

Math Anxiety in Community College Students

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Introduction

Roughly half of college bound students enroll in two-year community colleges, and of these students, 60% are ill-equipped in mathematics and place into developmental, or pre-college, classes (American Association of Community Colleges, 2014; Silva & White, 2013). Unfortunately, remediation programs are failing these students; less than one-third pass their developmental mathematics courses, and even fewer meet the requirements needed to earn college credentials (Silva & White, 2013). Lower mathematics achievement is often associated with fear or apprehension about mathematics—termed *math anxiety*, (Hembree, 1990; Maloney & Beilock, 2012). However, there is not a large body of experimental research regarding the prevalence of math anxiety in two-year community colleges, and few studies have directly assessed the relation between student math anxiety and course success.

It is important to point out that though math anxiety, a fear or apprehension about mathematics, is often associated with poor mathematics achievement, it is not simply a proxy for suboptimal performance in mathematics (Ashcraft & Krause, 2007; Beilock, 2008; Maloney & Beilock, 2012). In actuality, anxiety about doing mathematics—over and above one's actual mathematics ability—can impede mathematics achievement (Ashcraft & Krause, 2007; Beilock, 2008). When faced with a mathematics task, mathematically anxious individuals tend to worry about the situation and its consequences (Maloney & Beilock, 2012). These worries compromise cognitive resources, such as working memory, a short-term system involved in the regulation and control of information relevant to the task at hand (Ashcraft & Krause, 2007; Maloney, Ansari, & Fugelsang, 2011; Miller & Bichsel, 2004). When

anxiety disrupts the ability of working memory to maintain task focus, mathematics performance often suffers. This points to math anxiety as an important factor to concentrate on to ensure that students succeed in remediating their math skills.

Interestingly, women place into developmental mathematics at a higher rate than men (Bailey, Jeong, & Cho, 2010). If math anxiety relates to suboptimal mathematics achievement and placement into developmental mathematics, then the fact that women require more remediation than men begs the question of whether women have higher levels of math anxiety than their male counterparts. Further, math anxiety may differentially relate to mathematics achievement for female as compared to male students. Of course, there are reasons to think there might not be gender differences in math anxiety. Though some studies have documented gender differences in math anxiety among younger students (Goetz, Bieg, & Hall, 2012; Jain & Dowson, 2009), college-aged students (Betz, 1978; Maloney, Waechter, Risko, & Fugelsang, 2012), and other adults (Miller & Bichsel, 2004), other studies found no gender differences in math anxiety (Ahmed, Minnaert, Kuyper, & van der Werf, 2012; Ashcraft, 2002; Ashcraft & Krause, 2007; Devine, Fawcett, Szucs, & Dowker, 2012; Hembree, 1990; Lopez, Lent, Brown, & Gore, 1997). Importantly, none of the above mentioned studies included populations requiring mathematics remediation. Gender differences in math anxiety within the developmental mathematics college-population have yet to be detected (Fannin-Carroll, 2014).

In the present study, we began by performing—to our knowledge—the first meta-analysis examining the prevalence of math anxiety in two-year community college students requiring math remediation. We predicted math anxiety would be prevalent in community college students because students who struggle early with mathematics often struggle later too (Mazzocco & Devlin, 2008), and math anxiety is associated with poor math performance (Maloney & Beilock, 2012). Additionally, since women tend to place into developmental mathematics at a higher rate than men (Bailey, et al., 2010),

we predicted that math anxiety would be greater for women than men.

Next, focusing on a subsample of community college students (our focal analysis), we examined how math anxiety among men and women related to overall course success. As a preview, the relation between math anxiety and final grade performance was stronger for women than men. In an attempt to understand this difference, we next explored differences in emotional regulation as a function of gender. Emotional regulation includes two strategies, reappraisal and expressive suppression (Arem, 2010; Gross & John, 2003; Jamieson, Nock, & Mendes, 2012). Both strategies alter a student's emotional state: reappraisal through reinterpreting an event to reduce the emotional impact, and suppression through preventing emotional expressions to emerge. In the context of a developmental mathematics course, we explored whether these strategies might be differently related to course success as a function of students' math anxiety and students' gender.

Methods

Participants

All participants were enrolled in American community colleges (Table 1). Community colleges typically grant two-year associates degrees, and not bachelors degrees. We first conducted a meta-analysis on math anxiety scores and gender on four samples. Students from samples 1, 2, and 4 were enrolled in the same urban community college. Sample 3 was obtained from the Community College Pathways program at the Carnegie Foundation for the Advancement of Teaching. Students were enrolled in either a developmental (i.e., remedial) mathematics class or a college level class, with the exception of sample 4 which included only developmental students. In addition, all students consented to participate in accordance with the local colleges and/or with the University

of Chicago's Social and Behavioral Sciences Institutional Review Board.

Samples 1 and 2 were collected in the spring of 2013. For sample 1, data from 107 students were collected during a regular class period (55 min.) among five mathematics classes and two professors. Twelve students did not report their gender, and three students reported their gender as "other." Ages ranged from 18 to 55, $M = 26.6$, $SD = 8.34$, 95% CI [24.8, 28.3]. Race and ethnicity were not collected due to time restrictions. Sample 2's data were surveyed online from 142 students. Eleven participants did not complete the survey, and an additional four participants reported their gender as "other" or did not respond. Ages ranged from 18 to 59, $M = 27.1$, $SD = 9.37$, 95% CI [25.4, 28.8]. Race and ethnicity were diverse: American Indian or Alaskan native (4.2%); Asian or Pacific islander (14.8%); black or African American (18.3%), Hispanic or Latino (16.2%), white or Caucasian (29.6%), prefer not to answer or no data (16.9%).

Sample 3 included 2,454 students from 28 colleges taught by 113 professors during the fall of 2013. There were 328 students who did not report their gender, and 21 students reported their gender as "other." Data were collected in the first week of classes during an online "Productive Persistence" survey. Ages were not reported. Students' reports of race and ethnicity included American Indian or Alaskan native (0.9%); Asian or Pacific islander (6.1%); black or African American (17.6%), Hispanic or Latino (11.1%), white or Caucasian (29.8%), two or more races (7.6%), other race (13.4%), and no data (13.4%).

Sample 4 served as data for our focal analyses, and data were collected in the fall of 2013. Data from 451 students were collected among 20 mathematics classes and 13 professors at one urban community college. Overall, two participants were excluded from analyses for answering, "prefer not to answer" on all questionnaires and inventories. An additional 38 students marked "prefer not to answer" on the mathematics

	Female			Male		
	M	SD	N	M	SD	N
Sample 1	2.60	0.728	55	2.58	0.951	37
Sample 2	2.68	1.040	74	2.47	0.798	53
Sample 3	3.14	0.961	1345	2.76	0.963	757
Sample 4	2.47	0.827	219	2.39	0.936	192

Table 1. Math anxiety across four samples of community college students enrolled in mathematics courses (1 is low anxiety, and 5 is high anxiety).

anxiety survey. Ages ranged from 18 to 66, $M = 25.9$, $SD = 8.8$, 95% CI [25.0, 26.7]. Race and ethnicity were similar to our previous samples: American Indian or Alaskan native (1.6%); Asian or Pacific islander (14.1%); black or African American (14.8%), Hispanic or Latino (8.4%), white or Caucasian (35.5%), two or more races (10.3%), prefer not to answer (9.8%), and no data (5.5%).

Meta-Analysis

We examined self-reports of gender and math anxiety from four previously unreported datasets. To measure math anxiety, participants rated nine items on the Abbreviated Mathematics Anxiety Scale (AMAS; Hopko, Mahadevan, Bare, & Hunt, 2003; Maloney, et al., 2011). Items included both events during mathematics assessments, such as “thinking about an upcoming mathematics test one day before,” and while learning mathematics, such as “watching a teacher work an algebraic equation on the blackboard.” Due to time limitations, Sample 3 answered five of the nine questions with the same ratio of items about mathematics assessments and learning mathematics as the original scale. Items were rated on a 5-point Likert scale: *low, some, moderate, quite a bit, high.*

Focal Analysis on Sample 4

Data were collected at the beginning of the school year. Students were brought to a computer lab with one computer for each student as a part of class time (50 min.). All questionnaires, described later, were reproduced with Inquisit (by Millisecond Software) and were administered over the Internet. All anxiety measures were assessed first. Demographics such as gender, age, and race were surveyed last. In between these surveys, students were asked to make simple number comparisons and take a basic mathematics test. These results are not reported here. In addition, Productive Persistence (Silva and White, 2013), a measure created by the Carnegie Foundation for the Advancement of Teaching, was also assessed at the request of the participating college. Productive Persistence data were not analyzed as a part of this study.

Course success. Final grades served as our measure of course success as it is most relevant measure to reaching requirements for post-secondary credentials (Meece, Wigfield, & Eccles, 1990). Grades were obtained from the college as grade point averages (GPAs). Final grades were given a grade of 0.0 if students' final grade was less than a GPA of 1.0, and in turn rendered the data discrete. We therefore only included data from students who achieved a 1.0 or above in our analyses to keep course success a continuous measure. There were 71 students out of 451 students who had grades of 0. Main analyses were also run using the excluded data by measuring course

success as pass or fail (< 2.0); the data showed a similar pattern of results.

Math anxiety. Participants self-reported their math anxiety on the AMAS as described earlier (Hopko, et al., 2003).

Test & trait anxiety. First, since high levels of test anxiety relate to lower performance on tests (e.g., Cassady, 2004), and the majority of our outcome measure, final course GPA, was based on tests taken throughout the semester, we controlled for test anxiety. Test anxiety was reported using the Test Anxiety Inventory (Spielberger, Gonzalez, Taylor, Algaze, & Anton, 1978) by rating items on a 4-point Likert scale: *almost never, sometimes, often, almost always*. The inventory contained 20 items such as, “I feel tense during tests,” and “During tests, I think of failing.” Second, we controlled for Trait anxiety because more non-traditional students, or older students who have not immediately graduated secondary school, enroll in community colleges (American Association of Community Colleges, 2014), and consequently may have more trait anxiety (Baloglu, Abbasi, & Masten, 2007). Trait anxiety was similarly reported using the State Trait Anxiety Inventory (Spielberger, Gorsuch, & Lushene, 1970), again by rating 20 items on how they generally feel on a 4-point Likert scale: *almost never, sometimes, often, almost always*. Items included “I feel nervous and restless,” and “I worry too much over something that doesn't really matter.”

Emotional regulation. The Emotional Regulation Questionnaire was designed to assess individual differences in the habitual use of two emotional regulation strategies: cognitive reappraisal and expressive suppression. Both strategies are used to decrease emotional expression, reappraisal through reinterpretation and suppression through concealment. An example of reappraisal is “I control my emotions by changing the way I think about the situation I'm in”, and an example of suppression is “I keep my emotions to myself” (Gross & John, 2003). Students rated 10 phrases on 7-point Likert scale (with three anchors: 1 = *strongly disagree*, 4 = *neutral*, 7 = *strongly agree*). One designated low use of the strategy.

Results

Math Anxiety Meta-Analysis

We investigated math anxiety across four samples of college students enrolled in community colleges, providing the first synthesis of math anxiety in two-year community college students enrolled in mathematics classes. Given that there are no known reports of math anxiety in this subsample of higher education learners, we conducted a meta-analysis on previously unreported samples (Table 1; Cumming, 2014). Nearly half of the students (1361/2780) reported having moderate, quite a bit, or high math anxiety (i.e., 3 or higher

	Men		Women	
	LMA	HMA	LMA	HMA
Scale	N = 88	N = 65	N = 92	N = 93
Final Grade	1–4	3.0 (0.8)	3.1 (0.8)	3.3 (0.7)
Math anxiety	1–5	1.7 (0.4)	3.3 (0.6)	1.8 (0.4)
Test Anxiety	1–4	2.0 (0.6)	2.4 (0.7)	2.2 (0.7)
Trait Anxiety	1–4	2.0 (0.5)	2.2 (0.6)	2.0 (0.5)
				2.3 (0.6)

Table 2. Means (standard deviations) for course success and anxiety measures for our focal sample.

N = number of participants (1 indicates a low score, and 4 or 5 indicates a high score).

on the AMAS). Interestingly, women reported 0.196, or 4.9%, more math anxiety than men across our data sets (95% CI [−0.010, 0.402], variance = 0.001). As shown in Table 1, women consistently reported more math anxiety than men.

Anxiety's Contribution to Course Success

If math anxiety is relevant to success in community college mathematics, it follows that this type of anxiety should predict final mathematics grades. Moreover, given the above mentioned observed gender differences in math anxiety, it seemed possible that there would be gender differences in the predictive ability of math anxiety on final course grades. Looking specifically at our fourth sample enrolled in developmental mathematics classes, we measured anxiety levels at the beginning of the school year and end-of-semester grades continuously (see Table 2). We regressed grades onto math anxiety, gender and their interaction between gender and math anxiety,

while accounting for trait and test anxiety, $F(5, 332) = 3.29$, $p = 0.006$, Adj. $R^2 = 0.033$; see Table 3. Not surprisingly, test anxiety did predict final grades such that students with more test anxiety earned lower grades. Also, women earned higher grades than men overall. Critically, final grades for men and women were differentially associated with math anxiety: higher math anxiety was associated with lower final grades for women ($r = -0.230$, $p = 0.002$), but not men ($r = 0.284$, $p = 0.087$); see Figure 1. Importantly, the interaction of gender and math anxiety on final course grades mentioned above was not simply due to female students having more math anxiety than male students, and thus more variability in math anxiety to covary with mathematics achievement. As seen in Table 1, if anything, math anxiety was slightly more variable in male than female students in Sample 4.

Using Reappraisal Strategies Relates to Better Course Success

Why might higher math anxiety relate to lower mathematics grades in women but not men? Differences in reappraising negative mathematics-related emotions may improve class performance. Students who reappraise, reinterpret their math anxiety into manageable emotions (Gross & John, 2003), in turn this decreases the impact of math anxiety like avoiding learning mathematics (Maloney & Beilock, 2012). Actively creating a positive emotional state that improves the ability to learn may ultimately impact final course grades.

Overall, men and women reported generally using reappraisal strategies at the same rate (men: $M = 5.31$, $SD = 1.23$; women: $M = 5.22$, $SD = 1.31$; $t(331) = -1.79$, $p = 0.858$), similar to previous reports (Gross & John, 2003). However, there were differences in reappraisal use as function of gender when math anxiety was also taken into account. To

Independent Variable	B	T	P
Constant		18.7	< 0.001
Math Anxiety	-0.049	-0.86	0.39
Trait Anxiety	0.026	0.41	0.68
Test Anxiety	-0.129	-1.98	0.048
Gender	0.513	3.29	0.001
Gender x Math Anxiety	-0.469	-3.02	0.003

Table 3. Predictors of Math Course Success.

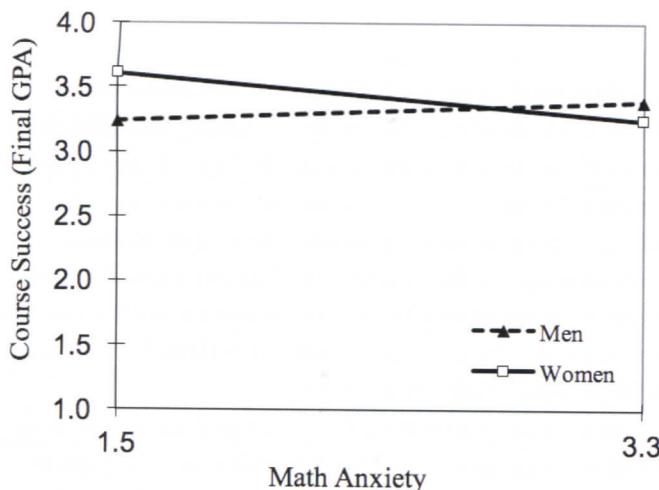


Figure 1. Math anxiety as a function of gender. Math anxiety related to course outcomes in women, not men. Unstandardized betas plotted for math anxiety (AMAS, scale 1–5) ± 1 SD from the mean for men and women. GPA = grade point average.

demonstrate such differences, students were categorized as low math anxious (LMA) if their math anxiety was 1 SD below the mean or as high math anxious (HMA) if their math anxiety was 1 SD above the mean. The number of men and women happened to be equal in each math anxiety group, $\chi^2(1, N=114) = 0.146, p = 0.703$. A two-way between subjects ANOVA was conducted to compare reappraisal reports between LMA and HMA men and women. A significant interaction between gender and math anxiety was found, $F(1, 105) = 8.92, p = 0.004$, Adj. $R^2 = 0.066$. Men tended to reappraise more than women, but only for students high in math anxiety (HMA – men: $M = 5.50, SE = 0.217$; women: $M = 4.89, SE = 0.233$, vs. LMA – men: $M = 5.13, SE = 0.225$; women $M = 5.86, SE = 0.221$). Main effects of gender and math anxiety group were not significant ($p > 0.18$).

If HMA men use reappraisal strategies to help them succeed in a mathematics class, then it follows that reappraisal may relate to overall course success. Confirming our hypothesis, for HMA men, more reappraisal was associated with better final grades ($r = 0.471, p = 0.010$). This relation was not seen in HMA or LMA women, or LMA men ($r = -0.280, p = 0.175; r = -0.337, p = 0.079; r = 0.139, p = 0.490$, respectively). Together these results suggest that, unlike their HMA male counterparts, HMA women may not utilize emotional regulation strategies as frequently or effectively and, as a result, their mathematics grades suffer.

Suppression is an alternative emotional regulation strategy. Men reported ($M = 4.28, SD = 1.45$) greater suppression than women ($M = 3.88, SD = 1.31$); $t(331) = 2.66,$

$p = 0.008$. However, suppression was not related to final grades ($r = -0.035$), and was not analyzed further.

Discussion

Through a meta-analysis across multiple samples, we determined that, first, math anxiety was prevalent among two-year community college students, and second, women reported higher levels of math anxiety than men. In a focal analysis, math anxiety predicted course success only for women. Additional analyses of emotional regulation strategies, specifically reappraisal, indicated that high math anxious men reappraise more than high math anxious women, and reappraisal strategies are associated with better course grades in the former group and not the latter.

Nearly half of two-year community college students in mathematics classes reported having moderate to high math anxiety. These levels of math anxiety are slightly higher on average than reports from university students (Betz, 1978; Hopko, et al., 2003; Maloney, et al., 2011; Miller & Bichsel, 2004), and high school students (Lopez, et al., 1997). Students enrolled in community college mathematics classes reported average math anxiety (on a scale of 1–5) that ranged from 2.39 to 3.14 (Table 1), whereas students enrolled in four-year university reported an average math anxiety (converted to a scale of 1–5) that ranged from 2.2 to 2.34 (Hopko, et al., 2003; Maloney, et al., 2011). Furthermore, for four-year university students, the lower 25% of students (LMA) generally reported about an average of 2.2, or just above “some math anxiety,” and the upper 25% of students (HMA) reported about 3.3, or just above “moderate math anxiety” (Maloney, et al., 2011). Math anxiety then seems to be more prevalent in community college students with nearly 50% of community college students falling into ranges of university students with high math anxiety.

Why might there be more math anxiety in students taking community college mathematics classes? First, the better part of students taking mathematics in community college enroll in developmental math classes (Bailey, et al., 2010; Silva & White, 2013), suggesting they still lack fundamental mathematics skills they struggled to learn previously (Mazzocco & Devlin, 2008). Also, mathematics achievement is negatively associated with math anxiety. Second, students with math anxiety tend to avoid taking classes requiring mathematics knowledge (Hembree, 1990; Maloney & Beilock, 2012). Unlike some university students, avoiding mathematics is not an option for community college students who must complete one college-level mathematics course to earn post-secondary credentials (Bailey, et al., 2010). Third, the majority of community colleges students do not successfully remediate their mathematics skills, and likely repeat developmental

mathematics courses (Bailey, et al., 2010; Silva & White, 2013). Thus, these students may have high levels of math anxiety because they are once again attempting to learn mathematics they failed to master in the past.

Math anxiety affected course success more for women than men; however, few studies show that math anxiety differentially predicts performance as a function of gender (for review, Ashcraft, 2002; Ashcraft & Krause, 2007; Devine, et al., 2012). Two studies that do find differences show mixed results among men and women (Hembree, 1990; Miller & Bichsel, 2004). Hembree (1990), showed math anxiety predicted only men's performance in high school, but gender differences disappeared among university students. However, among a sample that included adults with and without post-secondary credentials, math anxiety predicted performance on more basic calculations problems for men, and on more applied mathematics problems for women (Miller & Bichsel, 2004). Such problems tend to rely on visuo-spatial skills measured via tasks like mental rotation or paper-folding (Miller & Bichsel, 2004). It has been suggested that—on average—women tend to perform more poorly on tests of visuo-spatial ability than men, and that poor visuo-spatial skills may contribute to poor mathematics performance and increased math anxiety. (Maloney, et al., 2012). Course assessments in the current study varied in content across classrooms, but they may have contained a higher ratio of applied problems to basic calculations, possibly increasing the likelihood that women with high math anxiety (and concomitant poor visuo-spatial skills) would perform poorly on them. Of course, future research is needed to explore this possibility.

Overall, these findings highlight the need to explore math anxiety (and means to alleviate it) in developmental mathematics. Several tools such as reappraisal have been shown to reduce anxiety or stress responses (Hembree, 1990; Jamieson, et al., 2012). Given, in the current work, math anxious men reported using reappraisal strategies more so than math anxious women, and the more math anxious men reappraised, the better their final course grades, reappraisal might be a possible intervention tool. Participants who reappraised while under stress have been shown to be more likely to decrease physiological arousal and, in turn, maintain their cognitive abilities (Jamieson, et al., 2012). Further, reappraisal strategies such as changing thoughts like "I feel overwhelmed" into "I can do this one step at a time" have been suggested as tools to reduce math anxiety (Arem, 2010). Boosting students' ability to reappraise their negative reactions towards mathematics may improve mathematics outcomes both while learning and during assessments.

Limitations

Due to the nature of the grading system, we were not able to fully examine students with grades below a GPA of 1.0, that is, students who earned the lowest grades. However, our data showed the same pattern of results for math anxiety and gender differences when including these students and measuring course success as pass or fail. Nevertheless, further work needs to carefully examine students who earn the lowest grades to ensure strategies like reappraisal are as efficacious as with students who earn better grades, especially for men and older students (Bailey, et al., 2010).

In addition, the focal analysis examined students seeking remediation in order to earn college credentials. We cannot conclude how math anxiety and gender differences would manifest in other populations such as struggling high school or university students. However, with 50% of college-bound students enrolling in community colleges (American Association of Community Colleges, 2014), the impact of math anxiety in this population cannot be overlooked.

Finally, we also did not exhaust the list of measures that may relate to course outcomes and math anxiety. For example, math anxiety is correlated with student motivation and self-perception about mathematics (Hembree, 1990; Jain & Dowson, 2009). Positive beliefs about mathematics skills reduce the effect of math anxiety at least in younger students (Ahmed, et al., 2012). Also, by virtue of conducting a meta-analysis there are general limitations to the study such as heterogeneity of the datasets and the lack of uniformity of measurement outcomes. For example, we could not take into account how grades were earned. It would be beneficial for future studies to address how beliefs about mathematics change as new instruction strategies are employed to reduce math anxiety.

Conclusion

For the first time we determined, across multiple samples, that math anxiety was prevalent among students enrolled in two-year community colleges. Further, women consistently reported higher levels of math anxiety than men, and this math anxiety related to lower course success. Finally, for high math anxious men (but not women), reappraisal was associated with increased course success. We suggest that future work on interventions may help advance math achievement in community college students, especially strategies that reduce math anxiety like reappraisal. That is, it is important to not solely focus interventions on efficaciously learning math content, but also improving math attitudes as well. Together this work adds to a body of research that informs educational practices to improve learning success.

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