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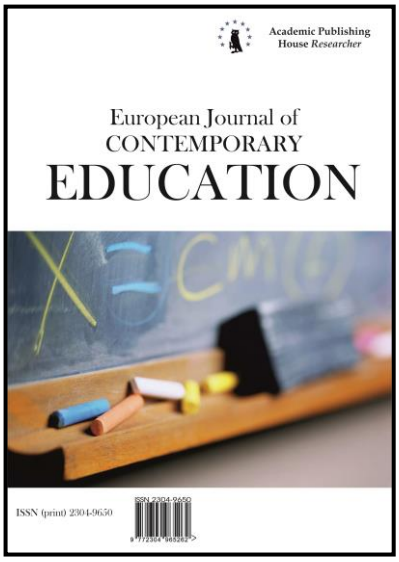

Gender Differences in Mathematics Anxiety Across Cultures: A Univariate Analysis of Variance Among Samples from Twelve Countries

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Abstract

Mathematics anxiety (MA) has a debilitating impact on learning, achievement, mental health, and the future career life of students. Though MA is a popular research theme, there is little agreement among researchers regarding the cross-cultural effect of gender. The purpose of this paper was to explore the perceived MA differences among males and females across cultures using the Anxiety Towards Math Scale (ATMS; Muñoz and Mato, 2007). Data were collected between October 2019 and September 2020) from students (N = 4,340) in 12 countries. Using univariate analysis of variance, the results indicate that gender has a significant main effect on MA with females recording higher mean scores than males, [71.816 > 68.118]. Examining the interaction effect of gender and location, significant differences in MA scores exist between males and females across all locations except for Egypt, Malaysia, and Nigeria (Enugu State). Conversely, females reported significantly higher MA scores than males in the rest of the locations, except Iran (Tehran and Qom) and Pakistan (Faisalabad). Gender-based ranking of the top-three locations with high MA scores indicates that females, starting from Malaysia, Thailand (Bangkok), and Nigeria (Enugu State) ranked the highest. Similarly, males beginning from Malaysia, Nigeria (Enugu State), and Thailand (Bangkok) ranked the top-three in MA. The implications are that mathematics teachers need to adopt different culturally-appropriate and gender-focused interventions to support students with MA challenges. Though interpreting the results from this survey need to de done with caution due to the smaller community and national online samples, the role of cross-cultural gender differences in MA cannot be overlooked.

Keywords: cross-cultural study, gender differences, mathematics anxiety, mathematics, univariate analysis of variance.

1. Introduction

Learning and achievements in mathematics are affected by several factors. Occasionally, persons with specific mathematical learning disabilities may see the use of numbers and mathematics operations as cognitively demanding (Dowker et al., 2016). However, emotional factors like mathematics anxiety (MA) are also known to negatively affect learning and performance in mathematics (Ahmed et al., 2012; García-Santillán et al., 2016). Specifically, MA is known for causing serious mathematical impairment in students as early as primary school levels (Sorvo et al., 2017).

MA is an essential psychological phenomenon to researchers, educators, and psychologists since mathematics provide a universal language to define concrete and abstract events (Alvarado-Mateo, 2007; García-Santillán et al., 2016; Wang et al., 2020). Dreger and Aiken (1957) first introduced the concept of MA as "number anxiety". It can be described as a feeling of pressure and fear that impede the use of numbers and mathematical operations in both academic and in real-life situations (Alam, Halder, 2018; Richardson, Suinn, 1972). Furthermore, studies have attributed MA to many causal factors such as poor test result, age, negative classroom experience, lack of eagerness to complete a difficult assignment, negative attitude towards mathematics learning, and gender (Alam, Halder, 2018; Dowker et al., 2016; Mollah, 2017).

Unlike the considerations given to the subject of mathematics instruction and students' achievements in research circles, MA has often received less attention over the years (Foley et al., 2017). From the revolutionary work of Fennema and Sherman (1976) to design a 108-factor scale to assess the student's MA, the subject of MA is gradually gaining relevance in research and practice (Glencross, Cheriam, 1992; Stoet et al., 2016; Tapia, Marsh, 2004). The acceptance of MA in research is steadily growing primarily because of the negative impact of MA on an individual's initial and future learning, achievements, and use of mathematics (Dowker et al., 2016; Soumen, Susanta, 2018). However, the role of gender within and among cultures remains less explored using large-scale data (Morsanyi et al., 2016)

Over the years, most of the MA studies were usually conducted using samples from a single western country (Morsanyi et al., 2016). Besides, most of these studies could not account for the

prevalence of cross-cultural MA gender differences because of the methodological limitation of excluding samples from Africa (Abraham et al., 2017; Abraham et al., 2017; García-Santillán et al., 2016; Soumen, Susanta, 2018). Additionally, there have been reports of conflicting gender differences in MA among most researchers (Dowker et al., 2016). While some researchers (Abraham et al., 2017; Pourmoslemi et al., 2013) observed gender-based differences in MA, others (Soumen, Susanta, 2018; Zakaria et al., 2012) reported no such differences. Besides, the need to examine the cross-cultural gender effect on MA in this current study is necessary since the use of numbers and mathematical operations go beyond mere "test anxiety" (Richardson, Woolfolk, 1980: 271) to include daily-life activities like payment for goods and services (García-Santillán et al., 2016).

The purpose of this study is to identify the role gender plays in determining MA among students in 12 countries. We also calculated the gender and location pairwise comparisons of MA.

2. Method

All participants were purposively sampled using a combination of face-to-face, paper/pencil test, and an online survey. The MA dataset comprised a total of 4,342 students (males= 1,738, females= 2,602) from 12 countries and 18 locations, with an overall mean age of 19.75 (SD = 2.12) and an overall mean MA score of 71.83 (SD = 21.62). A detailed description of research sites and their respective Mean ages (SD) are reported in Table 1.

Table 1. Sample descriptions of data from the mathematics anxiety survey

Country	Region collected	Gender (n)		Mean age (SD)
		Male	Female	
Egypt	Online	84	417	20.45 (3.05)
Ghana	Cape Coast	93	137	19.63 (2.02)
	Koforidua	95	72	19.67 (2.33)
India	Puducherry	47	203	20.39 (1.70)
	Uttar Pradesh	76	131	19.41 (2.47)
Iran	Qom	75	80	19.09 (2.27)
	Tehran	79	71	19.04 (2.31)
Malaysia	Online	279	231	19.97 (2.15)
Mexico	Veracruz	132	69	20.22 (2.23)
Nigeria	Enugu State	53	64	17.03 (1.04)
Pakistan	Faisalabad	40	116	20.60 (1.42)
	Lahore	148	183	20.00 (1.88)
	Rawalpindi	83	121	20.03 (1.40)
	Sargodha	168	226	19.77 (1.54)
Romania	Online	83	111	19.53 (2.12)
Thailand	Bangkok	82	73	20.63 (1.77)
Ukraine	Sumy	32	69	19.14 (2.17)
United Arab Emirates	Online	89	228	19.94 (1.70)
Total	18	1,738	2,602	19.75 (2.12)

Instrument

All participants were requested to complete the ATMS (Muñoz, Mato, 2007) as a written paper and pencil test or an online test. This scale has 24-items clustered into five subscales: anxiety towards the evaluation of mathematics, anxiety towards temporality, anxiety towards the understanding of mathematical problems, anxiety towards numbers and mathematical operations, and anxiety towards mathematical situations in daily life. This scale has been reported by studies like García-Santillán et al. (2018) to have a higher Cronbach's alpha coefficient of 0.97. Similarly, our data indicated a higher Cronbach's alpha coefficient of above 0.90 for all the sites.

Procedure

Ethical clearance for the project was acquired from the Institutional Review Board of the International Network Center for Applied Research (INCFAR-IRB/009/01-2020). However, collaborators who needed additional local or institutional ethics approval were allowed to apply for them. Also, collaborators were allowed to translate the study protocol and instrument (where necessary into their national/native language). Each collaborating location was to collect a minimum of 150 community-based participants (relaxed in two cases: Ukraine [Sumy] and Nigeria [Enugu State] from their respective communities (relaxed in four cases: Romania, Malaysia, Egypt, and United Arab Emirates where online data was collected).

Data Analysis

The data for male and female students and their respective locations were compared on their respective perceived MA scores. Both descriptive statistics (mean, standard deviations, reliability estimates, inter-item associations, Levene's Test of Equality of Error Variances, normality of data distribution test, and Pearson's correlations) and univariate analysis of variance were conducted after data cleaning was completed. This process enabled us to examine the gender differences in MA scores across individual sites.

Additionally, we set the likelihood of type I error (alpha) at .05 and calculated the effect size estimates for respective comparisons (Cohen, 1987). To measure the gender differences in MA across individual sites, Type III Sum of Squares was preferable as it is the most secured approach to analyse data with unequal sample sizes. Further, the global MA score which was derived from the addition of all the 24-items were computed to observe the differences between genders across locations. Also, pairwise comparisons for both gender and location were calculated using the Bonferroni test with their mean differences significant at the .05 level.

3. Results

Generally, the analysis shows that females significantly have higher MA scores across all the locations when compared with males (see Figure 1 for the mean plot). Pairwise comparisons using the Bonferroni test are based on estimated marginal means of gender alone. These comparisons indicate that females were seen to have a high MA mean score than males, [71.816 > 68.118].

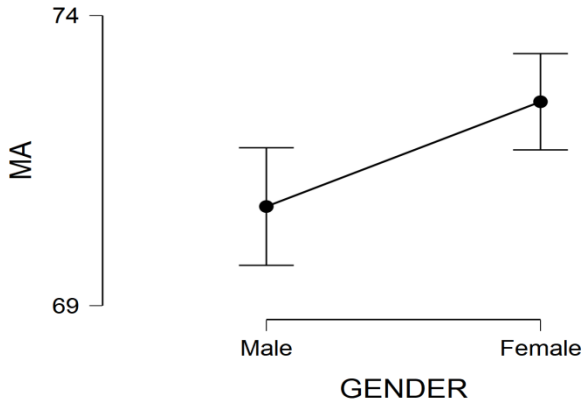

Fig. 1. Gender differences in mathematics anxiety

Furthermore, the results show that gender and location of data collection had significant main effects on perceived MA score. From Table 2, gender had a main significant effect on students' perceived MA score [F (1, 4,339) = 28.357, ρ = .000]. Concerning the interaction effect of gender and location on MA, females reported significantly higher MA scores than males in the rest of the locations, except Iran (Tehran and Qom) and Pakistan (Faisalabad). Nonetheless, there were no significant differences in MA scores between males and females in Egypt, Malaysia, and Nigeria (Enugu).

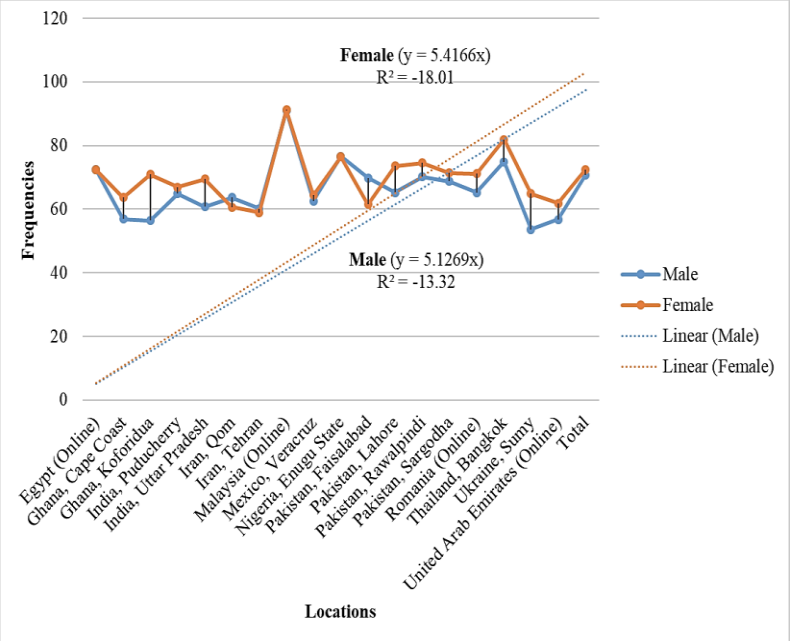

Fig. 2. Mean gender differences in mathematics anxiety across locations

Specifically, females from Malaysia (online), Thailand (Bangkok), and Nigeria (Enugu State) are the top three regions with the highest MA scores. Nonetheless, males from Malaysia (online), Nigeria (Enugu State), and Thailand (Bangkok) also ranked among the top three regions with the highest MA scores (see Figure 2).

Table 2. Univariate effects of location and gender on mathematics anxiety

Country	Region collected	N = 4,340		
		Male Mean (SD)	Female Mean (SD)	Mean (SD) of MA
Egypt	Online	72.33 (22.76)	72.42 (23.58)	72.40 (23.43) ^{ns}
Ghana	Cape Coast	56.87 (20.69)	63.70 (20.25)	60.94 (20.66) *
	Koforidua	56.41 (21.46)	70.93 (20.35)	62.67 (22.14) **
India	Puducherry	64.85 (20.80)	66.99 (18.29)	66.59 (18.77) *
	Uttar Pradesh	60.82 (20.99)	69.53 (23.84)	66.33 (23.17) *
Iran	Qom	63.73 (19.15)	60.69 (20.38)	62.16 (19.79) *
	Tehran	60.20 (16.91)	58.94 (18.89)	59.67 (17.82) *
Malaysia	Online	91.01 (6.31)	91.22 (6.78)	91.11 (6.52) ^{ns}
Mexico	Veracruz	62.63 (20.41)	64.42 (18.69)	63.24 (19.81) *
Nigeria	Enugu State	76.55 (12.35)	76.43 (12.41)	76.48 (12.33) ^{ns}
Pakistan	Faisalabad	69.85 (17.39)	61.56 (16.84)	63.67 (17.31) *
	Lahore	65.29 (22.38)	73.54 (21.20)	69.85 (22.09) *
	Rawalpindi	70.23 (19.19)	74.50 (19.51)	72.76 (19.45) *
	Sargodha	68.76 (20.45)	71.38 (21.10)	70.26 (20.84) *
Romania	Online	65.29 (17.69)	71.12 (17.01)	68.62 (17.50) *
Thailand	Bangkok	74.89 (17.38)	81.90 (16.04)	78.19 (17.07) **
Ukraine	Sumy	53.63 (16.42)	64.86 (18.63)	61.30 (18.63) *
United Arab Emirates	Online	56.81 (17.10)	61.91 (20.50)	60.47 (19.71) *
Total		70.75 (21.56)	72.55 (21.63)	71.83 (21.62) *

	df	*F*	η^2_p
Gender	1	28.834***	.007
Location	17	49.971***	.165
Gender * Location	17	3.391***	.013
Total	4,339		

Notes: ****p<.001, **p<.01, *p<.05*

Additionally, location of data collection had a main significant effect on students' perceived MA score [F (17, 4,339) = 28.357, ρ = .000]. Specifically, linearly independent pairwise comparisons among the estimated marginal means using the Bonferroni test show that there were several significant differences among the regions. For example, Malaysia (Online) had a significantly higher MA mean score than all the regions while the rest of the regions indicated varied differences against the other locations (see Table 3 for respective means).

Table 3. Ranked Means and Mean Differences in Locations' Mathematics Anxiety

Location	Mean	Mean Difference																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Malaysia (Online)	90.95	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2. Thailand, Bangkok	81.64	9.4*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3. Nigeria, Enugu State	79.49	11.5*	2.2^{ns}	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4. Pakistan, Rawalpindi	75.38	15.6*	6.3^{ns}	4.1^{ns}	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5. Pakistan, Sargodha	73.05	17.8*	8.6*	6.4^{ns}	2.3^{ns}	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6. Egypt (Online)	72.38	18.6*	9.3*	7.1^{ns}	3.0^{ns}	.7^{ns}	-	-	-	-	-	-	-	-	-	-	-	-	-
7. Pakistan, Lahore	72.12	18.8*	9.5*	7.3^{ns}	3.2^{ns}	.9^{ns}	.3^{ns}	-	-	-	-	-	-	-	-	-	-	-	-
8. Romania (Online)	70.74	20.2*	10.9*	8.8*	4.6^{ns}	2.3^{ns}	1.7^{ns}	1.4^{ns}	-	-	-	-	-	-	-	-	-	-	-
9. India, Puducherry	68.41	22.4*	13.2*	11.1*	7.0^{ns}	4.6^{ns}	4.0^{ns}	3.7^{ns}	2.3^{ns}	-	-	-	-	-	-	-	-	-	-
10. Pakistan, Faisalabad	68.28	22.7*	13.4*	11.2*	7.1^{ns}	4.8^{ns}	4.1^{ns}	3.8^{ns}	2.5^{ns}	.1^{ns}	-	-	-	-	-	-	-	-	-
11. India, Uttar Pradesh	67.43	23.5*	14.2*	12.1*	8.0*	5.7^{ns}	5.0^{ns}	4.7^{ns}	3.3^{ns}	1.0^{ns}	.9^{ns}	-	-	-	-	-	-	-	-
12. Ghana, Koforidua	65.52	25.4*	16.1*	14.0*	9.9*	7.5*	6.9^{ns}	6.6^{ns}	5.2^{ns}	2.9^{ns}	2.8^{ns}	5.1^{ns}	-	-	-	-	-	-	-
13. Mexico, Veracruz	65.32	25.6*	16.3*	14.2*	10.1*	7.7*	7.1*	6.8*	5.4^{ns}	3.1^{ns}	3.0^{ns}	2.1^{ns}	.2^{ns}	-	-	-	-	-	-
14. Iran, Qom	64.37	26.6*	17.2*	15.1*	11.0*	8.7*	8.0*	7.8*	6.4^{ns}	4.0^{ns}	3.9^{ns}	3.1^{ns}	1.2^{ns}	1.0^{ns}	-	-	-	-	-
15. Ghana, Cape Coast	62.35	28.6*	19.3*	17.1*	13.0*	10.7*	10.0*	9.8*	8.4*	6.1^{ns}	5.9^{ns}	5.1^{ns}	3.2^{ns}	3.0^{ns}	2.0^{ns}	-	-	-	-
16. Iran, Tehran	61.55	29.4*	20.1*	18.0*	13.8*	11.5*	10.8*	10.6*	9.2*	6.9^{ns}	6.7^{ns}	5.8^{ns}	4.0^{ns}	3.8^{ns}	2.8^{ns}	.8^{ns}	-	-	-
17. Ukraine, Sumy	61.07	29.8*	20.5*	18.4*	14.3*	12.0*	11.3*	11.1*	9.7*	7.3^{ns}	7.2^{ns}	6.4^{ns}	4.5^{ns}	4.3^{ns}	3.3^{ns}	1.3^{ns}	.5^{ns}	-	-
18. United Arab Emirates (Online)	59.36	31.5*	22.3*	20.1*	16.0*	13.7*	13.0*	12.8*	11.4*	9.0*	8.9*	8.1*	6.2^{ns}	6.0^{ns}	5.0^{ns}	3.0^{ns}	2.2^{ns}	1.7^{ns}	-

Notes:
**. The mean difference is significant at the .05 level.*
ns = not significant.
Adjustment for multiple comparisons: Bonferroni.

4. Discussion

The study explored the role of gender in determining MA across locations in 12 countries (Malaysia, Thailand, Nigeria, Pakistan, Egypt, Romania, India, Ghana, Mexico, Iran, Ukraine, and United Arab Emirates), and 18 locations or sites (see Tables 1, 2). Further, we calculated the pairwise comparisons in MA scores for both gender and location.

Our findings indicated that gender differences play a significant role in determining MA across different locations or cultures (Dowker et al., 2016; Sokolowski et al., 2019). Though the results painted different pictures of the effects of gender on MA, females were seen to have an overall higher MA score than males. This is a common perception that has been shared by several studies over the years. For example, studies conducted in the Southeast Anatolia Region of Turkey (Erdem, 2017) and Hamedan, Iran (Pourmoslemi et al., 2013) found females to rate themselves higher in MA than males. This increase in anxiety among females may be because mathematics and other related-subjects are culturally perceived to be fields for the male-gender instead of females (Dowker et al., 2016).

However, the results pointed out that male participants in three locations (Iran [Qom and Tehran], Pakistan [Faisalabad]) reported higher MA than their female counterparts. This finding is also supported by a study by Abraham et al. (2017) with samples from southern, central, and northern parts of Kerala, India. Another explanation for the recent positive perception of Iranian females towards

mathematics and a possible lower MA scores than their male counterparts as compared to some past studies in Iran (Keshavarzi, Ahmadi, 2013; Pourmoslemi et al., 2013) might be derived from a proposition by Castelvecchi (2020). According to Castelvecchi (2020), Iranian girls have been motivated to take up mathematics as a result of the success of the late Maryam Mirzakhani (the first woman to win the Fields Medal; the highest global mathematics prize in 2014). Thus, such a role model could be very positive in lowering national mathematics-related anxiety among females.

Furthermore, the study's findings showed that there are no significant differences between males and females in Egypt, Malaysia, and Nigeria (Enugu State). Likewise, analogous findings were observed in studies conducted in Selangor, Malaysia (Zakaria et al., 2012), Purulia district, India (Soumen, Susanta, 2018), Ciamis District, Indonesia (Amam et al., 2019), and Shiraz, Iran (Keshavarzi, Ahmadi, 2013). However, these nations (Malaysia and Nigeria [Enugu State]) recorded overall high scores in MA, which need to be explored further to understand the factors affecting such results.

5. Limitations

This survey is among the few recent studies of MA with participants from 12 countries. Nonetheless, the findings from our study cannot be generalised for the entire national populations of these countries owing to the nature of the small exploratory community samples collected across the various locations. Additionally, samples that were collected via online surveys (Romania, Malaysia, Egypt, and United Arab Emirates) are limited to individuals with access to internet services and may not be representative of all students in these countries. Though our results should be interpreted with caution, they provide a broader picture of the effect of gender on MA scores across several countries.

6. Conclusion

The study suggests that the effects of gender on MA is a cross-cultural phenomenon. Moreover, ATMS (Muñoz, Mato, 2007) is a reliable and valid scale for measuring and screening MA among students across different countries and locations. Based on our findings, we suggest that mathematics teachers need to adapt to different gender-focused teaching and learning interventions according to their prevailing psychosocial environment. These interventions would assist students to work with mathematics better. Moreover, particular attention is needed to explore further the MA perceptions in Malaysia, Thailand (Bangkok), and Nigeria (Enugu) since they ranked among the locations with highest MA scores.

7. Acknowledgments

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