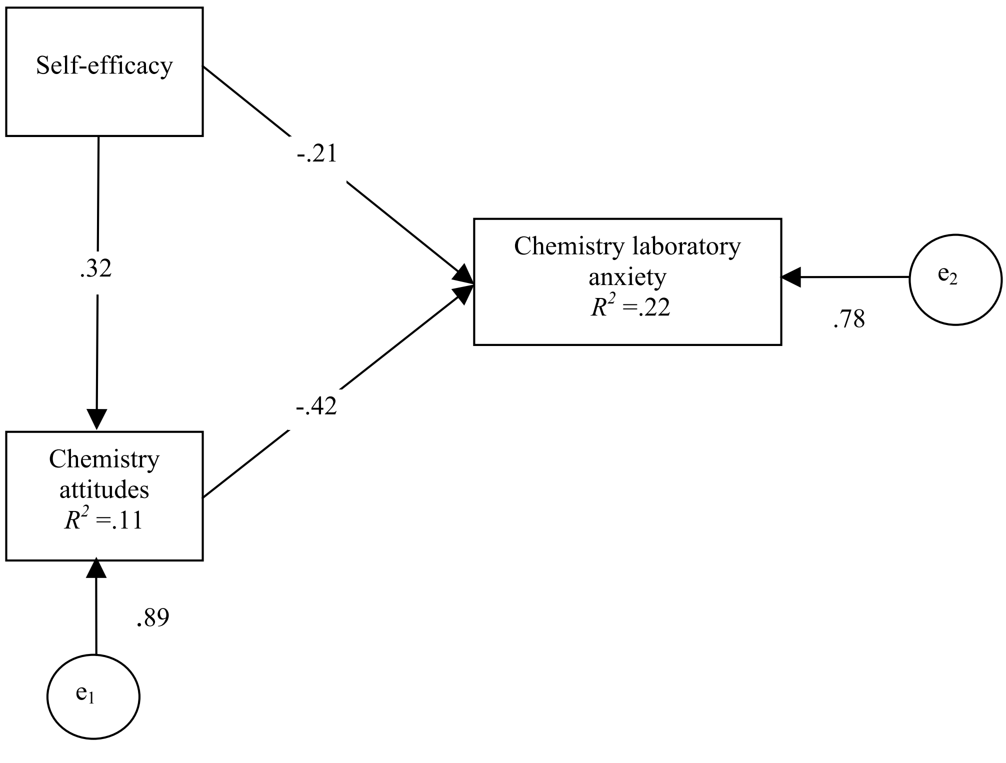

Figure 1: Path analysis between self-efficacy, chemistry attitudes, and chemistry laboratory anxiety

The standardized coefficients in Figure 1 clearly showed that self-efficacy predicted chemistry laboratory anxiety in a negative way (-.21). Also self-efficacy has a direct and positive effect on chemistry attitudes (.32) which in turn affects chemistry laboratory anxiety. Finally chemistry laboratory anxiety was explained negatively by chemistry attitudes (-.42).

Discussion

In this study the relationships between chemistry laboratory anxiety, chemistry attitudes, and self-efficacy were examined using structural equation modelling. Findings have demonstrated that there are significant relationships between these variables. Moreover, the goodness of fit indexes indicated that correlations among measures were explained by the model and that its formulation was psychometrically acceptable (Hu & Bentler, 1999).

Firstly, as hypothesized, the model delineated that self-efficacy has predicted chemistry laboratory anxiety in a negative way. This result is in agreement with previous studies (Britner, 2008; Britner & Pajares, 2006; Eddy, 2000; Kurbanoglu et al., 2009; Usher & Pajares, 2006; Uzuntiryaki & Azizoğlu, 2004) which indicate that anxiety and self-efficacy are two closely related constructs and with Bandura's social cognitive theory (1986) which states that anxiety has a negative effect on self-efficacy. Social learning theory also suggests that anxiety can be considered as a result of low self-efficacy and individuals only experience anxiety when they believe themselves to be incapable of managing potentially detrimental events (Bandura, 1997). This result further support Bandura's (1986, 1997) claims that efficacy beliefs play a central role in regulating anxiety. In addition, the negative relationship between self-efficacy and chemistry laboratory anxiety which was found in the present study supports Hackett's (1995, p. 248) suggestion that "it is possible, that lowered anxiety not only enhances self-efficacy directly but also facilitates successful performance attempts in occupationally related areas." Furthermore, there is a common view in much of the scientific literature which claims that feelings of anxiety toward academic tasks work to undermine students' beliefs in their academic capability (Usher & Pajares, 2006). Namely, a student who feels anxious about chemistry laboratory almost cannot feel capable of doing laboratory activities. Thus, self-efficacy could be a negative predictor of chemistry laboratory anxiety, and higher anxiety in chemistry laboratory is related to lower reported levels of self-efficacy.

Secondly, as expected and consistent with previous research findings (Jones & Young, 1995; Liu, Hsieh, Cho, & Schallert, 2006; Smist & Owen, 1994) path analysis revealed that chemistry attitudes were predicted positively by self-efficacy. In addition, self-efficacy reduced indirectly chemistry laboratory anxiety through chemistry attitudes. In other words, chemistry attitudes served as a mediator in linking self-efficacy and chemistry laboratory anxiety. Students' chemistry attitudes are important factors highly associated with chemistry success and motivation. Students with positive attitudes towards chemistry are more likely to sustain their efforts and have the desire to be involved in the learning tasks. Similarly students' self-efficacy beliefs play an integral role in their academic motivation, learning, and achievement (Pajares & Schunk, 2005). Students who believe they can succeed academically tend to show greater interest in academic work, set higher goals, put forth greater effort, and show more resilience when they encounter difficulties (Bandura, 1997; Pajares, 1997). Correspondingly according to Bandura (1986), self-efficacy is one's belief in his/her capacity to perform a specific task. Individuals may assess their skills and capabilities prior to performing certain actions or activities. If individuals have high self-efficacy for carrying out certain activities, they are more likely to attempt doing those activities and to develop positive attitudes toward them. On the contrary, if individuals have low self-efficacy for carrying out some activities, they are less likely to attempt doing those activities and they develop negative attitudes toward them (Bandura, Adams, & Beyer, 1977). When thought in this context, the correlations found in this research seem understandable.

Thirdly, as anticipated, results demonstrated that chemistry laboratory anxiety was predicted by chemistry attitudes, negatively. This finding is in agreement with the results of earlier investigations (Keeves & Morgenstern, 1992; Kurbanoglu et al., 2009; Meece, Wigfield, & Eccles, 1990; Uzuntiryaki & Azizoğlu, 2004). In general, there is a widespread agreement that the students' attitudes are related to expectations of success and the subjective value of the task, and will ultimately have some effect on his/her level of anxiety (Child, Duffy, Kirkley, & Hubbard, 1997). Supporting this view, Keeves and Morgenstern (1992) pointed out 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. When it was considered that chemistry laboratory anxiety is a state of discomfort occurring in response to situations regarding chemistry tasks which can often create a negative attitude toward the subject (Eddy, 2000), the relationships between chemistry laboratory anxiety and chemistry attitudes are easily understandable. That is negative attitudes towards chemistry are promoted while positive attitudes are decreased by chemistry laboratory anxiety.

This study has several implications for future research. Firstly, further research investigating the relationships between chemistry laboratory anxiety, chemistry attitudes, self-efficacy, and other psychological constructs are needed to reinforce the findings of this study. Second, studies can examine these relationships with structural equation modelling by establishing a mediating or latent variable. Third, we urge researchers to use quantitative methodology to complement findings from qualitative perspectives.

This study has also several implications for chemistry educators. First of all, reducing or controlling anxiety in laboratory situations potentially may enhance learning of complex laboratory and problem-solving skills. Helping students to control anxieties and fears related to chemistry laboratory studies can facilitate the development of positive self-efficacy beliefs, which will in turn, lead to more positive attitudes toward chemistry. As Pajares (2005) has pointed out, students can get a fairly good sense of their confidence by the emotional feelings they experience as they contemplate an action. Negative feelings provide cues that something is amiss, even when one is unaware that such is the case. Students who approach a chemistry laboratory activity with apprehension likely lack confidence in their science skills. Moreover, those negative feelings can themselves trigger additional stress and agitation that help ensure the inadequate performance feared. Worse yet, anxiety and dread can be paralysing. A chemistry teacher can help students read their emotional feelings and understand that these feelings should not be ignored (Britner & Pajares, 2006).

There are some interventions that might be used by any chemistry educator to reduce or optimize the anxiety of a student. For example, incorporating more cooperative learning strategies may help foster a more positive attitude toward the course and reduce debilitating anxiety (VanZile-Tamsen & Boes, 1997). Mealey and Host (1992) suggest that cooperative learning can provide a sense of social support for students which can decrease feelings of isolation and the belief that everyone understands this but me. In addition, Feldmann, Martinez-Pons, and Shaham (1995) found that collaborative learning is related to self-regulated learning. Those students who are more effective self-regulated learners tend to have less evaluation anxiety in courses (Kleijn, van der Ploeg, & Topman, 1994). Another way to decrease anxiety is to increase a student's attention to the task at hand. Since attention has limited capacity, a mind well focused on the dynamics of a particular activity cannot easily shift that focus to its fears and apprehensions (Britner & Pajares, 2006). Besides, the task and the purposes of laboratory work, as highlighted by Hodson (1996) requires crucial attention so that anxiety in the school chemistry laboratory can be harnessed and changed into learning opportunities to help students realize the true spirit and intent of laboratory work. Tan (2008) has suggested three areas that can potentially help to ease anxiety in the laboratory. Firstly, clear goals and objectives for the tasks need to be spelt out. This will help in aligning teaching/learning expectations of the teacher and the students so that they work towards the same goal. Secondly, more time needs to be set aside during laboratory sessions for exploration, reflection, argumentation, and more student–student interaction. Increased interaction time can help increase the proportion of time spent doing science. Finally, well-designed and purposeful laboratory tasks will help to focus attention on gathering data and will allow for more evidence-based laboratory learning in chemistry to take place (Tan, 2008)

Another implication for chemistry educators is to create laboratory experiences whereby students can improve their sense of self-efficacy. As suggested by Bandura (1997), students develop efficacy beliefs based on authentic accomplishments. Thus, if students have low sense of self-efficacy, educators may spend more instructional time in performing chemistry experiments. In this way, students will have more evidence about their success and their sense of efficacy will be enhanced accordingly. Similarly, for students with weak self-efficacy in everyday applications, educators may design instruction in such a way that develop students' abilities to cope with the application of chemistry in daily life issues. For instance, students can be encouraged to involve in chemistry projects. It is also found that majors having more experience with chemistry tasks were more efficacious than non-major students (Uzuntiryaki & Capa, & Aydin, 2009). Moreover, instructional strategies such as inquiry-based instruction in which students are mentally and physically active in their learning environment can be implemented. Such instruction would also help students become more self-aware of their improvement (Uzuntiryaki & Capa Aydin, 2009).

Although the results of the present study have implications for interventions that could decrease students' chemistry laboratory anxiety and increase their self-efficacy, limitations of the study may be acknowledged. First, participants were university students and replication of this study for targeting other student populations should be made in order to generate a more solid relationship among constructs examined in this study, because generalization of the results is somewhat limited. Second, as correlational statistics were utilized, no definitive statements can be made about causality. Third, the self-report instruments used in this study may not appropriately capture the participants' perceptions and feelings. Finally, since the proportions of variance explained were low, it is difficult to make any firm conclusions about the findings.

In conclusion, this investigation reports that self-efficacy affects chemistry laboratory anxiety and chemistry attitudes, directly. Students low in self-efficacy are more likely to vulnerability to chemistry laboratory anxiety and negative chemistry attitudes. So, the current findings increase our understanding of the relationships between self-efficacy, chemistry laboratory anxiety and chemistry attitudes.

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