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# THE RELATIONSHIPS BETWEEN UNIVERSITY STUDENTS' ORGANIC CHEMISTRY ANXIETY, CHEMISTRY ATTITUDES, AND SELF-EFFICACY: A STRUCTURAL EQUATION MODEL

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**Abstract.** *The purpose of this study is to examine the relationships between organic chemistry anxiety, chemistry attitudes, and self-efficacy. Participants were 368 sophomore undergraduate students. In this study, the Organic Chemistry Anxiety Scale (O-CAS), the Chemistry Attitudes Scale, and the Self-efficacy Scale were used. Pearson correlation coefficient and structural equation modeling was utilized to determine the relationships between organic chemistry anxiety, chemistry attitudes, and self-efficacy. In correlation analysis, organic chemistry anxiety was found negatively (r=-0.52) related to chemistry attitudes and self-efficacy (r=-0.36). According to path analysis results, chemistry attitudes were predicted positively (β=0.44) and organic chemistry anxiety predicted negatively (β= -0.16) by self-efficacy. Also chemistry attitudes predicted organic chemistry anxiety in a negative way (β=-0.44). The results were discussed in the light of literature.*

**Key words:** *chemistry attitudes, organic chemistry anxiety, path analysis and self-efficacy.*

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## Introduction

Organic chemistry is simply defined as the study of the physical and chemical properties of organic compounds that take place in the chemistry and it affects every aspect of our daily life from life-saving drugs to exciting new materials in technology. It is a dynamic field in chemical science. Therefore, organic chemistry is an important course taught in the field of agriculture, biology, health sciences, medical school, veterinary medicine, pharmacy and medical chemistry in many universities. From the viewpoint of many university students' studying in these areas, organic chemistry course seems to be difficult and also academic achievement of these students is probably low (Mahajan & Singh, 2005; Turner & Lindsay, 2003). According to Seymour and Hewitt (1997), the difficulties of the course and the negative image arising from these difficulties create an important problem for those who are interested in increasing the number of science students. In order to achieve this goal, educators should be aware of factors that affect students' organic chemistry achievements (Turner & Lindsay, 2003). Students' achievements in organic chemistry depends on general chemistry achievements, high school chemistry course performance, test scores and cognitive variables such as spatial visual performance (Krylova, 1997; Pribyl & Bodner, 1987; Rixse & Pickering, 1985; Sevenair, Carmichael, O'Connor, & Hunter, 1987).

In addition, students' achievement in organic chemistry was influenced from students' attitudes toward chemistry and non-cognitive variables such as anxiety levels and self-efficacy beliefs (Turner & Lindsay, 2003). Eddy (2000), chemistry anxiety has generally defined as fear of chemicals and chemistry courses (McCarthy & Widanski, 2009). More specifically, Turner and Lindsay (2003) have defined chemistry anxiety as students' feelings such as timidity towards chemistry, nervousness and physical manifestations of these emotions. Researches in chemistry education

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has shown that organic chemistry anxiety negatively affects students' success and learning processes, and was also a frequent problem that educators face (Turner & Lindsay, 2003) and that there was a negative relationship between the students' organic chemistry anxiety and achievement (Berdonosov, Kurzmenko, & Kharisov, 1999; Black & Deci, 2000; Chiarelott & Czerniak, 1987; Eddy, 2000). Regarding this issue, Mahajan and Singh (2001) stated that the presence of anxiety affects students' understanding related to the subject. Thus, anxiety was the factor that reduces the performance in the organic chemistry course (Mahajan & Singh, 2005).

Organic chemistry anxiety is closely related to a broad spectrum of cognitive, psychological, and behavioral problems. This anxiety cause consequences like feeling impotence in organic chemistry operations, avoiding organic chemistry class, feeling of shame and guilt, terminating organic chemistry learning even though having the capacity, developing negative attitudes towards activities and operations related to organic chemistry, evading branches and occupations that necessitate quantitative knowledge and skills, and dislike for organic chemistry class when the individual becomes a teacher (Turner & Lindsay, 2003). Therefore it is a reality that organic chemistry anxiety is also closely related to attitudes. Eagly and Chaiken (1993) expressed attitude as "psychological tendency which measures the degree of favor or disfavor a particular case". Attitudes towards science were defined by Koballa and Crawley (1985) as liking-disliking science or negative-positive feelings towards science.

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). Steiner and Sullivan (1984) pointed out that there was a relationship between students' perceptions and attitudes towards chemistry course and their course achievements. Accordingly, they expressed that more successful students defined their approaches towards the lesson like that "relevant", "coordinate", "have confidence", "enthusiastic", and it was also common among these students that chemistry was useful and opens new prospects. Enhancement of students' positive attitudes to chemistry is very important considering two main reasons. First of all, research on the link between attitudes and academic achievements discovered that these variables were closely related to each other (Bennett, Rollnick, Green, & White, 2001; Cheung, 2009; Freedman, 1997; Salta & Tzougraki, 2004; Weinburgh, 1995). The second reason that makes attitudes important is that attitudes predict behaviors (Glasman & Albarracín 2006). Another constrain related to organic chemistry anxiety is self-efficacy. Self-efficacy expectations are a person's beliefs concerning his or her ability to successfully perform a given task or behavior, are a major determinant of whether a person will attempt a given task, how much effort will be expended, and how much persistence will be displayed in pursuing the task in the face of obstacles. Perceived self-efficacy influences, is in turn influenced by, thought patterns, affective arousal, and choice behavior as well as task performance (Bandura, 1977, 1986). 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, and at the same time on 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). 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). As a matter of choice, 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 organic chemistry anxiety.

**Methodology of Research**

*The Present Study*

Self-efficacy can be regarded as a significant factor which plays an important role on chemistry attitudes and organic chemistry anxiety. Also, organic chemistry anxiety may be influenced by chemistry attitudes. Although studies typically have focused on science and chemistry anxiety (Eddy, 2000; Laukenmann et al., 2003), organic chemistry anxiety has received relatively little attention in the science education literature. For this reason, the present research aims to analyze the relationships between organic chemistry anxiety, chemistry attitudes, and self-efficacy. Based on the relationships of self-efficacy with attitudes and anxiety (Bandura, 1977; Hackett & Betz, 1981; McCarthy & Widanski, 2009; Turner & Lindsay, 2003), we hypothesized that organic chemistry anxiety would be associated negatively and chemistry attitudes positively with self-efficacy. Also, since studies (Betz, 1978; Bourquin, 1999; Meece, Wigfield & Eccles, 1990; Pajares & Miller, 1994; Ramirez & Dockweiler, 1987; Richardson & Suinn, 1972; Wigfield & Meece, 1988) display a negative relationship between anxiety and attitudes we assumed that organic chemistry anxiety would be related negatively to chemistry attitudes. This model is represented schematically in Figure 1.

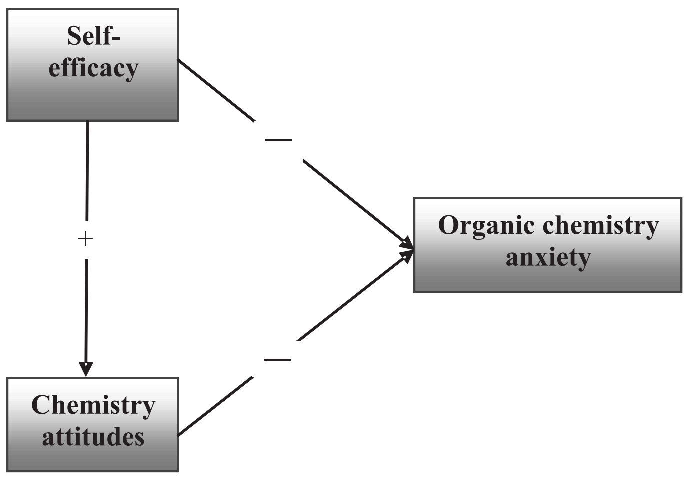


**Figure 1: Hypothesized model of the relationship among self-efficacy, chemistry attitudes, and organic chemistry anxiety.**

*Participants*

Participants were 368 sophomore undergraduate students (230 female and 138 male) who were enrolled in Organic Chemistry I from four different state universities Chemistry Department, in Turkey. Their ages ranged from 19 to 22 years and the mean age of the participants was 20.5 years. The course under investigation was Organic Chemistry, the first course in a two-course sequence designed for chemistry majors in Turkey. The Chemistry Department at the University of Turkey ordinarily offers two sections of Organic Chemistry I and II per year, with one section offered in the fall and another in the summer. Consequently, all applications were performed at the end of the fall.

*Measures*

*The Organic Chemistry Anxiety Scale (O-CAS; Akın & Kurbanoglu, 2011).* This scale is a 24-item self-report measurement and consists of three factors; (1) writing bond type of carbon compounds, formulas and naming carbon compounds (seven items, e. g., write the type of carbon atom bond in organic molecules), (2) writing the types of carbon compounds and their isomers (ten items, e. g., write the type of isomer of an organic molecule), and (3) writing the reaction mechanism of carbon compounds (seven items, e. g., write the steps of the reaction mechanism). Each item is rated on a 5-point Likert scale ranging from 1 (never makes me anxious) to 5 (always makes me anxious). The Cronbach-alpha reliability values for writing bond type of carbon compounds, formulas and naming carbon compounds was 0.87, for writing the types of carbon compounds and their isomers was 0.92, for writing the reaction mechanism of carbon compounds was .90, and for overall scale was 0.95.

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*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 0.83.

*Self-efficacy Scale.* Self-efficacy was measured by using the Turkish version of the Self-efficacy subscale of the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich, Smith, Garcia, & McKeachie, 1991). Turkish adaptation of this scale had been done by Büyüköztürk, Akgün, Özkahveci, & 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*). As a result of factor analysis in construct validity, it was found that factor loadings of items were between 0.52 to 0.65. In the reliability study, the internal consistency alpha coefficient was calculated 0.86.

*Procedure of the Study and Data Analysis*

A survey methodology was adopted for this study. Convenience sampling was used in the selection of participants. Convenience sampling is a nonprobability sampling technique in which the participants are selected because of their convenient accessibility and proximity to the researcher (Bryman, 2004). For this reason, the results of this study did not make inferences from the population, which led to a decrease in external validity. Participants voluntarily participated and were free to fill out the questionnaires without pressure. Completion of the questionnaires was anonymous, and there was a guarantee of confidentiality. The instruments were administered to the students in groups in the classrooms. The measures were counterbalanced in administration. Before the administration of measures, all participants were told about the purposes of the study. Three hundred and eighty-three students participated in the study. However, 15 students were excluded from the study, because 7 of them did not respond to the instruments as required, and 8 were found to produce extreme scores. Therefore, the data obtained from 368 students were statistically analyzed. To determine the relationships between organic chemistry anxiety, chemistry attitudes, and self-efficacy the Pearson correlation coefficient and structural equation modeling (SEM) were used. These analyses were carried out via LISREL 8.54 (Jöreskog & Sorbom, 1996) and SPSS 11.5.

## Results of Research

*Descriptive Data and Inter-correlations*

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

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

| Variables | 1 | 2 | 3 |
|---|---|---|---|
| 1. Self-efficacy | 1.00 | | |
| 2. Chemistry attitudes | 0.44** | 1.00 | |
| 3. Organic chemistry anxiety | -0.36** | -0.52** | 1.00 |
| Mean | 36.33 | 49.30 | 69.83 |
| Standard deviation | 10.47 | 11.47 | 16.91 |
| Cronbach's α | 0.80 | 0.82 | 0.87 |

*$^{**}p<0.01$*

When Table 1 is examined, it is seen that there are significant correlations between self-efficacy, chemistry attitudes, and organic chemistry anxiety. Organic chemistry anxiety related negatively to chemistry attitudes ($r = -0.52$) and to self-efficacy ($r = -0.36$). On the other hand chemistry attitudes were found positively associated with self-efficacy ($r = 0.44$).

*Structural Equation Modeling*

SEM was used for testing the hypothesis model [(a) organic chemistry anxiety would be associated negatively and chemistry attitudes positively with self-efficacy. (b) Organic chemistry anxiety would be related negatively to chemistry attitudes]. Through using SEM, all the parameters of models could be tested simultaneously in one step. The specifications on the model were for direct paths from self-efficacy to chemistry attitudes and to organic chemistry anxiety. The results of testing whether self-efficacy has a direct effect on chemistry attitudes and to organic chemistry anxiety and whether chemistry attitudes have a direct effect on organic chemistry anxiety are presented in Figure 2.

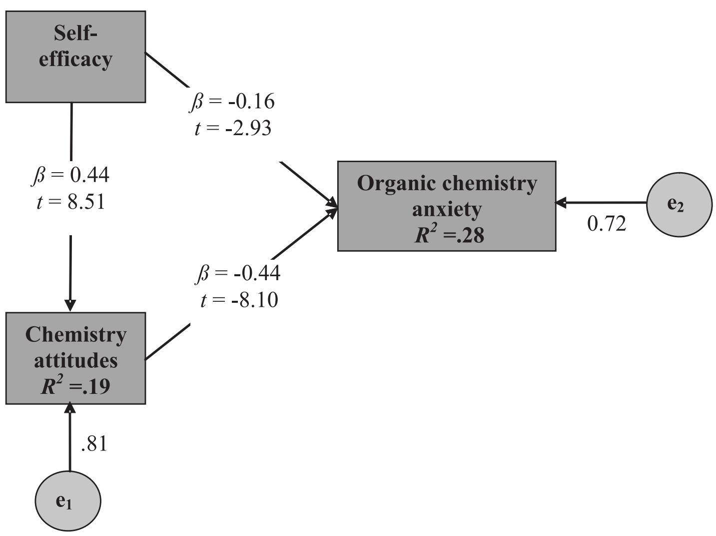


**Figure 2: Path analysis between self-efficacy, chemistry attitudes, and organic chemistry anxiety.**

Figure 2 showed that the model is saturated (i.e., there are no unused degrees of freedom). Consequently, the fit of the model is necessarily perfect (Hu & Bentler, 1999). The model accounted for 19% of the chemistry attitudes and 28% of the organic chemistry anxiety variances. The standardized coefficients in Figure 2 clearly showed that chemistry attitudes were predicted positively ($\beta$=0.44) and organic chemistry anxiety predicted negatively ($\beta$= -0.16) by self-efficacy. Also chemistry attitudes predicted organic chemistry anxiety in a negative way ($\beta$=-0.44).

## Discussion

In this study the relationships between organic chemistry anxiety, chemistry attitudes, and self-efficacy were examined using structural equation modeling. 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 showed that self-efficacy has explained organic chemistry anxiety in a negative way. This result is in agreement with previous studies (Britner, 2008; Britner & Pajares, 2006; Eddy, 2000; Kurbanoglu & Akın, 2010; Usher & Pajares, 2006) which indicate that anxiety and self-efficacy

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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 organic chemistry 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 organic chemistry almost cannot feel capable of doing organic chemistry activities. Thus, self-efficacy could be a negative predictor of organic chemistry anxiety and higher anxiety in organic chemistry is related to lower reported levels of self-efficacy.

Secondly, as expected and consistent with previous research findings (Kurbanoglu & Akın, 2010; 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 organic chemistry anxiety through chemistry attitudes. In other words, chemistry attitudes served as a mediator in linking self-efficacy and organic chemistry 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 organic chemistry anxiety was predicted by chemistry attitudes, negatively. This finding is in agreement with the results of earlier investigations (Keeves & Morgenstern, 1992; Kurbanoglu & Akın, 2010; Kurbanoglu et al., 2009; Meece, Wigfield, & Eccles, 1990). In general, there is a widespread agreement that the students' attitudes are related to expectations of success 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 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 organic chemistry anxiety. When it was considered that chemistry 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 organic chemistry anxiety and chemistry attitudes are easily understandable. That is negative attitudes towards chemistry are promoted while positive attitudes are decreased by organic chemistry anxiety.

This study has several implications for future research. Firstly, further researches investigating the relationships between organic chemistry 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 modeling by establishing a mediating or latent variable. Third, we urge researchers to use qualitative methodology to complement findings from quantitative perspectives.

This study has also several implications for chemistry educators. First of all, reducing or controlling anxiety in organic chemistry lessons potentially may enhance learning of complex organic chemistry topics and problem-solving skills. Helping students to control anxieties and fears related to organic chemistry 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 an organic chemistry 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 paralyzing. A chemistry teacher is encouraged to 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).

Another implication for chemistry educators is to create organic chemistry 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' organic chemistry 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, 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.

**Conclusion and Implications**

In conclusion, this investigation reports that self-efficacy affects organic chemistry anxiety and chemistry attitudes, directly. Students' lows in self-efficacy are more likely to vulnerability to organic chemistry anxiety and negative chemistry attitudes. So, the current findings may increase our understanding of the relationships between self-efficacy, organic chemistry anxiety, and chemistry attitudes. This study has several implications for future research. Firstly, further research investigating the relationships between organic chemistry anxiety, chemistry attitudes, and self-efficacy, and other psychological

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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 organic chemistry anxiety potentially may enhance learning of complex organic chemistry topics and problem-solving skills. Helping students to control anxieties and fears related to organic chemistry 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 an organic chemistry lesson 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).

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