Exploring the Impact of Test Anxiety on Performance and Retention of First Year Engineering Students

Abstract

Underrepresented populations (e.g., women in engineering majors) often report higher levels of test anxiety, which has been related to the use of surface study strategies, procrastination, and poor exam performance. The purpose of this study is to gain a better understanding of the relationship between test anxiety and first semester performance and first year retention among engineering students in two cohorts. Compared to males, females reported higher levels of anxiety and there was a negative correlation between anxiety scores and first semester GPA for both males and females. The relationship between anxiety and retention was mixed based on the anxiety measure used and gender. These results suggest the need to explore psychologically informed interventions to help ameliorate the negative impact of test anxiety on academic performance. Educators in engineering could leverage empirically validated interventions to help improve the mental health, performance, and retention of students who struggle with test anxiety.

Introduction

Academic exams are a major source of stress for university students and test anxiety is associated with lower academic performance at every educational level. Meta-analyses of the effect of test anxiety on academic achievement have converged on a modest, but significant negative correlation around –.21[1,2,3]. Compared to non-anxious individuals, students with high levels of test anxiety tend to rely more on surface-level study strategies and have less complete conceptual representations of course content[4] are more likely to procrastinate[5], take less informative notes from course lectures and readings[6], and struggle to encode information[7] as well as retrieve that information from memory[8].

Despite these findings, it has proven difficult for researchers to establish the directional relationship between test anxiety and poor academic performance given that it resembles a "chicken or the egg" causality debate over which preceded the other. It is plausible that test anxiety leads to poor exam performance due to an inability to retrieve information from memory, often referred to as the cognitive interference perspective. However, it is also plausible that poor exam performance leads the individual to internalize the failure as diagnostic of their low intelligence and even rely on ineffective study strategies before their subsequent exam, which could induce anxiety regarding their poor preparation and low academic ability. This second view is often referred to as the skill deficiency perspective. Importantly, there is empirical evidence to support both views of causality (for a review, see Cassady[9]). Zeidner and Matthews[10] attempted to account for all of the available evidence by conceptualizing test anxiety as a dynamic self-regulatory feedback loop based on the interplay among evaluative situations, motivation, cognition, emotion, and coping strategies. While this contemporary view accounts for the reciprocal nature of the anxiety-performance relationship, more research sensitive to the proposed feedback loop (e.g., a microgenetic study with children in a classroom) is required to empirically support this integrative framework.

Test anxiety is often conceptualized using a two component model[11], namely (1) emotionality, or physiological arousal, and (2) cognitive test anxiety, or worry. Emotionality refers to experiences such as elevated heart rate and galvanic skin response, feelings of panic or nausea, and disruptions to sleep. Cognitive test anxiety is characterized by intrusive thoughts about the consequences of failure, comparing one's self to others, or the inability to focus on relevant cues. While both of these components are important and interact with one another, the cognitive component of test anxiety has consistently been associated with the greatest declines in intellectual performance[12]. This is not surprising given that success on cognitive tasks (e.g., academic exams) relies on the same resource (i.e., working memory) that is most negatively impacted by test anxiety.

Prevalence rates of test anxiety range from 25-40% of students, with higher rates for racial minorities and females[13,14,15]. One proposed explanation for these differences is stereotype threat, whereby negative stereotypes (e.g., women are not good at math) cause stereotyped individuals to experience higher levels of anxiety on tasks within the stigmatized domain (e.g., math) compared to non-stereotyped individuals[16]. This framework may help explain why women and racial minorities are underrepresented in engineering departments. When viewed holistically, test anxiety should have a direct bearing on the performance and retention of engineering majors. Furthermore, test anxiety may serve as a greater hindrance for some students (i.e., women and racial minorities) than others. The intent of the present investigation is to provide descriptive results to better understand the experience of test anxiety within a group of students in a gateway engineering course and to investigate the relationship between anxiety and first year performance and retention of engineering students.

Research questions

The following research questions were investigated in the current study:

1. What are the distributions of test anxiety scores for male and female first year engineering students and do these distributions differ from one another?
2. What is the relationship between test anxiety scores and first semester GPA and are these relationships different for males and females?
3. Is there a significant difference in the test anxiety scores for males and females who remain in engineering, switch majors, or leave college after one year?

Method

Procedure

Data were gathered from student surveys administered to engineering students in the first level of calculus during the eighth week of the Fall 2012 and 2013 semesters. Students were emailed links to the survey and were allotted class time to complete it, but no rewards were given for participating in the study. In 2012, the survey was comprised of multiple measures, including the five item subscale measuring test anxiety from the Motivated Strategies for Learning Questionnaire (MSLQ-TA)[17]. The 2013 survey was also comprised of multiple measures, but the MSLQ-TA was replaced by the 27 item Cognitive Test Anxiety Scale[18]. First year retention status, first semester GPA, and gender were extracted from official student records.

Participants

The participants were all first time, full time engineering students from one large metropolitan research university. Only students who completed all items measuring test anxiety were included in the analysis. In 2012, the analytic sample included 360 students which represented 83% of the cohort. Eighty-two (22%) of the participants were female and 278 (78%) were male. The majority of the students were Caucasian (85%) and no other ethnic group represented more than 5% of the sample. More than 99% of the students were traditional college students directly out of high school. In 2013, the analytic sample included 402 students which represented 80% of the 2013 cohort. Eighty-seven (22%) of the participants were female and 315 (78%) were male and they had similar ethnic representation to the 2012 cohort.

Instruments

The Motivated Strategies for Learning Questionnaire (MSLQ)[19] was developed to assess the (1) motivational orientations and (2) use of different learning strategies among students in a single college-level course. The MSLQ is comprised of 15 subscales, which can be used together or singly, and each item is rated on a seven point Likert scale from one ("not at all true of me") to seven ("very true of me"). The test anxiety subscale (MSLQ-TA) includes five items, with two items measuring emotionality (e.g., "I feel my heart beating fast when I take an exam") and three items measuring cognitive test anxiety (e.g., "When I take a test I think of the consequences of failing"). An overall test anxiety score was computed by averaging the five items, thus higher scores represent greater levels of trait test anxiety. The creators of the MSLQ-TA published a Cronbach's alpha of .80[20], which is consistent with the current sample alpha of .82.

Since prior research has shown that the cognitive component of test anxiety is a better predictor of educational outcomes, in 2013 we selected a new measure called the Cognitive Test Anxiety Scale (CTAS)[21] because it was developed to measure only the cognitive component of test anxiety. Each of the 27 items (e.g., "During tests, I find myself thinking of the consequences of failing"; "During a course examination, I get so nervous that I forget facts I really know") is rated on a four point Likert scale from one ("not at all typical of me") to four ("very typical of me"). An overall cognitive test anxiety score was computed by summing the 27 items, thus higher scores represent greater levels of trait cognitive test anxiety. The creators of the CTAS published a Cronbach's alpha of .91[22], which is consistent with the current sample alpha of .94.

Analysis

Data were analyzed using descriptive and inferential statistics in SPSS Version 21. Before t-tests were run to test for statistically significant differences between means, F-tests were run to test for equal variances. F-test results are only reported when significant differences were revealed.

Results

Figures 1 and 2 show the distribution of scores for males and females on the MSLQ-TA and CTAS. On average, female students rated themselves higher on both instruments (see Table 1: MSLQ-TA $p = .001$; CTAS $p = .006$). Based on responses from over 1,000 participants, Cassady[23] established cut-points based on percentiles to delineate low (scores ranging from 27 to 61), moderate (scores ranging from 62 to 71), and high (scores ranging from 72 to 108) levels of test anxiety. These categories offer a convenient descriptive title that can be viewed as a course-grained analysis rather than indicating dramatic differences between individuals who score 71 (moderate anxiety) and 72 (high anxiety), although higher test anxiety scores are associated with lower academic performance. In the 2013 cohort, 48.3% of the females ($n = 42$) and 32.4% of the males (n = 102) reported scores in the high-anxiety category. This suggests that nearly half of the females were highly anxious whereas only a third of the males fell into this category. Given that the categories were originally established to evenly divide individuals into three groups, the females are overrepresented in the high anxiety category. Furthermore, Table 3 indicates that the only groups with a mean in the high anxiety category are (a) females who switch majors and (b) females who left the university. All other groups had a mean in the moderate anxiety category, which would be expected. This provides additional evidence that test anxiety was particularly problematic for females (i.e., the underrepresented gender). Given that the percent of students who were not retained in engineering in 2013 were similar for males (22%) and females (21%) and that males reported lower levels of test anxiety, females' decision to leave engineering may have been influenced by their higher levels of test anxiety.

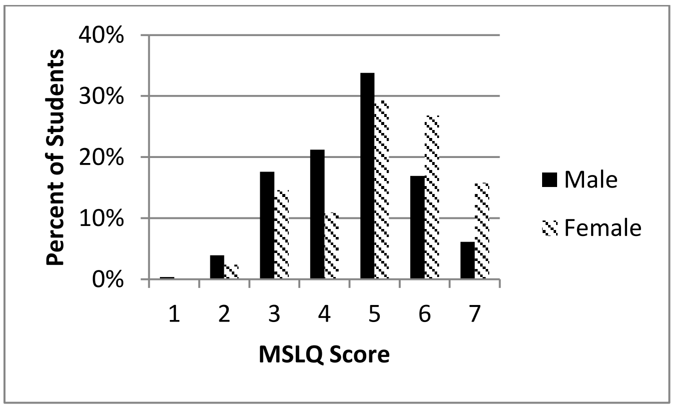

Figure 1. Distribution of MSLQ-TA scores for males and females in the 2012 cohort

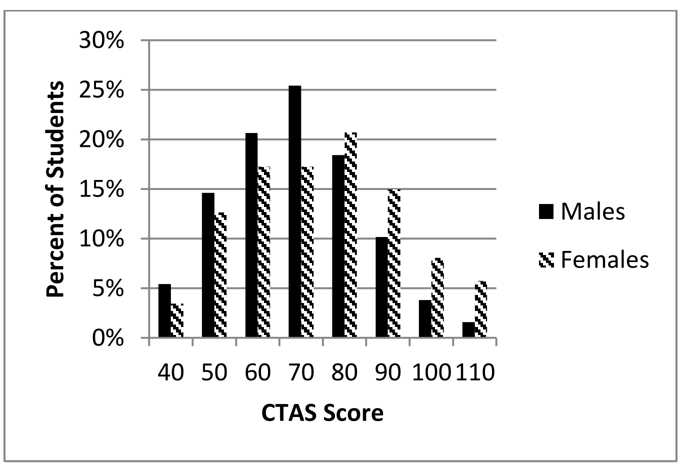

Figure 2. Distribution of CTAS scores for males and females in the 2013 cohort

Table 1. Descriptive Statistics and t-test Results for the MSLQ-TA and CTAS

	M	*SD*	*df*	*t*	*p*
MSLQ-TA					
Males	4.17	1.24	358	-3.343	.001
Females	4.70	1.35			
CTAS*					
Males	64.37	15.40	126	-2.815	.006
Females	70.14	17.30			

*Used *t*-test for unequal variance ($F = 3.855$, $p = .05$)

Table 2 displays statistics for the first semester GPAs for the 2012 and 2013 cohorts. There was a significant negative correlation between first semester GPA for the 2012 cohort and MSLQ-TA scores for males ($r = -.140$, $p = .03$), however the correlation was not significant for the female students ($r = -.091$, $p = .446$). The correlation between CTAS scores and first semester GPAs for the 2013 cohort was significant for both males ($r = -.201$, $p < .001$) and females ($r = -.355$, $p = .001$).

Table 2. First Semester GPA Summary Statistics

	n	Min	Max	*M*	*SD*
2012					
Overall	360	0	4.00	2.90	.83
Females	82	.39	4.00	2.96	.75
Males	278	0	4.00	2.88	.85
2013					
Overall	402	.22	4.00	2.98	.74
Females	87	.99	4.00	3.19	.68
Males	315	.22	4.00	2.92	.73

The results of the t-test comparing the MSLQ-TA scores of the students who remained in engineering versus those who switched majors or left the university are detailed in Tables 3. The results indicate that male students who switched out of engineering or left the university did not have a significantly different MSLQ-TA score than the students who remained in engineering. On average, females who switched majors had the highest MSLQ-TA score, which was significantly different from the female students who remained in engineering, but not for the students who left the university. Caution should be exercised when interpreting these results since the samples of females who left the university ($n = 10$) or switched majors ($n = 13$) were small.

Table 4 replicates the previous analysis using data from the CTAS. The difference in CTAS scores for male or female students who remained in engineering as compared to those who switched majors or left the university was not significant. Again, the female sample sizes are small and further study is needed before any conclusions can be made.

Table 3. MSLQ-TA Scores Grouped by Gender and Retention Status

	n	*M*	*SD*	*df*	*t*	*p*	*Hedge's g*
Males							
Switch majors	29	4.14	1.15	239	.027	.978	.01
Left the university	37	4.42	1.34	247	1.303	.194	.23
Retained in engineering*	212	4.13	1.23				
Females							
Switch majors	13	5.35	1.08	70	2.258	.027	.69
Left the university	10	5.28	1.44	67	1.781	.079	.61
Retained in engineering*	59	4.46	1.32				

* Retained in engineering was the comparison group

Table 4. CTAS Scores Grouped by Gender and Retention Status

	n	*M*	*SD*	*df*	*t*	*p*	*Hedge's g*
Males							
Switch majors	39	65.62	17.91	284	.505	.614	.09
Left the university	29	63.55	15.71	274	-.245	.807	.05
Retained in engineering*	247	64.28	14.99				
Females							
Switch majors	12	75.33	11.63	79	1.302	.197	.40
Left the university	6	79.33	20.12	73	1.436	.155	.61
Retained in engineering*	69	68.43	17.65				

* Retained in engineering was the comparison group

Discussion

It has been well documented that test anxiety is associated with poor exam performance and that underrepresented groups experience greater levels of test anxiety. Therefore, academic majors with clear minority groups, as often found in engineering, must consider the impact of test anxiety on the academic performance of these “at risk” students. In the current study, we investigated the relationships between test anxiety, gender, performance, and retention among engineering students. Consistent with previous research[24], the current analyses found that, on average, females reported significantly higher levels of test anxiety. The reliability of these results is bolstered by the fact that multiple measures of test anxiety were employed and were consistent across cohorts. Furthermore, females who switched out of engineering had the highest average level of test anxiety and lowest variability on the MSLQ-TA. As measured by both scales, on average, males with higher levels of test anxiety had lower first semester GPAs. This relationship held for females when using the CTAS scores, but not the MSLQ-TA scores. This inconsistency could have been caused by variability in the samples, a small number of females in the study, or the fact that the MSLQ-TA measures both emotionality and worry instead of solely cognitive test anxiety.

A major strength of this study is that performance and retention were measured in an authentic academic setting, thus avoiding the gap of uncertainty about whether the results will translate from the research lab into a real-world classroom. The pattern of these results should extend to any underrepresented group with a negative stereotype specific to that domain (e.g., women are not good at math). In other words, stereotype threat applies across domains and demographic categories, so it is not limited to science, technology, engineering, and math (STEM) disciplines or a particular race or gender. Additional research is needed to elucidate causal relationships between test anxiety, gender, performance, and retention among engineering students (e.g., if higher levels of test anxiety are an underlying cause for females switching out of engineering).

A few limitations of this study must be acknowledged. First, all measures of test anxiety were self-report and there is a possibility of response bias in the results. Second, due to the small number of female students in both cohorts, there are some concerns with statistical validity in the analyses investigating the differences in test anxiety scores and retention status for female students. Finally, all of the students in this study were from one college of engineering that is less ethnically diverse than the national population of engineering students, so more representative populations could improve the generalizability of the results to other engineering departments.

Overall, this study justified the need to investigate test anxiety among engineering students and suggests the need to explore psychologically informed interventions to help ameliorate the negative impact of test anxiety on academic performance. The literature details several empirically validated interventions that strategically reduce stereotype threat in underrepresented populations (e.g., see the effect of role models and self-affirmations detailed by Shapiro, Williams, & Hambarchyan[25]) as well as minimize the impact of cognitive test anxiety among students (e.g., see the effect of expressive writing detailed by Ramirez & Beilock[26]). Educators in engineering could leverage these interventions to help improve the mental health, performance, and retention of students who struggle with test anxiety.

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