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THE RELATIONSHIP BETWEEN PRE-SERVICE TEACHERS' PHYSICS ANXIETY AND DEMOGRAPHIC VARIABLES

Mehmet Şahin

Abstract. *The purpose of this study was to investigate the relationship between pre-service teachers' physics anxiety and gender, grade point average (GPA), major of study, and high school type they graduated. The sample consisted of 849 pre-service teachers of different majors. Data were collected, using the Physics Anxiety Rating Scale (PARS) at the beginning of the semester. Post-semester data were obtained from 175 pre-service teachers who were included in the pre-semester data. Results revealed gender difference in physics anxiety. Females scored higher on the PARS and its factors than males. It was found that students with medium GPA scored lower on the whole anxiety scale than students with low and high GPA. Pre-service primary teachers scored higher on the PARS than all other majors. High school type had an effect on physics anxiety, vocational high school graduates being the highest physics anxious of all. One semester of traditional physics instruction did not seem to have a significant influence on students' physics anxiety. Implications of the results were discussed for instructional purposes and future studies.*

Key words: *demographic variable, physics, physics anxiety rating scale, science anxiety.*

Mehmet Şahin
Dokuz Eylül University, Turkey

Introduction

There is an increasing recognition that affective factors play a significant role in science teaching and learning. Many studies have suggested that students' interest in physics declines during secondary education and that, girls were found to be less interested in physics than boys (Gardner, 1998). Efforts have been made to enhance girls' interest and hence achievement in physics classes (Häussler & Hoffmann, 2002). Recently, number of students choosing physics-related careers is reported to be decreasing in many countries worldwide (Oon & Subramaniam, 2010, 2011; Osborne, Simon, & Collins, 2003; Reid & Skryabina, 2002, 2003). The problem of students' lack of confidence and gender differences in physics classes has long been recognized (Fuller et al., 1985). Underrepresentation of women in the so called 'hard' sciences, especially in physics-related careers continues to be the focus of many research studies (Reid & Skryabina, 2002, 2003). Girls' interest has been shown to be higher toward science than males in the lower grades (Labudde, Herzog, Neuenschwander, Violi, & Gerber, 2000). However, in later schooling and at the time of career decisions, women tend to avoid science-related careers. Research suggests several explanations for career choices of women (Murphy & Whitelegg, 2006). Among them are the negative attitudes and anxiety they develop during school years.

Research suggests that cognitive learning theories should be expanded so that emotional and social aspects are no longer neglected (Pintrich, Marx, & Boyle, 1993; Strike & Posner, 1992). It was emphasized that learning processes could not just be defined cognitively, additional factors such as affective and social variables have to be taken into consideration, too. However, emotions have not been sufficiently attended to in classroom instruction in general (Gläser-Zikuda, Fuß, Laukenmann, Metz & Randler, 2005), and have been rather neglected in physics education research (Laukenmann et al., 2003; Shi, 2012). There are some recent studies that illustrate the significance of emotions in both learning and performance situations (Randler, 2009). In the psychology of learning, one can identify various theoretical approaches

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related to the role of emotions in learning. One aspect that is emphasized is the strong relationship between emotion and motivation. Another emotional dimension of the affective factors that has received increasing attention in recent decades is anxiety.

Anxiety is defined as an unpleasant emotional state of uncertainty, fear, worry, discomfort, loss of control, and expectation of something bad will happen (Sapir & Aronson, 1990). In general terms, anxiety is defined as a state of worry and discomfort felt by individuals when faced with a threatening situation (Scovel, 1978). Anxiety is an important variable that can influence the learning process (Chapin, 1989). Anxiety creating situations may sometimes enhance individual's performance. Although a low level of anxiety is considered good for learning, a high degree of anxiety may hinder achievement significantly. The psychology of emotions (Randler, 2009) distinguishes between current situational emotions – so called 'state-emotions' – and biographically developed, enduring 'trait-emotions'. Research showed that whereas trait-anxiety may influence success negatively, state-anxiety may have a positive effect on success. Therefore, the relationship between anxiety and achievement is complex, and causal influences are not well defined (King, Heinrich, Stephenson, & Spielberger, 1976). Some research studies have reported a significant relationship between academic achievement and anxiety (Diaz, Glass, Arnkoff & Tanofsky-Kraff, 2001).

One affective factor that has received considerable attention in the recent decades is science anxiety (Mallow, 1994; Mallow & Greenburg, 1983). Science anxiety has been defined as a fear of aversion toward science concepts, scientists, and science related activities (Mallow, 1986). It is recognized by many professors of science around the world that students enter the introductory science courses, especially physics, already fearful of the subject, and worry about failing the course. Westerback (1984) suggested that perceived failure and/or math anxiety may be factors in students' anxiety about teaching science in the physical sciences. Mallow (1986) suggested that anxiety may delay students' progression from concrete operational thought to formal operational thought if they are afraid to venture out of comfortable and safe thought processes.

Compared to the large body of research on anxiety, there have been few research studies on science anxiety. Even fewer studies exist dealing with physics anxiety as a separate concept (Westerback & Long, 1990). Mallow (1978) coined the term "science anxiety" and cofounded with psychologists the first Science Anxiety Clinic, at Loyola University of Chicago. Science anxiety often manifests itself as panic in science classes and exams, but is said to be different from performance or test anxiety and from math anxiety (Alvaro, 1978). Mallow and his colleagues developed techniques in the Science Anxiety Clinic to reduce science anxiety by blending three separate approaches: (1) science skills learning, (2) changing of students' negative self-thoughts, and (3) desensitization (through muscle relaxation exercises) to science anxiety producing scenarios (Mallow, 1986).

Several studies were carried out in the Clinic and they demonstrated significant decreases in anxiety, measured by the Science Anxiety Questionnaire (SAQ), for students in clinic groups over those in control groups (Alvaro, 1978; Hermes, 1985; Mallow, 1986, 1994). Mallow and his colleagues then conducted a series of studies using the SAQ. Mallow (1994) and Bryant et al. (2013) found that in American and Danish students, females scored higher on science anxiety than did males. Other studies (Udo, Ramsey, & Mallow, 2004; Udo et al., 2001) indicated that the leading factor contributing to science anxiety were nonscience anxiety, gender, and to a much lesser degree, course of study (major). Post-course responses indicated some improvement in science anxiety for both genders. Education majors (future teachers) were found to have the highest science anxiety of all groups. The females and Physics Project in Denmark (Beyer, 1991; Beyer & Vedelsby, 1983; Beyer & Reich, 1987) studied classroom interactions in the Danish high school. They identified science anxiety as a factor creating special obstacles for female students in the fields of humanities and science. Contrary to most science anxiety literature, Brownlow, Jacobi, and Rogers (2000) did not find a gender effect in a group of American university students. In another study, Turkish pre-service elementary teachers' science anxiety decreased slightly in a science methods course and no significant gender effect on science anxiety scores was detected (Bursal, 2008).

Several explanations for causes of science anxiety have been suggested: Gender appropriateness (Fouad & Smith, 1996), parental expectations (Eagly, 1987), teachers' views and beliefs (Cherian & Siweya, 1996; Kahle, Parker, Rennie, & Riley, 1993), and adult role models and media (Signorella & Jamison, 1986; Trankina, 1993). Mallow et al. (2010, p. 356) suggests similar causes for science anxiety including but not limited to, "past bad experiences in science classes, science-anxious teachers in elementary and secondary schools, lack of role models, gender and racial stereotyping, and the stereotyping of scientists in the popular media."

Teachers were attributed special importance for the possibility of conveying their own science anxiety to students. Mallow (2006) argued that teachers might provoke anxiety. It was also suggested that teachers may implicitly discourage girls in science classes (Kahle, et al., 1993; Rennie & Dunne, 1994). Teachers' own world view, attitudes, needs, knowledge and priorities determine their ability to teach science (Watters & Ginns, 1994) and negative attitudes toward teaching science (Sharma, Stewart, Wilson, & Gökalp, 2013) leads to science anxiety (Cox & Carpenter, 1989), leading inevitably to decreases in the likelihood of pursuing and achievement in science (Mallow, 1994). It is suggested that elementary teachers can play a significant role in the development of students' attitudes to science (Westerback, 1982) and often reported to express anxiety or negative attitudes related to teaching science (Westerback, 1982). In studies measuring science anxiety of schoolchildren in fourth through ninth grade (ages 9–14) researchers found science anxiety (Sağır, 2012) and gender differences (females were more anxious) in students at age nine (Chiarelott & Czerniak, 1987; Czerniak & Chiarelott, 1985). They also demonstrated that teachers of these students showed negative attitudes toward teaching science and hence science anxiety since they thought they were not good at it.

Most in-service programs and courses were criticized for dealing almost entirely with the cognitive domain (Cox & Carpenter, 1989). There are very few courses that include efforts to reduce teachers' science anxiety (Seçken & Zan, 2013) and negative attitudes toward science teaching. It was argued that teaching only science and methods courses may not be effective in reducing science anxiety and negative attitudes to science teaching. Studying anxiety about teaching science may help us understand why elementary teachers avoid teaching science (Westerback, 1984). It may also prove useful in the teaching and learning process of science and help prepare more confident science teachers. American pre-service elementary teachers' personal science teaching efficacy beliefs, science anxiety levels, and common science misconceptions were investigated during a science methods course (Bursal, 2012). It was found that the inclusion of inquiry activities and micro-teaching experiences into science methods course resulted in a slight -but statistically insignificant- decrease in the science anxiety scores (Bursal, 2012).

A variety of techniques and practices have been developed over the past several decades to help students and teachers alleviate their science (Bryant et al., 2013; Mallow, 2006; Udo, Ramsey, & Mallow, 2004) and math anxiety (Udo, Ramsey, & Mallow, 2004), and to help teachers in building student confidence in math and science (Udo, Ramsey, & Mallow, 2004). Mallow (2006) discusses several recommended practices that can help reduce science anxiety: Explicit science skills teaching, group work, theme-based curricula, attention to wait time and gender equity in calling on students, gender-equitable laboratory practice, balancing content and relationship in teacher-student interactions, explicit focus on metacognition, and response to the wide variety of student learning styles. Details of these discussions and other recommendations can be found in Mallow (2006) and Udo et al. (2004). Astleitner (2000) describes instructional strategies that can be used to decrease negative feelings (fear, envy, and anger) and to increase positive feelings (sympathy and pleasure). It is important that instructional strategies should be put into action to reduce gender bifurcation in science anxiety.

Despite the similarities between math and science anxiety, the role math anxiety (Furner & Gonzalez-DeHass, 2011) plays in science learning is not very clear. Although a significant correlation was found between math anxiety and poor performance in math courses, no such correlation was observed regarding performance in physics. Differences in math and science may cause one anxiety but not the other (Mallow, 1986). Udo et al. (2004) argues that lack of math preparation may have a role in science anxiety, but it is unlikely to play a large role.

In summary, research on science anxiety showed that nonscience majors were highly science anxious, regardless of what science courses they were taking. In addition, science anxiety varies as a function gender and major of study. One semester of a physics course may alleviate science anxiety in students.

Methodology of Research

General Background of Research

Research studies in the field of physics education, psychology, or social psychology have not directly measured anxiety about physics or teaching physical science subjects in pre-service teachers. Pre-service teachers in the fields of elementary, elementary science, physics, chemistry, biology, and mathematics education have compulsory physics courses in their program. As suggested by previous studies, situations involving failure or threats to self-esteem are situations in which anxiety reactions are likely to be aroused. When an individual faces a threatening situation (i.e., physics course/dealing with physics) a state of worry or discomfort may be felt. We hear complaints about students' physics anxiety and low grades in physics courses. Are we aware that our students are physics anxious? Does our physics courses increase or decrease students' physics anxiety? What can we do to alleviate our students' anxiety in physics courses? To answer these questions or to work toward the solutions we need to investigate the current situation in our physics classes. Physics anxiety may have a hindering role in students' low interest, achievement, and dropout in physics courses and related careers. Therefore, it may reveal useful information to investigate the complex relationships between anxiety and demographic variables such as gender, achievement, and the course of study to offer remedies to alleviate physics anxiety of our future teachers. In addition, physics anxiety was usually dealt with as part of affective variables (i.e., Gungor, Eryılmaz, & Fakıoglu, 2007), but not as a separate concept in research studies. Treating physics anxiety as a separate concept in researches may reveal more information about the complex relationship between physics anxiety and achievement situations.

Purpose of Research

The purpose of this study was to examine pre-service teachers' anxiety in physics courses. More specifically, the study investigated the relationship between student teachers' physics anxiety, gender, grade point average (GPA), discipline, and type of high school they graduated. This study is unique in its instrument (the Physics Anxiety Rating Scale) which was developed to measure solely physics anxiety in university students taking physics courses.

Data Analysis

Data were collected from pre-service teachers while they are in physics classes. Descriptive statistics and ANOVA and follow up post hoc analyses were carried out using IBM SPSS 21. The significance level was set as 0.05 for all analyses. The research questions examined in this study were:

1. Is there a gender difference in the pre-service teachers' physics anxiety?
2. Is physics anxiety related to pre-service teachers' academic performance?
3. Does pre-service teachers' physics anxiety differ across majors?
4. Does pre-service teachers' physics anxiety differ according to their high schools?
5. What is the effect of a one-semester traditional physics course on pre-service teachers' physics anxiety?

Sample of Research

A total of 849 undergraduate students (492 female, 357) from a public university in Turkey participated in the study. The majority of the participants were education majors (pre-service teachers). Demographic information such as gender, GPA, major and high school type were collected from students. Post semester data were also collected from 175 students whose pre-anxiety scores were available. This made it possible to examine any possible shifts in students' physics anxiety after a semester of traditional physics instruction. Physics courses offered to participating students differed somewhat in terms of format and content. Descriptive information about the physics courses offered to different majors is presented in Table 1. All the physics courses offered are compulsory in all departments. Some majors take physics in their first year while others take it in their second year. Physics courses are taught by physics education department faculty members. All the instructors are physics education majors, conducting research in physics education, teacher education, and other related areas of science education. In general, physics courses are taught via traditional lecturing by all the instructors. The author of this paper is one of the several physics instructors teaching physics as well as education courses.

Table 1. Number of hours per week and teaching method of the physics courses by major.

Major	Year	Hrs/week	Lab (Hrs/week)	Teaching Method
Physics Education	1	4	2	Traditional lecture
Science Education	1	4	2	Traditional lecture
Chemistry Education	1	4	2	Traditional lecture
Secondary Math Education	1	3	-	Traditional lecture
Elementary Math Education	2	4	-	Traditional lecture
Biology Education	2	2	2	Traditional lecture

Major	Year	Hrs/week	Lab (Hrs/week)	Teaching Method
Primary Education	1	2	-	Traditional lecture
Environmental Engineering	1	4	2	Traditional lecture
Comp. and Inst. Tech. Educ.	2	3	-	Traditional lecture

A significant difference among the physics courses offered is the number of class hours per week. This difference is due to the requirements of each department's educational program. The weekly hours of a course heavily influences the course content. For instance, pre-service biology, computer education and primary education teachers take one general physics course of two hours per week. This course deals only with simple introductory physics concepts ranging from mechanics to electricity. Instructors do not treat concepts in this course as deep as they do in other physics courses. The other department students take two or more physics courses during four to five years of teacher preparation program. Pre-service science education teachers take five compulsory physics courses during the first three years of their program. Finally, physics education department's courses are mostly physics courses.

Another significant difference among the physics courses offered to these departments is that some programs do not require a physics laboratory section and others have a two-hour lab session. Students carry out five to eight traditional physics experiments related to the concepts taught in the physics courses. Especially primary education and biology education majors are weak in terms of science background. These students obtain markedly lower scores in the university entrance examination (UEE) than that of students in the other majors. Secondary and elementary mathematics education majors along with environmental engineering students obtain generally higher scores in the UEE than that of students in all other departments in this study.

Instrument and Procedures

Students' anxiety in physics courses was measured using the Physics Anxiety Rating Scale (PARS). Application of the scale took about 10 minutes. The validity and reliability studies of the PARS were carried out and reported by Şahin, Çalışkan, and Dilek (2012). After a rigorous literature review a pool of 60 items related to physics anxiety were generated. The 60 items were presented to a panel composed of one science education and two physics education experts. Experts were asked to examine the items in terms of face validity, clarity, and meaning. According to expert suggestions, ten items were removed and two were revised to clarify the meaning. Then a 50-item 5 point Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree) was constructed. The draft scale was pilot tested with 15 pre-service physics teachers and 12 pre-service science education teachers. The results of the pilot test revealed that students could understand all the items. The final form of the 50-item scale was administered to 495 undergraduate education faculty students (pre-service teachers) enrolled in a physics course. For construct validity, exploratory factor analysis was carried out and for reliability analysis, item-total correlations for each item and Cronbach's Alpha reliability coefficients of the scale and subscales were calculated using IBM SPSS 21. During the factor analysis process, eliminating factor cross loadings and factors whose loadings were less than 0.40 led to the exclusion of 18 items from the analyses. Using the factors whose eigenvalues were greater than 1 and the scree plot test, four factors were formed including 32 items (Dalgety, Coll, & Jones, 2003). Factor identification included several analyses steps such as observing Cronbach's Alpha values of each factor with and without including troubling items, examining scree plot in each case and rereading items for avoiding any misinterpretation while including an item into a specific factor. A 4-factor model was decided as the best factor structure for the PARS. The factor loadings of the items constituting the PARS range between .455 and .773. The final form of the scale has a maximum score of 160, and minimum score of 32. High score represents a high level of anxiety. Final form of The PARS was a 32-item 5-point Likert-type scale consisting of four factors (components). The physics course/test anxiety (C/TA) factor contains 9 items and its reliability value is 0.92. The second factor, anxiety about lack of physics knowledge (LPKA), consists of 8 items with an alpha value of 0.85. The mathematics anxiety (MA) factor includes 8 items producing an alpha value of 0.86. The fourth factor, physics laboratory anxiety (PLA) contains 7 items and its reliability value is 0.83. The reliability coefficient for the whole instrument, using the sample (n=495) in the analysis is 0.95 (Dilek, Şahin, Güler, & Eslek, 2013). The PARS is included in the appendix. This study is unique (in using the PARS) since it is the first of its kind examining physics anxiety as a separate concept and its relationships to student

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demographics (Şahin, Çalışkan, & Dilek, 2012). As the reviewed literature in this paper emphasizes, science anxiety may influence performance and learning of students. Particularly, physics anxiety is not dealt with separately as observed in the literature. Although significant suggestions were provided to alleviate students' anxiety, one cannot locate an instrument directed specifically to measure students' physics anxiety. Therefore, to help researchers and educators determine students' anxiety towards physics, an easy to use Likert-type scale was developed. Using the PARS we can measure students' physics anxiety and modify or revise our teaching and physics courses accordingly to include any affective thoughts along with cognitive aspects.

Results of Research

Relationship between Physics Anxiety and Gender

To examine the relationship between physics anxiety and gender, ANOVA was conducted for the total anxiety scores. The result was significant, $F(1,847) = 51.21$, $p < 0.001$. The effect size was medium, as assessed by partial eta square, η^2, with the gender factor accounting for 6% of the variance of physics anxiety. The physics anxiety scores of the females ($M = 92.41$, $SD = 21.69$) were greater than that of males ($M = 81.61$, $SD = 22.36$), indicating higher anxiety levels for females. Results of descriptive and ANOVA statistics for the whole scale (PA) and the four factors CT/A, LPKA, MA, and PLA), by gender are shown in Table 2. Females scored higher (showed higher physics anxiety) in all factors, than males.

Table 2. Descriptive and ANOVA statistics for the relationship between physics anxiety and gender for the whole sample.

	Male		Female				
Variable	*M*	*SD*	*M*	*SD*	*F(1,847)*	*p*	*η2*
Whole (PA)	81.61	22.36	92.41	21.69	51.21	< 0.001	0.06
C/TA	25.07	7.96	30.69	8.31	98.02	< 0.001	0.10
LPKA	17.52	5.73	18.72	5.57	9.32	0.002	0.01
MA	21.66	6.71	23.17	6.27	11.26	0.001	0.01
PLA	17.35	5.07	19.83	5.70	43.01	< 0.001	0.05

Note. PA = Physics Anxiety; C/TA = Course/Text Anxiety; LPKA = Lack of Physics Knowledge Anxiety; MA = Math Anxiety; PLA = Physics Laboratory Anxiety. Mean scores are out of 160 points for PA, 45 points for C/TA, 40 points for LPKA, 40 points for MA and out of 35 points for PLA.

Gender difference in the whole scale was also analyzed in physics education and primary education departments. Results of descriptive and ANOVA statistics for the whole scale (PA) by gender are shown in Table 3. Female students in physics education department obtained significantly higher PA scores than that of males ($p = 0.050$). However, females and males were equally physics anxious in primary education department ($p = 0.053$). Although females obtained a higher mean anxiety score than males, the difference was not statistically significant.

Table 3. Descriptive and ANOVA statistics by gender for Primary and Physics Education departments.

Physics Anxiety	Male			Female					
Major	*n*	*M*	*SD*	*n*	*M*	*SD*	*F*	*p*	*η2*
Physics Edu.	69	73.03	20.32	101	79.13	19.37	3.91	0.050	0.02
Primary Edu.	21	90.62	19.06	61	101.64	23.14	3.85	0.053	0.05

Relationship between Physics Anxiety and GPA

Students' GPA was tabulated as low (GPA<2), medium (2≤GPA<3), and high (3≤GPA). Descriptive statistics of students' GPA for the whole scale and the factors are presented in Table 4. To examine the relationship between physics anxiety and GPA, univariate analyses of variance were conducted for the whole scale and factor scores. The ANOVA was significant for the whole scale (PA), $F(2,846) = 7.27$, $p = .001$, $\eta^2 = 0.02$. Post hoc analyses using Benferroni procedure revealed that students with medium GPA scored lower on the whole anxiety scale than students with low ($p = 0.02$) and high GPA ($p = 0.01$).

Table 4. Descriptive statistics for the relationship between physics anxiety and GPA.

GPA Group	Low GPA (n=181)		Medium GPA (n=303)		High GPA (n=365)	
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*
Whole (PA)	89.48	20.74	83.99	22.84	90.29	22.34
C/TA	28.95	8.11	27.08	8.83	29.06	8.59
LPKA	18.60	5.73	17.40	5.59	18.70	5.64
MA	24.02	6.28	21.68	6.65	22.51	6.37
PLA	17.91	5.19	17.83	5.58	20.02	5.54

To analyze the group differences of GPA on four factors, univariate analyses of variance were conducted. The ANOVA's were significant for all factors. $F(2,846) = 5.02$, $p = 0.007$, $\eta^2 = 0.012$ for the course/test anxiety (C/TA), $F(2,846) = 4.90$, $p = 0.008$, $\eta^2 = 0.011$ for the anxiety about lack of physics knowledge (LPKA), $F(2,846) = 7.42$, $p = 0.001$, $\eta^2 = 0.017$ for the mathematics anxiety (MA), and $F(2,846) = 16.20$, $p < 0.001$, $\eta^2 = 0.037$ for the physics laboratory anxiety (PLA). Post hoc analyses using Bonferroni procedure revealed that students with high GPA had higher anxiety scores than students with medium GPA who had similar scores to students with low GPA on factors C/TA and LPKA ($p = 0.009$ and $p = 0.01$, respectively). Students with low GPA were more physics anxious than students with medium ($p < 0.001$) and high GPA ($p = 0.03$) whose anxiety scores were similar on factor MA. Finally, for factor PLA, students with low and medium GPA had lower anxiety scores than students with high GPA ($p < 0.001$ for both GPAs).

Relationship between Physics Anxiety and Major

The distribution of the participants by major is shown in Table 5. To determine if physics anxiety differed across majors, univariate analyses of variance were carried out for the whole scale and factors and they were found as significant. The results of these analyses were displayed in Table 6.

Table 5. Distribution of the participants by major.

Major	n
Physics Education	170
Science Education	151
Chemistry Education	96
Secondary Math Education	104
Elementary Math Education	70

Major	n
Biology Education	65
Primary Education	82
Environmental Engineering	38
Computer and Instructional Technology Education	73
Total	849

Table 6. ANOVA statistics for the relationship between physics anxiety and major.

Dependent variable	F(8,840)	*p*	*η2*
PA	10.32	< 0.001	0.09
C/TA	9.43	< 0.001	0.08
LPKA	8.99	< 0.001	0.08
MA	5.08	<0.001	0.05
PLA	11.66	< 0.001	0.10

Note. PA = Physics Anxiety; C/TA = Course/Text Anxiety; LPKA = Lack of Physics Knowledge Anxiety; MA = Math Anxiety; PLA = Physics Laboratory Anxiety.

Follow up post hoc analyses using Dunnett C statistics were carried out to reveal the differences in anxiety across majors. The results of these analyses are presented in Table 7 for the dependent variable physics anxiety (PA). The results of the analyses for the factors were not discussed here due to space considerations. However, results of all post hoc analyses using Dunnett C statistics revealed similar findings as the whole scale.

Several findings stand out in these analyses. The mean anxiety score of physics education students is found to be lower than those of other majors (as may be expected). Mean differences were significant at .05 significance level except for the difference between physics education and environmental engineering majors. Mean anxiety scores of the primary education students is found to be higher than those of other majors. Mean anxiety score of science education students is not significantly lower than those of other majors. Primary education majors obtained the highest mean physics anxiety score, followed by computer and instructional technology education majors.

Table 7. Mean physics anxiety scores (PA), standard deviations and mean differences across majors.

Major	M	SD	Phy	Sci	Chem	Math	EMath	Bio	Prim	Eng
Phy	76.65	19.93								
Sci	90.93	19.94	-14.28*							
Chem	87.18	20.76	-10.52*	3.76						
Math	89.35	20.69	-12.69*	1.59	-2.17					
EMath	89.26	21.71	-12.60*	1.68	-2.08	0.09				
Bio	90.80	23.38	-14.15*	0.13	-3.62	-1.45	-1.54			
Prim	98.82	22.58	-22.16*	-7.88	-11.64*	-9.47	-9.56	-8.02		

Major	M	SD	Phy	Sci	Chem	Math	EMath	Bio	Prim	Eng
Eng	81.05	18.07	-4.40	9.88	6.12	8.29	8.20	9.75	17.76*	
Comp	93.78	27.19	-17.13*	-2.85	-6.60	-4.43	-4.52	-2.98	5.04	-12.73

Note. An asterisk indicates that the difference in means is significant at the .05 significance using Dunnett C procedure.
Phy: physics education; Sci: science education; Chem: chemistry education; Math: secondary math education; EMath: elementary math education; Bio: biology education; Prim: primary education; Eng: environmental engineering; Comp: computer and instructional technology education

Relationship between Physics Anxiety and Type of High School

In Turkey, apart from private schools, there are different high schools established for different purposes. The school types included in the study were, Anatolian Teacher High School (ATH), Super High School, Science High School, State (Regular) High School (SH), and Vocational High School (VHS). Recently, there has been an increase in the number of Anatolian high schools since regular high schools have been converted into Anatolian high schools. In demographic variables section, school types were grouped under four categories: Private, Super, and Science high schools (PSSH) were put into one category due to similarities in their heavily science-math-based program. Actually, all types of schools offer a similar program, however, in addition to baseline program, all Anatolian high schools have a full year of English prep school in the program and all Vocational schools have different vocational courses. A total of 836 students provided high school information. The distribution of the students from high school, mean anxiety scores, and standard deviations are provided in Table 8.

Table 8. Descriptive statistics and distribution of participants by high school type.

Type of High School	M	SD	n
Anatolian Teacher (ATH)	86.41	21.88	472
Private, Super, and Science (PSSH)	88.72	21.29	107
State (Regular) (SH)	88.20	22.48	170
Vocational (VHS)	95.26	24.33	87
Total	87.99	22.31	836

To evaluate the relationship, if any, between physics anxiety and high school type, univariate analyses of variance were conducted for the physics anxiety (PA) scores. The ANOVA was significant, $F(3,832) = 3.95$, $p = 0.008$, $\eta^2 = 0.01$. Post hoc analysis using Benferroni procedure revealed that students graduated from VHS had significantly higher physics anxiety scores than students graduated from ATH ($p = 0.004$). It is interesting to note that PSSH and SH students obtained similar anxiety scores.

Change in Physics Anxiety after a Semester of Physics Instruction

Pre- and post anxiety data were obtained from 175 elementary science, chemistry, secondary school math, elementary math, biology, and computer education majors. To examine students' pre- and post anxiety scores based on gender and department, t-test and ANOVA were conducted. Descriptive statistics used in these analyses are presented in Table 9. Results indicated that mean physics anxiety score for the total group was reduced slightly (not significantly, $p > 0.05$) from pre- ($M = 91.82$) to post application ($M = 88.42$). When the shift was examined based on gender the statistics revealed that mean anxiety score for females increased slightly (not significantly, $p > 0.05$), while mean anxiety score for males decreased significantly from pre- to post application. ANOVA statistics also indicated that females and males did not differ in mean anxiety scores at pre-semester data ($p > 0.05$); however, the difference was statistically significant for post-semester data ($p < 0.001$).

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Table 9. Descriptive statistics for pre- and post-application based on gender.

	Male (n = 100)		Female (n = 75)		Total (N = 175)	
Anxiety	*M*	*SD*	*M*	*SD*	*M*	*SD*
Pre	94.53	22.36	89.78	19.31	91.82	21.00
Post	80.35	7.96	94.48	16.84	88.42	20.52

Analyses were also conducted to examine changes in physics anxiety of students based on department and also on gender within a department. Results of analysis by department revealed that anxiety scores did not change significantly from pre- to post application for all departments ($p > .05$ for all majors). Significant differences existed in students' anxiety scores in pre-application based on departments. However, no significant difference was determined among departments at post-semester anxiety scores. For biology students, while mean anxiety score for females increased significantly ($M_{pre} = 82.42$, $M_{post} = 94.38$, $p = 0.038$), there was a significant decrease in mean anxiety score for males ($M_{pre} = 101.88$, $M_{post} = 69.13$, $p = 0.018$) in biology education from pre- to post application.

As explained in the Sample of Research section, the instructors of the physics courses have backgrounds in physics and physics education. All of the instructors conduct research from time to time as part of their academic career. They conduct research related to physics education, teacher education, and other related areas in science education. All the courses are taught using traditional lecture method in the faculty. No special effort is put on affective aspects in the physics classes. Instructors may still use different interpersonal skills and teaching abilities to teach physics. Therefore, there is a possibility that instructors may influence students' anxiety in physics classes. Another factor is the content and type of the physics course offered to different majors. Whether students attend a lab session or not may also affect the level of students' anxiety in physics classes.

Discussion

This study used an exploratory approach to investigate the relationships between the variables involved. The purpose of this study was to examine pre-service teachers' physics anxiety and its relationships to gender, GPA, major, and type high school they graduated. It can be argued that the study produced valuable results which may suggest further research areas.

Aligned with most of the studies in the literature (i.e. Bryant et al., 2013; Mallow, 1994; Udo, Ramsey, & Mallow, 2004; Udo et al., 2001) which found females to have higher science anxiety, results of the present study revealed a gender effect, indicating that females tended to have higher physics anxiety than males. To the knowledge of the author, since there is no study in the literature dealing with physics anxiety as a separate factor, the results are compared and contrasted with research studies about science anxiety which is a very close concept. Bursal (2008) reported no significant gender effect on science anxiety scores of Turkish pre-service elementary teachers in a science methods course. A similar result was obtained by Brownlow, Jacobi, and Rogers (2000) suggesting that women and men displayed similar science anxiety in a group of American university students. Although not shown explicitly in the results section due to space considerations, when the data were analyzed for gender differences by department, it was found that in some departments (environmental engineering, physics, chemistry, and primary), physics anxiety scores of females and males was not significantly different. In fact, in chemistry department, females had slightly less physics anxiety than males. Overall, the difference between physics anxiety scores of males and females was significant.

Results of this study revealed that physics anxiety of pre-service teachers differed according to major of study supporting the results of previous science anxiety research (Bryant et al., 2013; Udo et al., 2001). Most physics anxious pre-service teachers were primary education students. Both females and males in this department displayed significantly higher physics anxiety than any other majors. It is important to note that as literature showed students' science anxiety starts at primary school level (Chiarelott & Czerniak, 1987; Czerniak & Chiarelott & 1985). Preparing primary teachers who are physics anxious may inevitably lead to physics and science anxious primary school students. Because research suggests that science-anxious teachers in elementary and secondary schools are among the causes for science anxiety (Cherian & Siweya, 1996; Kahle, Parker, Rennie, & Riley, 1993). Science anxiety in teachers may lead science avoidance and hence a negative attitude toward science in their students. Studies with Turkish and American elementary teachers found science anxiety in these teachers (Bursal, 2008, 2012). Primary pre-service teachers have a weak background in science and hence in physics. They begin the general physics course with very high anxiety and fear. They demonstrate this fear and anxiety at the beginning of the semester in the physics classes as observed by the author. They mention that they have no high school physics background and fear that they will fail the course. This may be false information provided by the students as an excuse for their low performance in the course since all types of high schools in Turkey offer some physics courses during high school education. It seems that one semester of a general physics course in this study did not help much to alleviate physics anxiety of these students.

A group of engineering students were participants in this study. Perhaps because of their inclusion in a heavy science and math workload, or perhaps due to these students' high level of achievement in basic science courses, they displayed a significantly lower level of physics anxiety than education majors, except physics education majors who had similar anxiety scores as engineering students.

The relationship between physics anxiety and GPA revealed interesting results. Students with low and high GPA had comparable physics anxiety which was significantly higher than anxiety of students with medium GPA. This result suggests that a high level physics anxiety is related to high GPA; it is also related to low GPA. Literature generally supports a negative relationship between anxiety and achievement situations (Diaz et al., 2001). Low levels of anxiety is said to promote motivation and increase achievement however, higher levels of anxiety may hinder academic achievement. Since there has been no such research studying the relationships between physics anxiety and academic achievement, the negative relationship between general anxiety and achievement was taken as contrast. Actually, literature suggests a complex and sometimes nonlinear relationship between anxiety and achievement (King et al., 1976) which seems to agree with the results of this study. However, caution should be taken in how GPA calculated in different studies. In addition, examining the relationship between physics anxiety and GPA may lead false conclusions about this relationship since as in this study, GPA includes not only science-related or physics courses.

High school type seemed to have an effect on students' physics anxiety. Students graduated from vocational high schools showed the highest level of anxiety. Causes of these results may vary. The education program of these schools may not be emphasizing enough science courses. Teachers of these students may be avoiding science courses and not fulfilling the requirements of the program in terms of science topics to be covered. The root of this anxiety may also reach to these students' middle and elementary school education. Research did not find any effect of math and science preparation in high school on students' science anxiety (Brownlow, Jacobi, & Rogers, 2000). In addition, students with high levels of science anxiety reported that they had ineffective high school science teachers. Therefore, as suggested by the results of the current study, "poor experiences with high school science" (p.127) may be responsible for science anxiety at university.

Apparent differences between males and females in physics anxiety scores in the second sample may be due to a number of factors such as background science, instructor gender, instructional differences, and nature of the physics course offered. Generally students were taught traditionally in all courses and majors in this faculty. However, if any instructor used any different approach, the author was not aware of it. Slight but not significant reduction in physics anxiety for all students was also seen in science anxiety in other studies (Udo et al., 2001). Since content of physics courses students take in this study differed according to major, this may have an effect on students' anxiety. In addition, in some cases anxiety for females increased while anxiety of males decreased after a semester of physics instruction. Research showed that instructor gender may have a role in these shifts. Girls may have benefit more than boys from the same gender instructors, or vice versa (Bryant et al., 2013; Mallow, 1994, 2006, Mallow et al., 2010; Udo et al., 2001, 2004). In any case, as suggested by past research, it may be possible to positively influence students' physics anxiety using different instructional strategies.

Conclusions and Implications

It may not be possible drawing too broad conclusions depending on the results of a single study. However, it may be said that the present study achieved its purpose of examining the relationships between the variables involved and may have some implications. Results showed that many factors may contribute to physics anxiety. It is now commonly accepted that gender difference has been significantly decreased among university students. However, science and physics anxiety still continue to play a significant role in preventing both male and female

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students from entering physics-related areas. Thus, effort is required to alleviate anxiety for both males and females. Previous researches and the current study suggest that teachers perhaps have a significant role in shaping students' attitudes (negative or positive) toward science. Teachers using ridicule or sarcasm toward their students in science classes may intentionally or unintentionally cause their students to avoid science in their future life at all costs.

Since the participants of this study were pre-service teachers and some displayed significant levels of physics anxiety, it may prove to be useful to take measures to alleviate future teachers' physics anxiety. Personal observations of the author of this paper indicated that if possible (when they let to choose) pre-service science teachers tend to prefer teaching mostly biology and chemistry topics in science methods courses in their teacher education program and field experiences. They avoid choosing physics-related topics to prepare and teach in their field experience courses. These teachers will be teaching science and physics to next generation students. They may convey their negative attitudes toward science to their students without being aware of it. As the results suggest, physics courses offered to different departments may be designed to include some affective portions. Especially the general physics courses offered to pre-service elementary teachers taking should be designed very carefully. Intervention studies may be conducted in an effort to reduce physics anxiety of students in physics courses. As past studies suggest, instructional strategies involving elements of anxiety reduction helps to alleviate students' science and math anxiety, similar interventions may work for physics anxiety. Instructors may be reminded to take measures to prevent the arousal of anxiety. Students can be informed about the nature of anxiety and told that negative messages they send to themselves can be avoided. In addition, students can be trained in relaxation techniques (by a psychologist) and physics learning skills.

The present study has some limitations in its scope in examining the concept of physics anxiety. Students' age was not considered as a variable. Students' anxiety may differ with age and this may have an influence on their physics anxiety. Although students' class level information was available, it was not used as a variable because most of the students were at their second year. This produced a bias in the data. In addition, most of the second year students were pre-service elementary teachers who showed the highest physics anxiety. Therefore, using class level as a variable indicated that second year students had the highest score on the scale, which would be a biased result. Further research may include age and year of study as variables of anxiety. The present study used students' GPA as a measurement of performance. However, GPA score includes a student's all grades from all the courses, some of which may not be related to science courses or physics anxiety. Further research may use standardized tests, along with GPA to measure students' achievement in physics courses and examine the relationship between physics achievement and physics anxiety, which might yield more meaningful results. Although support could not be found for the relationship between math and science anxiety in the literature, present study suggests that students with lack of mathematics knowledge or ability may fear from physics courses (also from calculations and graphs in physics labs) or may achieve lower in physics courses. Therefore, mathematics may play a role in university students' physics anxiety in physics courses they take. Future studies in the field of physics education may also include middle and high school physics/science and mathematics background. As implied by the results of the second sample, anxiety may be reduced depending on instructional differences, instructor gender, and course content. Future studies may consider different instructional interventions, instructor gender, and the nature of physics courses offered as variables in researches. Finally, future studies may include, in addition to the PARS, different measures to enhance reliability and validity of the results such as attitude and interest scales, standardized physics tests as well as some qualitative measures.

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Appendix

The Physics Anxiety Rating Scale (PARS)

1. I feel very comfortable when studying for a physics exam.
2. I feel very comfortable and peaceful in physics courses.
3. Physics experiments make me very tense.
4. I am very comfortable with using lab materials.
5. I am afraid to raise my hand to ask a question in physics courses.
6. I am usually stressed out before a physics exam.
7. I would feel very embarrassed if the instructor corrected the answer that I gave to a physics question in front of the class.
8. When preparing an apparatus for a physics experiment, I panic about whether I will be able to conduct the experiment or not.

9. If I was asked to discuss the mathematical proof of a physics law, I would panic.
10. I am very comfortable when solving physics problems.
11. Discussing the physics laws with my friends outside the school tenses me up.
12. I usually feel uncomfortable and worried when taking physics exams.
13. I am worried about becoming an underachiever in physics due to my lack of mathematical knowledge.
14. If my instructor asked me to explain a physical event from daily life, I would be worried.
15. Taking a physics exam usually scares me.
16. Among all the other courses, the course which makes me most anxious is physics.
17. Being unable to use units of quantities appropriately in physics courses makes me very anxious.
18. Being watched by a friend while conducting a physics experiment makes me anxious.
19. When the instructor is solving a problem, I worry that the others understand the solution better than I do.
20. When solving a physics problem, I worry about not being able to recall relevant formulas or physics laws.
21. I would be worried if my math instructor wrote some physics formulas on the board.
22. Explaining my opinion about a physical event occurring in nature concerns me.
23. Compared with other courses, I worry more about succeeding in the physics course.
24. I worry about not being able to remember the mathematical formulas of physics laws.
25. Helping a primary school student with her/his physics project tenses me up.
26. When I open a physics book, seeing a page full of formulas without any explanation scares me.
27. I am usually very nervous when I am studying for a physics exam.
28. Explaining the findings of an experiment that I have conducted in the physics lab to the instructor stresses me out.
29. Being obliged to use mathematical expressions in the physics course makes me feel very anxious.
30. Trying to read a sentence full of mathematical physics formulas involving symbols of which I do not know the meaning scares me a lot.
31. Being watched by the physics instructor while I am conducting an experiment stresses me out.
32. I worry about running out of time to complete the experiment in the physics lab.

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Mehmet Şahin Ph.D., Dokuz Eylül University, Faculty of Education, Department Science Education, Buca, 35150 Izmir, Turkey.
E-mail: mehmet.sahince@gmail.com
Website: http://kisi.deu.edu.tr/mehmet.sahin/