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Mathematics Anxiety, Mathematics Performance and Gender differences among Undergraduate Students

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Abstract-This study aimed to investigate the level of mathematics anxiety and the relationship between mathematics anxiety and mathematics performance among undergraduate students of Payame Noor university (PNU) in Hamedan, Iran. In particular, the study investigated the relationship between mathematics anxiety and gender, and field of study. The sample of the study consisted of 275 (162 women and 113 men) undergraduate students of various fields of study. To measure the mathematics anxiety level, the participants responded to the 24 Items of The Revised Mathematics Anxiety Rating Scale (RMARS), which consisted of learning mathematics anxiety and mathematics evaluation anxiety subscales. The data were analyzed by One-way ANOVA and independent-samples t- tests using the Statistical Procedures for Social Sciences (SPSS 11.5). The results showed significant differences between men and women's evaluation anxiety and no significant difference was observed concerning field of study. Also, there is a significant correlation between high level anxiety and low academic performance.

Index Terms- Mathematics Anxiety, Mathematics performance, Gender differences.

I. INTRODUCTION

Mathematics anxiety is one of the most important problems for many students. "mathematics anxiety involves feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (Richardson & Suinn, 1972, p. 551). However, Byrd (1982) accepted this kind of definition as deficient both from conceptualization of mathematics and also from conceptualization of anxiety perspectives. Thus, it should be regarded from a larger perspective as a complex construct consisting of "affective, behavioral and cognitive responses to a perceived threat to self-esteem which occurs as a response to situations involving mathematics" (Atkinson, 1988). Generally, high level of anxiety is more closely associated with lower performance among low ability students (Sena et al., 2007). Mathematics anxiety can be defined as a state of discomfort created when students are required to perform mathematical tasks (Cemen, 1987). However, there is no general consensus among the scholars on its causes and effects. In fact, mathematics anxiety is more than a dislike toward mathematics (Vinson, 2001). Thus it can be observed that mathematical basic skills or concepts acquired in lower form are vital for students (Siti & Rohani, 2010). The findings will help to improve understanding of mathematics learning concerning mathematics anxiety.

II. MATHEMATICS ANXIETY AND GENDER DIFFERENCES

A particular focus of the present study was gender differences and mathematics anxiety. The studies concerning the relationship between gender and mathematics anxiety show different results (Anglin, Pirson, & Langer, 2008; Hall, Davis, Bolen, & Chia, 1999; Meelissen & Luyten, 2008; Penner & Paret, 2008). Some studies report that women have higher mathematics anxiety than men (Baloglu & Koçak, 2006). As Aiken (1970) pointed out, ''no one would deny that sex can be an important moderator variable in the prediction of achievement from measures of attitude and anxiety''. Specifically, Aiken (1970) stated that ''measures of attitude and anxiety may be better predictors of the achievement of females than that of males''. Similarly, Eccles and Jacobs (1986) asserted that gender differences in mathematics anxiety are directly attributable to gender differences in mathematics achievement. However, some studies indicated that the achievement disparity in mathematics is "small and declining" with competence beliefs as a stronger driver of performance outcomes. (Frenzel, Pekrun, & Goetz, 2007). Ma's (1999) meta-analysis concluded that gender differences are not statistically significant in mathematics anxiety.

III. MATHEMATICS ANXIETY AND MATHEMATICS ACHIEVEMENT

Researchers have made efforts to examine individual differences in the relationship between mathematics anxiety and mathematics achievement. The relationship between Mathematics anxiety and mathematics achievement was studied by Ma and Jiangming Xub (2004). Tocci & Engelhard (1991) found that students with a higher level of mathematics anxiety perform at a lower level of mathematics achievement. Similarly, Hembree's (1990) meta-analysis reported an average correlation of -.34 between mathematics anxiety and mathematics achievement. In a more recent meta-analytic review on the relationship between mathematics anxiety and mathematics achievement, Ma (1999) found that the common population correlation for this relationship is -.27. This magnitude was associated with a prediction that ''measures (or treatments) that resulted in the movement of a typical student in the group of high mathematics anxiety in the group of low mathematics anxiety would be associated with improvement of the typical student's

level of mathematics achievement from the 50th to the 71st percentile''. Also a negative correlation between mathematics anxiety and mathematics achievement was reported by (Ashcraft, 2002; Ashcraft & Kirk, 2001; Bandalos, Yates, & Thorndike-Christ, 1995; Cates & Rhymer, 2003; Miller & Bichsel, 2004). The goal of the present research is to answer the question: Is there any relationship between mathematics achievement and mathematics anxiety?

IV. Sample and participants

The sample of the present study was 275 undergraduate students from 960 students who took the general mathematics courses in 2010-2011 semesters at Payame Noor University of Hamedan, Iran. The participants number was determined by Cochran's formula (Cochran, 1977).

The students were selected by using a random sampling method. Of these students, 162 (58.9%) were female and 113 (41.1%) were male. The participants' age ranged between 18 to 30 years with a mean of 20.65 (SD = 2.43). Nineteen different departments were represented in the study: 3 (1.1%) subjects were from the Agricultural Mechanization department, 30 (10.9%) from Agricultural Engineering department, 83 (30.2%) from Computer Engineering department, 28 (10.2%) from Geology department; 17 (6.2%) form Hydraulics, 17 (6.2%) from Industrials engineering, 21 (7.6%) from Mathematics, 5 (1.8%) from Agricultural Economics, 4 (1.5%) from Economics, 4 (1.5%) from Law, 7 (2.5%) from Psychology, 5 (1.8%) from Environmental Engineering, 10 (3.6%) from Geography, 11 (4%) from Biology, 2 (.7%) from Social Sciences, 2 (.7%) from Business Management, 7 (2.5%) from public Management and 4 (1.5%) from Animal sciences and 6 (2.2%) from educational sciences. 9 students did not write down the names of their Fields of study.

V. Instruments and Procedure

Mathematics anxiety was measured by using The Revised Mathematics Anxiety Rating Scale (RMARS, Plake B.S and Parker C.S, 1982) and the participants were required to complete a demographic information sheet used to collect data. The participants were informed about the research which was carried out in their classrooms. The time allocated to their answering the questions of the study was 25 minutes.

Let us say a few words about the instruments used in this study. Because the pioneering assessment was 98-item Mathematics Anxiety Rating Scale (MARS), with high reliability and validity (Richardson F.C and Woolfolk R.L, 1980), MARS was too time demanding for students (Pajares F and Urdan T, 1996), following MARS, researchers developed several shorter versions Scale. Plake and Parker (1982) developed, a 24-item shortened version of the MARS, the Revised Mathematics Anxiety Rating Scale (RMARS) and the 9-item Abbreviated Mathematics Anxiety Scale (AMAS) was introduced by Hopko D.R et al in 2003. In Iran, Vahedi and Farrokhi (2011) evaluated the psychometric properties of an Iranian version of the AMAS and to test measurement invariance across gender. Their Results showed that the AMAS has high internal consistency, with Cronbach's Alpha .82.

In this study, Revised Mathematics Anxiety Rating Scale was a 5-point, Likert-type scale composed of 24 items and two subscales: learning mathematics anxiety (the 16 first questions) and mathematics evaluation Anxiety (the 8 final questions). The Cronbach alpha coefficient for the reliability of the measurement of the RMARS was .9368, .9184 for measurement of mathematics evaluation Anxiety, and .8816 for measurement of learning mathematics anxiety. The Iranian grading system is similar to that of France in secondary schools and universities; the passing grade for undergraduate students is 10 and the maximum grade is 20. Iranian grades are not converted to the 4.0 scale GPA directly. (WES Grade Conversion Guide). Table 1 Shows the information about converting the Iranian grades to the 4.0 scale GPA.

Table1. The Iranian grading system

Iran Grading system	Grade Description	U.S. Grade Equiv.
16-20	4	A
14-15	3	B
12-13	2	C
10-11	1	D
0-9	0	F

In order to find the student mathematics performance, the participants were required to answer a question about their mathematics grades. The students' grades were divided into four sections: 12 students had mathematics grade less than 10 (4.4%). The mathematics grade of 55 students was between 10 and 12 (20%). 110 students had mathematics grade between 12 and 15 (40%) and mathematics grade of 91 students was between 15 and 20 (33.1%). 7 students did not write down their mathematics grade (2.5%) on the paper sheet.

The Statistical Procedures for Social Sciences (SPSS) 11.5 was used to code and analyze the data. T-tests were conducted to determine if the results were affected by gender and also to measure RMARS scores. In order to test the role of the independent variables, a between-subjects factorial analysis of variance (ANOVA) was used with a non-orthogonal design. In the case of any significance, the analysis followed with Scheffe's post hoc tests to assess the importance of each independent variable. Since we used a repeated measures analysis of variance (ANOVA) method to answer the research questions, the normality of the dependent variables, the homogeneity of variance, and the homogeneity of covariance were tested in order to receive unbiased and reliable F-values and descriptive statistics for the dependent variables (Mathematics experience) in each case were provided.

VI. RESULTS

This study assessed mathematical anxiety based on two sub-categories (learning mathematics anxiety and mathematics evaluation anxiety). According to one sample t-tests, there were significant differences between the test values and the mean of the observed data scores for the total mathematics anxiety ($t(274) = -5.248$, $p<.01$), mathematics evaluation anxiety ($t(274) = -6.713$, $p<.01$), and learning mathematics anxiety ($t(274) = -11.580$, $p<.01$) of all students. The mean of the observed data scores for the total mathematics anxiety was 65.8764, and the test value was 72. It means that the total mathematics anxiety of the students was less than the test value. The mean of the learning mathematics anxiety scores was 38.7309 and the test value was 48. The findings showed that the students had low learning mathematics anxiety in general. The data was detected for mathematics evaluation anxiety. The mean of the observed data was 27.1455 and the test value was 24. It showed that the students had high mathematics evaluation anxiety. The findings are presented in Table 2.

Table2. One sample T-test scores of the Revised Mathematics Anxiety Rating Scale and its Subscales.

Dependent variables	Mean	df	T	Test value	p
Learning mathematics anxiety	38.7309	274	-11.580	48	.0001**
Mathematics evaluation anxiety	27.1455	274	6.713	24	.0001**
Total Mathematics anxiety	65.8764	274	-5.248	72	.0001**

**p<.01, n=275

The results presented in Table 3 show the gender differences in mathematics anxiety among the students. The findings from T-tests, indicated that there were significant differences ($t(273)=3.56$, $t(273)=2.4$, $p< .05$) between male and female students in their total mathematics anxiety and mathematics evaluation anxiety. Although, the mean of learning mathematics anxiety for female students (39.68) was greater than that of male (37.36), there is no significant difference ($t(273)=1.43$, $p>.05$) between male and female students in their mathematicslearning anxiety.

Table 3. The independent sample t- test to show Gender differences in mathematics anxiety.

Variables	Group	N	M	SD	SE	T	df	P Value
Learning mathematics anxiety	Male	113	18.25	7.64	.71	3.56	273	.0001
	Female	162	28.51	7.58	.51			
Mathematics evaluation anxiety	Male	113	37.6	13.62	1.28	1.43	273	.154
	Female	162	39.68	12.98	1.01			
Total mathematics anxiety	Male	113	62.54	19.59	1.84	2.4	273	.017
	Female	162	68.19	18.89	1.48			

In order to investigate the total mathematics anxiety between various fields of study, One-way ANOVA was used and the test indicated no significant difference ($F(18,274) =1.533$, $p>.05$). Also the test showed no significant difference in learning mathematics anxiety ($F(18,274) =1.529$, $p >.05$) and mathematics evaluation anxiety ($F(18,274) = 1.508$, $p >.05$) for students of various fields of study (table 4). It should be noted that Scheffe's post hoc tests was not used because of no significant differences.

Table 4. One-way ANOVA for comparing the mathematics anxiety between various fields of study

Source		Sum of squares	Df	Mean squares	F	P-value
Learning mathematics anxiety	Between groups	4694.270	18	260.793	1.529	.080
	Within groups	42136.242	247			
	Total	46830.511	265	170.592		
Mathematics evaluation anxiety	Between groups	1594.648	18	88.592	1.508	.087
	Within groups	14506.740	247			
	Total	16101.387	265	58.732		
Total mathematics anxiety	Between groups	10127.761	18	562.653	1.553	.073
	Within groups	89509.355	247			
	Total	99637.117	265	362.386		

Differences in mathematics anxiety scales based on the students mathematics grades were investigated. One-way ANOVA indicated a significant difference between the students' total mathematics anxiety with respect to the mathematics grades ($F(3,264) = 7.243$, $p <.05$), but Scheffe's post hoc analysis showed that the only significant difference was between the

students with 10-12 and those with 15-20 mathematics grades. Students with 10-12 mathematics grades have more total mathematics anxiety than those with 15-20 mathematics grades. One-way ANOVA indicated a significant difference between students' learning mathematics anxiety ($F(3,264) = 4.77$, $p < .05$), and mathematics evaluation anxiety ($F(3,264) = 8.82$, $p < .05$), with respect to mathematics grades. Scheffe's post hoc analysis showed that the students with 10-12 mathematics grades had more learning mathematics anxiety than those with 15-20 mathematics grades and the those with 10-12 and 12-15 mathematics grades had more evaluation mathematics anxiety than students with 15-20 mathematics grades. Scheffe's post hoc analysis showed no significant differences between learning mathematics anxiety and evaluation mathematics anxiety of other students with respect to mathematics grades (Table 5).

Table 5. One-way ANOVA for comparing mathematics anxiety and mathematics performance

Source		Sum of squares	df	Mean squares	R Squared	F	P-value
Mathematics evaluation anxiety	Between groups	1444.127	3	481.376	.91	8.82	.0001
	Within groups	14406.779	264				
	Total	15850.907	267	54.571			
Learning mathematics anxiety	Between groups	2191.521	3	730.507	.51	4.77	.0001
	Within groups	40428.136	264				
	Total	42619.657	267	153.137			
Total mathematics anxiety	Between groups	7048.363	3	2349.454	.76	7.243	.0001
	Within groups	85632.514	264				
	Total	92680.877	267	324.366			

VII. Discussion AND conclusion

The aim of the present study was to investigate the relationship between mathematics anxiety and mathematics performance among undergraduate students. In addition, the study measured the mathematics anxiety scores and indicated the relationship between gender, fields of study and mathematics anxiety.

According to the results, although the total mathematics anxiety and learning mathematics anxiety levels of all students was not higher than the mean, evaluation mathematics anxiety scores was more than the mean and the students had high evaluation mathematics anxiety. In fact we can conclude that the students had low mathematics anxiety in the classrooms when they were learning mathematics, but the examination situation could create high mathematics anxiety for them. The results showed that the differences were complex. It was probably because of the multivariate factor construction of mathematics anxiety. (Baloglu & Koçak, 2006; Kazelskis, 1998)

The results also indicated that the total mathematics anxiety scores and the evaluation mathematics anxiety scores showed a significant difference between females and males. The women scored higher than the men. However, no significant difference was observed between learning mathematics anxiety scores of females and males. Furthermore, the results of total mathematics anxiety supported previous studies which had concluded that there is a significant difference between females and males. (Baloglu & Koçak, 2006; Cook, 1998; D'Ailly & Bergering, 1992; Flessati & Jamieson, 1991). It means that the mathematics testing situations caused more anxiety in females than males in Iran. Special programs seem to be necessary to reduce mathematics anxiety in women. Playing video games, has shown to be a good remedy (Feng, Spence, & Pratt, 2007).However, some other studies did not detect any gender differences (Coates, 1998; Cooper & Robinson, 1991). This demands further investigation to compare areas with high sex differences and those without any sex differences in order to find part of the causes of anxiety, especially for women.

One of the purposes of this study was to make comparisons between fields of study and mathematics anxiety. There was no significant difference in mathematics anxiety of students of various fields of study. The results indicate that all two subscales as well as the total mathematics anxiety appear in the same way in all academic disciplines. This finding is notable, because it is obtained from a large number of the departments in the study. We may conclude that mathematics anxiety was not dependent on the variety of mathematics lessons: the mathematics anxiety of mathematics students was the same as those of social sciences students, but the mathematical lessons of mathematics students are different than the mathematical lessons of social sciences students.

One of the most important impacts of mathematics anxiety relates to performance, because there is a negative correlation between mathematics anxiety and mathematics achievement. (Ashcraft & Kirk, 2001; Cates & Rhymer, 2003; Ma & Xu, 2004; Miller & Bichsel, 2004). Our study showed a significant difference between mathematics anxiety and mathematics performance. The results also showed that the students with mathematics grades near the passing grade had more mathematics anxiety than others. Perhaps the optimistic belief in a successful outcome and more ability of answering mathematics questions necessitates less mathematics anxiety.

Finally, mathematics instructors should also pay closer attention to the fact that the requirements of the female and male learners may be different in the classroom. Further studies seem to be needed to compare mathematics anxiety in various fields of study. Other studies may focus on new evaluation methods to reduce the mathematics evaluation anxiety.

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