Undergraduates' Statistics Anxiety and Mathematics Anxiety: Are They Similar or Different Constructs?

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Abstract
Statistics anxiety and mathematics anxiety are widely researched constructs (Cruise, Cash, & Bolton, 1985; Fennema & Sherman, 1976; Pan & Tang, 2005; Richardson & Suinn, 1972). Few researchers have discussed both of them simultaneously; further, they have argued that these are distinct variables (Baloğlu, 2004; Zeidner, 1991). Most students and educators, however, perceive the phenomena of mathematics anxiety and statistics anxiety as the same. This paper includes a brief literature review on reasons for this misconception followed by a comparison of the constructs of mathematics anxiety and statistics anxiety with respect to undergraduates' gender, college year, STEM and non-STEM fields of study, and mathematics background. This will add support to the fact that these are two distinct constructs and therefore must be dealt with in different ways.

Key Words: Mathematics anxiety, statistics anxiety, regression analysis, STEM and non-STEM majors, survey research

1. Statistics Anxiety

Some commonly accepted conceptions of *statistics anxiety* are “the feelings of anxiety encountered when taking a statistics course or doing statistical analyses; that is, gathering, processing, and interpret[ing]” (Cruise, Cash, & Bolton, 1985, p. 92). Onwuegbuzie, DaRos, and Ryan (1997) defined it as the anxiety that occurs as a result of encountering statistics in any form and at any time.

2. Mathematics Anxiety

Mathematics anxiety has been defined in myriad ways. A commonly accepted definition of the construct is “the feelings of anxiety, dread, nervousness, and associated bodily symptoms related to doing mathematics” (Fennema & Sherman, 1976, p. 324). Richardson and Suinn (1972) defined it as the apprehension and tension concerning manipulation of numbers and completion of mathematical problems in various contexts.

3. Literature Review

Even though both constructs have been defined similarly, giving an impression that they are more or less the same, many researchers and educators believe and have argued otherwise (Baloğlu, 2004; Cruise et al., 1985; Zeidner, 1991). The reasons provided in the literature for this misconception are based on the fact that both the constructs: (1) have physiological, cognitive, psychological, emotional, and behavioral impacts on individuals (Baloğlu, 2004; Dew, Galassi, & Galassi, 1984; Onwuegbuzie et al., 1997; Tobias & Weissbrod, 1980; Zeidner, 1991); (2) are classified as situation-specific, content oriented, state anxieties (Cruise et al., 1985; Dew et al., 1984; Richardson & Suinn, 1972; Onwuegbuzie & Seaman, 1995; Zeidner, 1991); and (3) are multi-dimensional and the dimensions show some resemblance (Baloğlu, 2004; Cruise et al., 1985; Onwuegbuzie et al., 1997; Zeidner, 1991). Furthermore, statistics courses offered within mathematics departments contributes mainly for perceiving mathematics anxiety and statistics anxiety as the same (Baloğlu, 2004). This often leads to undergraduate students being baffled as to whether certain statistics courses will suffice their mathematics course requirement. A student posed a question on an online forum asking, “does anyone know if stats is a math course???” The responses provided were conflicting. One student replied, “stats are math-i took about 36 hours in the stats department, not math and they were all counted as math.” Another student responded to this question by saying, “my stats class was counted as a math course because it was taught directly by the math department.”

These misconceptions mostly occur among those students who do not further their education beyond high school and those educators who did not have to take graduate level mathematics and statistics courses. To them, both the constructs deal with numbers and are therefore similar. Demaria-Mitton (1987), for example, concluded the two constructs to be identical based on the fact that statistics, like mathematics, is a number and involves a symbol system that requires thinking at an abstract level. These students and educators are certainly unfamiliar with the content of higher level courses and remain unaware of the real-world application of these two disciplines. For example, at the undergraduate level, mathematics courses, such as, Calculus and Abstract Algebra are very distinct content-wise as compared to statistics courses like Introductory Statistical Analysis and Probability & Statistics. At the master’s level, applied mathematics required courses include: Real Analysis, Functional Analysis, Algebra, Differential Equations, Discrete Math, etc., whereas a typical applied statistics core is comprised of: Theory of Statistics, Regression Analysis, Statistical Methods, Linear Models, and Experimental Designs, etc. There might be some mathematics prerequisites, such as, multivariate calculus and linear algebra for statistics courses; however, all of the mathematics courses listed above have no statistics involved. In support of this statement, a quote from the blog of a civil statistician is included. He says that,

> “I’ll admit it: before grad school I wasn’t fully clear on the distinction between statistics and applied mathematics. In fact — gasp! — I may have thought statistics was a branch of mathematics, rather than its own discipline. Of course the two fields overlap considerably; but clearly a degree in one area will not emphasize exactly the same concepts as a degree in the other” (Wieczorek, 2013, para. 1)

Some of the major differences between statistics anxiety and mathematics anxiety found in the literature are based on the fact that: (1) cognitive processes involved with statistics anxiety may be different from cognitive processes involved with mathematics anxiety due to the differences in cognitive processes involved in the mathematics and statistics course work (Baloğlu, 2004); (2) statistics involves different mental procedures and requires more than simply manipulating mathematical symbols (Cruise et al, 1985); (3) even though statistics employs basic mathematical concepts, it is more closely related to verbal reasoning than mathematical reasoning (Buck, 1987); and (4) to solve statistical problems, one uses more logical skills than mathematical skills (Zerbolio, 1999). Based on these reasons, a comparison and contrast of statistics and mathematics anxiety of undergraduates is provided to add support to the fact that they are different.

4. The Study Comparing Statistics Anxiety and Mathematics Anxiety

4.1 Overview

In the spring of 2013, a non-experimental survey research study was conducted to investigate the differences in mathematics anxiety levels and statistics anxiety levels of undergraduates. The investigation was based on their gender, college year, major field of study, and mathematics background. Participants were students in either a college algebra course or an introductory statistics course at the time of this study. The sample consisted of 309 undergraduates who voluntarily agreed to participate in this study and completed a survey. A modified version of Mathematics Attitudes Scale (Fennema & Sherman, 1976) was used to measure participants' statistics anxiety and mathematics anxiety. The modified instrument used in this study has been used by other researchers (Gundy et al., 2006; Malik & Traxler, 2012) and found to be highly consistent ($0.93 < \alpha < 0.95$). In this manuscript, the modified instruments are referred to as students' mathematics anxiety scale (SMAS) and students' statistics anxiety scale (SSAS).

4.2 Instrumentation

The reliability analysis was conducted using IBM SPSS Statistics 21 to assess the internal consistency of the items of the SMAS and SSAS. The reliability of the 12 items of SMAS and SSAS, using Cronbach's alpha, was quite high with $\alpha = 0.95$ and $\alpha = 0.94$, respectively. Both the reliability coefficients have been found to have values higher than the criterion value of > 0.8 (Gall, Gall, & Borg, 2007) adding further support to its reliability.

4.3 Anxiety and Gender

4.3.1 Statistics anxiety and gender

Results indicated no statistically significant difference in statistics anxiety, $t\,(196) = -0.92$, $p = 0.36$, between males (N = 74, M = 28.81, SD = 8.33), and females (N = 124, M = 29.83, SD = 7.05).

4.3.2 Mathematics anxiety and gender

Results indicated a statistically significant difference in mathematics anxiety, $t\,(109) = -2.09$, $p = 0.04$, between females (N = 59, M = 32.5, SD = 7.84), and males (N = 52, M = 29.5, SD = 7.09). See Table 1

Gender	n	M	SD	t	df	p
Females	59	32.5	7.84			
				-2.09*	109	0.04
Males	52	2.95	7.09			

'*' denotes significance at the 0.05 level

Table 1: Comparison of mathematics anxiety of undergraduate males and females

The mean mathematics anxiety scores for females were higher than those of males, which indicate that females were more anxious toward mathematics than their male counterparts.

4.4 Anxiety and College Year

4.4.1 Statistics anxiety and college year

Results indicated no statistically significant difference in statistics anxiety, t (196) = -1.35, p = 0.18, between freshmen's (N = 96, M = 28.7, SD = 7.27), and other students' (N = 102, M = 30.15, SD = 7.77).

4.4.2 Mathematics anxiety and college year

Results indicated no statistically significant difference in mathematics anxiety, t (109) = -0.30, p = 0.76, between freshmen's (N = 62, M = 30.9, SD = 7.45), and other students' (N = 49, M = 31.33, SD = 7.9).

4.5 Anxiety and Major Field of Study

4.5.1 Statistics anxiety and major field of study

Results indicated a statistically significant difference in statistics anxiety, F (2, 195) = 12.14, p < 0.05, between STEM majors (N = 117, M = 27.44, SD = 6.84), NON-STEM majors (N = 79, M = 32.18, SD = 7.6), and students with undeclared majors (N = 2, M = 39.00, SD = 7.07) students. See Table 2

Major	n	M	SD	F	Df	p
STEM	117	27.4	6.84			
Non-STEM	79	32.2	7.60	12.14*	2, 195	< 0.05
Undeclared	2	39.0	7.07			

'*' denotes significance at the 0.05 level

Table 2: Comparison of statistics anxiety of STEM and non-STEM majors

The mean scores in statistics for non-STEM majors were higher than they were for STEM majors indicating that non-STEM majors were more anxious toward statistics than STEM majors.

4.5.2 Mathematics anxiety and major field of study

Results indicated no statistically significant difference in mathematics anxiety, F (2, 108) = 1.71, p = 0.19, between STEM majors (N = 36, M = 31.3, SD = 7.9), non-STEM majors (N = 70, M = 30.6, SD = 7.45), and students with undeclared majors (N = 5, M = 37.00, SD = 6.82) students.

4.6 Anxiety and Mathematics Background

4.6.1 Statistics anxiety and mathematics background

The regression model was statistically significant, F (1, 196) = 22.85, $p < .0001$, indicating that undergraduates' mathematics background is a significant predictor of their statistics anxiety,

Y = statistics anxiety = 35.812 – 1.898 X, where X = mathematics background. According to this model, undergraduates' statistics anxiety levels reduce by 1.9 units with one additional course from the list of the following eight courses: Algebra 1, Algebra II, Pre-calculus, Trigonometry, Probability & Statistics, Calculus, AP Probability & Statistics, AP Calculus.

4.6.2 Mathematics anxiety and mathematics background

The regression model was statistically significant, F (1, 109) = 18.15, $p < .0001$, indicating that undergraduates' mathematics background is a significant predictor of their mathematics anxiety,

Y = mathematics anxiety = 37.404 – 1.955 X, where X = mathematics background. This model indicates that undergraduates' mathematics anxiety levels reduce by 2.0 units with one additional course from the list of eight courses: Algebra 1, Algebra II, Pre-calculus, Trigonometry, Probability & Statistics, Calculus, AP Probability & Statistics, AP Calculus.

4.7 Discussion

Although there were no significant differences between statistics anxiety with respect to undergraduates' gender and college year, the study reveals that STEM majors and non-STEM majors differed significantly in terms of their statistics anxiety. On the other hand, no significant difference was found between mathematics anxiety and major field of study or mathematics anxiety and college year; mathematics background and mathematics anxiety as well gender and mathematics anxiety were highly significant.

Findings of this study suggest that a mathematics background is an important component in predicting academic performance in statistics and mathematics courses. High school students may see a reduction in anxiety if required to take as many or all of the courses from the list of eight courses: Algebra 1, Algebra II, Pre-calculus, Trigonometry, Probability & Statistics, Calculus, AP Probability & Statistics, AP Calculus. This will improve students' performance in mathematics and statistics courses at the high school level. This will result in students being more confident about and less anxious toward mathematics and statistics.

The limitation of this study is that I used a modified version of mathematics anxiety instrument to measure statistics anxiety as well. Thus, the underlying construct in this study was mathematics anxiety. A better investigation of the nature of statistics anxiety may be achieved by using assessment instruments specially developed to measure statistics anxiety. This study has implications for research as well as for teaching. The findings of this research show that students' high school curriculum should have as many mathematics and statistics courses as possible to provide a good foundation for university-level courses. Furthermore, universities should consider offering different statistics coursework to non-STEM majors from STEM majors according to their pace of learning and mathematics background. A similar study involving elementary and middle school students should be conducted for deeper understanding of the similarities and differences between the two constructs. Finally, a qualitative follow-up study would certainly be beneficial in revealing factors related to mathematics anxiety and statistics anxiety.

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