

The Effects of Math Anxiety on the Performance of Undergraduate Business Majors Using Self-Efficacy as a Mediator

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This research contributes to the body of knowledge regarding mathematics anxiety, self-efficacy, and performance in mathematics. Specifically, this study analyzed these constructs as they pertain to undergraduate business students enrolled in entry-level, prerequisite mathematics courses. Information was collected via surveys utilizing the Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ). Results based on regression modeling were consistent with prior research involving the relationship between mathematics anxiety and performance, with self-efficacy serving as a mediator. Data indicated an inverse relationship between math anxiety and math self-efficacy, an inverse relationship between math anxiety and students' expected grade, differences in math self-efficacy by business major, and partial mediation support for math self-efficacy on the inverse relationship between math anxiety and expected grade. Discussion extends to instructional strategies for mathematics and business educators alike that support self-efficacy and alleviate mathematics anxiety for business students in the infancy of their program.

American college students often deal with math anxiety, which can prevent them from achieving their academic goals (Young et al., 2012). Previous studies have documented that students deal with high levels of anxiety when taking mathematics courses (Betz, 1978; Kazelskis, 1998). Many business students at 4-year universities in the United States are required to take a year of mathematical prerequisite courses as part of the business curriculum. Business colleges across the nation are required to include mathematics prerequisite courses as part of their undergraduate curriculum in order to fulfill the Association to Advance Collegiate Schools of Business (AACSB) accreditation standards. These courses are taken prior to enrollment in major specific business courses with an emphasis in mathematics, such as business statistics, accounting, or economics.

If students report having high levels of anxiety, this anxiety has effects on working memory and performance within their college career (Ashcraft & Kirk, 2001). Previous studies suggest that students can overcome math anxiety with math self-efficacy (Ahmed et al., 2012). Math self-efficacy refers to students' degree of confidence in solving math problems. Because studies have shown that math self-efficacy is related to mathematical achievement, students with high self-efficacy may be more likely to cope with their math anxiety (Lee, 2009; Zeldin et al., 2008).

Therefore, it was the goal of this particular study to examine the math anxiety and mathematics self-efficacy of undergraduate business students within their core mathematics curriculum. Knowledge gained from this population of students can aid in designing a curriculum within core and major level courses within a business major that are mathematics intensive. Information can also inform instructional strategies employed by mathematics and business undergraduate educators that promote the successful completion of mathematics-

heavy courses within a program of study. Understanding the levels of mathematics anxiety and self-efficacy in prerequisite mathematics courses can shed light on factors that may hinder success for a continued study in a business major that involves mathematics content. Information in this study could contribute to the conversation between mathematics and business departments looking to improve success on skills learned in the core level course that translate to the mathematics intensive business courses. Thus, it is the hope that this information will assist achievement in mathematics courses as students' progress through an undergraduate business degree program of study.

Theoretical Framework and Related Research

A diverse mathematical knowledge base is necessary for success in many fields of undergraduate study. Specifically, this statement can extend to subjects such as business where the ability to solve business-based mathematical problems is paramount (Azar & Mahnoudi, 2014). When looking to determine elements that contribute to success in mathematics, there are hosts of influences to consider. One factor that has garnered much attention by researchers for its effects on mathematics learning is mathematics self-efficacy. As such, this study draws on this construct within Bandura's (1986) general social cognitive theory for its theoretical basis. Application of this theory to the current research is grounded on the array of empirical evidence that exists for self-efficacy and the relationship of this construct to mathematics anxiety and performance (Beck & Schmidt, 2015). Self-efficacy can be defined as the belief in one's own ability to perform or accomplish a task or goal for a specified result (Bandura, 1986). As a construct of Bandura's (1986) social cognitive theory, self-efficacy has been known to impact individual

behavior in various ways by influencing courses of action and personal choices (Pajares, 1996). As Pajares (1996) states, not only does self-efficacy effect conduct through choice and action, but the belief in one's own ability can also determine effort, perseverance, and resilience in adverse situations. These authors further posit that the higher the self-efficacy, the greater the persistence, resilience, and effort expended.

With regard to mathematics, self-efficacy was shown to be more predictive of problem solving than mathematics self-concept, gender, or prior mathematics experience (Pajares & Miller, 1994). Research has also concluded that self-efficacy is one of the best predictors of mathematics achievement when considering a host of other factors such as attitude, gender, and other demographics (Pajares & Miller, 1994). In addition, several studies have explored the relationship between self-efficacy and mathematics anxiety in various academic settings (Akin & Kurbangolu, 2011; Alves et al., 2016; Galla & Wood, 2012; Malhotra, 2015; McMullan et al., 2012; Ramos Salazar, 2018). When considering the effect on performance, Wood and Locke (1987) found that self-efficacy was significantly related to academic performance in addition to self-set academic grade goals. While this can be beneficial for students with high self-efficacy, students at the other end of the spectrum may harbor feelings of discouragement that can lead to "a narrow vision of how to solve a problem" (Pajares, 1996, p. 545).

The study of fear and dread associated with mathematics is of great importance as academically able students' avoidance of mathematics often limits their options for courses of study (Hembree, 1990). Determining those elements that can impact perception, or success of a particular subject, is imperative to the creation of a productive learning experience for an individual. In their seminal work, Richardson and Suinn (1972) define mathematics anxiety as the "involvement of feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematics problems in a wide variety of ordinary life and academic situations" (p. 551). Individuals can experience a full range of reactions due to mathematics anxiety from mild frustration to full emotional and physiological disruption (Ashcraft & Moore, 2009). Low achievements and dwindling participation in mathematics has been attributed to mathematics anxiety and has been shown to severely affect learning and performance through disruptions to working memory (Dowker et al., 2016). Ample evidence exists that communicates the relationship between performance differences and mathematics anxiety (Ashcraft & Kirk, 2001).

Research regarding mathematics anxiety has verified the high reliability of the Mathematics Anxiety Rating Scale (MARS) created by Richardson and Suinn (1972) as a unidimensional measure of the apprehension

and angst associated with mathematics (Capraro et al., 2001). As one of the more popular and common instruments for testing mathematics anxiety, several revised forms of the original MARS have been created to broaden relevance to various groups (Capraro et al., 2001). In their historical review of the published literature, Ashcraft and Moore (2009) ascertained that "no other relationship is more troublesome as the negative correlation between mathematics anxiety and mathematics achievement" (p. 201). As such, these authors suggest that it is not enough to simply understand how mathematics anxiety affects performance but further research should extend to how individuals perform on mathematics while in the moment of engaging with the subject.

In regard to the effects of mathematics anxiety on individuals studying in the fields of business, Howard and Warwick (2016) surveyed 330 undergraduate students entering a university business school in the United Kingdom to determine what effect, if any, mathematics anxiety had on their course of study. These researchers found no significant differences in regard to age or gender. However, Howard and Warwick (2016) determined that students taking accounting or finance had significantly lower levels of mathematics anxiety than those enrolled in business informatics. Other studies conducted regarding mathematics anxiety focused on a particular area of business in which the students have entered their specific field of study such as marketing (Tasari et al., 2012), advertising (Fullerton & Umphrey, 2016), finance (Malhotra, 2015), and statistics (Van Gundy et al., 2006; Ramos Salazar & Hayward, 2018). In general, math anxiety has been known to affect many areas related to learning such as working memory (Ashcraft & Kirk, 2001), cognition (Sheffield & Hunt, 2007), attitude (Betz, 1978), test anxiety (Kazelskis et al., 2000), and general anxiety (Zettle & Raines, 2000).

While studies regarding business students, mathematics anxiety, self-efficacy, and performance have been conducted (Howard & Warwick, 2016; Malhotra, 2015; Ramos Salazar, 2018; Tasari et al., 2012; Van Gundy et al., 2006), participants in these studies were either attending an institution outside of the United States or were taking courses directly related to their determined program of study in the field of business. For example, and as mentioned, Howard and Warwick (2016) studied only mathematics anxiety as it pertained to 330 incoming undergraduate students entering a business school in the United Kingdom. In a similar vein, Akin and Kurbanoglu (2011) studied the relationship between mathematics anxiety, math attitudes, and self-efficacy in 372 university students in Turkey. While studying all undergraduate students, regardless of major, enrolled in a first-year College Algebra course, Peters (2012) ascertained that higher levels of mathematics self-efficacy corresponded to

higher levels of mathematics achievement. This author also conveyed that males reported having higher levels of mathematics self-efficacy than females though no differences in achievement were found to exist.

With regard to business specific majors and courses, Van Gundy et al. (2006) surveyed 175 students enrolled in an undergraduate online statistics course in the United States. Results of this study suggested that mathematics anxiety decreased over the duration of the course when implementing strategies that impacted sense of mastery and global self-esteem. Tasari et al. (2012) surveyed 118 marketing majors and found that these particular business majors were less likely to enjoy the quantitative aspect of their major but developed an appreciation for it upon the completion of a marketing research course. Looking specifically at the differences in self-efficacy and finance anxiety between adult learners and their traditional aged counterparts, Malhotra (2015) surveyed 347 students and found differences with respect to gender and age.

While the studies outlined have merit, looking at students in the early stages of their program of study may prove beneficial for several reasons. Larson et al. (2015) determined that mathematics self-efficacy significantly predicted graduation status 4 to 8 years following the first semester of enrollment. Analyzing information in the first year of enrollment may be useful for business programs seeking to retain as many students as possible. Understanding levels of self-efficacy and mathematics anxiety in the early stages, could determine interventions that may contribute to successful performance in mathematics courses now and throughout the collegiate career. As higher self-efficacy has been shown to mediate the negative effects of math anxiety (Ramos Salazar, 2018), knowing the levels of these constructs within the first year can inform programs of the quantity of targeted instructional interventions. Moreover, students who change their major have been shown to have a lower self-efficacy (Cunningham & Smothers, 2010). Thus, looking at this construct, and the related variable of mathematics anxiety, between business majors may also assist in the retention of students to more mathematics intensive majors. Therefore, this research seeks to examine the following

- Research Questions
- What relationships exist between math anxiety and math self-efficacy on undergraduate business student's expected course performance in first-year core-level mathematics courses for business majors?
 - What differences exist between math anxiety and math self-efficacy for various undergraduate business majors in core-level mathematics courses?

- To what extent does math self-efficacy mediate the relationship between math anxiety and expected course grade?

Method

Participants

A total of 266 students enrolled in business mathematics courses at the undergraduate core-level completed the questionnaire as part of this study. The participants were 42.5% female, 56.4% male, and 1.1% did not indicate a specific gender. The age of participants ranged between 17 to 49 ($M = 19.77$, $SD = 2.95$). The ethnic composition of participants included 54.5% Caucasian/Non-Hispanic, 29% Hispanic/Latino(a), 4.9% African American/Black, 3% Asian American/Asian, 1.1% Native-American/American Indian, and 7.5% Other. When asked about their first-generation college student status, 63.9% indicated no, 33.5% indicated yes, and 2.6% indicated no response. The high school senior GPA of participants included 3.7% no response, 4.5% 2.00–2.49, 11.3% 2.50–2.99, 33.1% 3.00–3.49, 39.1% 3.50–3.99, and 8.3% 4.0. When asked about their expected grade in business math, 6.0% indicated no response, 4.9% indicated a C, 35.3% indicated a B, and 53.8% indicated an A. Also, only 24.1% of the sample indicated having early math college credit. The average grade in high school mathematics courses was 80–89%. Participants' college major included 11.3% Accounting, 2.3% Economics, 9.4% Finance, 5.6% Computer Information Systems, 7.5% Management, 9.4% Marketing, 1.9% Pre-Business, 18.4% General Business, and 34.2% Other.

Procedure

After Instructional Review Board (IRB) approval, permission was obtained from the mathematics department head/dean to communicate with all business math instructors at a medium-sized, southwestern regional state university in the United States. Business math instructors were notified of this study through an electronic invitation that explained the nature of the study, and with a guide on data collection. Instructors that agreed to distribute the paper-based questionnaire, were provided with questionnaires and instructions guiding the administration of the survey. Students completed the paper-based questionnaire at two separate times during two 15-week semesters, as part of a larger research study. This study used data collected within the first 3 weeks after the Fall 2018 and Spring 2019 semesters commenced. After providing their informed consent, students spent approximately 10–15 minutes at each survey administration completing questions about their demographic information, perceived math anxiety,

and math self-efficacy. This process occurred using two sequential core-level mathematics courses designed specifically for business majors.

Measures

Math Anxiety

Math anxiety was measured using 15 items of the Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ). The short version of the Mathematics Anxiety Rating Scale (Suinn & Winston, 2003) includes items such as, "Working on mathematics homework is stressful for me;" "I worry that I do not know enough mathematics to do well in future mathematics courses;" "I worry I will not be able to understand the mathematics;" and "I worry that I will not be able to get an "A" in my mathematics course." Participants indicated agreement with each statement using a scale of 1 (*never*) to 5 (*usually*), with higher scores indicating higher math anxiety. The alpha reliability of this measure was 0.92.

Self-Efficacy

Self-efficacy was measured using 14 items of the Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ). The math self-efficacy scale (MSES) (Betz & Hackett, 1983) includes sample items such as, "I feel confident enough to ask questions in my mathematics class;" "I believe I can do well on a mathematics test;" and "I believe I can learn well in a mathematics course." Participants indicated their agreement on a scale of 1 (*never*) to 5 (*usually*), with higher scores indicating higher math self-efficacy. The alpha reliability of this measure was 0.95.

Control Variables

Demographic questions including high school grade point average (GPA), expected grade in class, major, and generation status were used as control variables in the analysis.

Analysis and Results

Preliminary correlations among the study's variables are available in Table 1. The statistical analyses were performed using IBM's statistical software SPSS (Version 22.0) and Hayes' (2013) SPSS PROCESS (Version 3). The correlation analyses indicated that math anxiety was negatively correlated with expected grade ($r = -0.31, p < .01$). Math self-efficacy was positively correlated with high school GPA ($r = 0.17, p < .01$), expected grade ($r = 0.34, p < .01$), and generation status ($r = 0.13, p < .05$). However, math self-efficacy was

negatively correlated with major ($r = -0.14, p < .05$) and math anxiety ($r = -0.58, p < .01$).

In response to the Research Question 1, hierarchical multiple regression analysis was conducted to analyze the relationship between mathematics anxiety and mathematics self-efficacy. The summaries of the multiple regression findings are located in Table 2.

After controlling for the demographic variables, high school GPA, expected grade in class, major, and generational status, it was predicted that math anxiety was negatively related to math self-efficacy. The multiple regression analysis provided a significant model [$R^2 = 0.17, F(4, 265) = 13.12, p < .001$], after putting the controlling variables in the first block and math anxiety in the second block. In the first block ($R^2 = 0.17$), high school GPA ($\beta = 0.14, t = 2.40, p < .05, pr^2 = 0.14$), expected grade in the class ($\beta = 0.32, t = 5.58, p < .001, pr^2 = 0.32$), major ($\beta = -0.13, t = -2.30, p < .05, pr^2 = -0.13$), and generation status ($\beta = 0.13, t = 2.20, p < .05, pr^2 = 0.12$), were found to be positively related to math self-efficacy. In the second block after accounting for the demographic variables ($R^2 = 0.41$), math anxiety ($\beta = -0.52, t = -10.40, p < .001, pr^2 = -0.54$) negatively related to math self-efficacy. The overall model accounted for 40% of the variance of the relationship between math anxiety and math self-efficacy. Thus, mathematics anxiety negatively relates to self-efficacy for this particular sample of participants. A simple linear regression was conducted to assess whether math anxiety inversely related to the expected grade in business math courses. A significant regression model was found ($F(1,264) = 28.76, p < .001$), with an R^2 of 0.10. Math anxiety accounted for 10% of the explained variability in expected grade ($B = -0.48, \beta = -0.31, t = -5.36, p < .001$). Expected grade decreased by -0.48 for each unit of measure of math anxiety. This result indicates that math anxiety inversely relates to the expected grade in business math courses.

In response to Research Question 2, a One-Way ANOVA was used to examine whether math self-efficacy differed by business major. To account for multiple comparisons and inflation of Type I errors, the Welsch and Bonferroni-Holm correction methods were used prior to the analysis of this study. The analysis revealed that math self-efficacy differed by students' major, ($F(8, 257) = 2.68, p < 0.01$). A Tukey post hoc test revealed that the highest mathematics self-efficacy was for Finance ($M = 3.91, SD = 0.67$), Economics ($M = 3.82, SD = 0.81$), and Accounting ($M = 3.74, SD = 0.89$). Interestingly, the lowest mathematics self-efficacy was reported by Marketing ($M = 3.09, SD = 0.75$), Computer Information Systems ($M = 3.10, SD = 0.88$), and Management ($M = 3.21, SD = 0.90$). Another One-Way ANOVA was conducted to examine whether math-anxiety differed by business major.

Table 1
Reporting Means, Standard Deviations, and Zero-Order Correlation Matrix (n = 266)

Measure	1	2	3	4	5	6
1. HSGPA	1					
2. Expected Grade	0.14*	1				
3. Major	0.01	-0.01	1			
4. Generation	-0.07	0.04	-0.03	1		
5. Math Anxiety	-0.02	-0.31**	0.06	0.01	1	
6. Math Self-Efficacy	0.17**	0.34**	-0.14*	0.13*	-0.58**	1
<i>M</i>	5.17	4.25	6.29	1.31	2.66	3.45
<i>SD</i>	1.39	1.22	2.85	0.52	0.81	0.88

Note * $p < .05$; ** $p < .01$

Table 2
Results of Multiple Regression Analyses Effective Math Self Efficacy

	Math Self-Efficacy			ΔR^2
	<i>B</i>	SE	β	
Block 1				0.15***
HS GPA	0.09	0.03	0.14*	
Expected Grade	0.23	0.04	0.32***	
Major	-0.04	-0.01	-0.13*	
Generation	0.21	0.09	0.13*	
Block 2				0.40***
Math Anxiety	-0.57	0.05	-0.52***	

Note. * $p < .05$; ** $p < .01$; *** $p < .001$; β = standardized beta coefficients.

Results demonstrated that math-anxiety did not differ significantly by students' major, ($F(8, 257) = 1.60, p = .12$).

Finally, and in response to Research Question 3, Hayes' (2013) Process v5 was used to determine whether self-efficacy mediates the effect of math anxiety on expected grade in business math courses. Table 3 summarizes the results of the mediation.

In Step 1 of the mediation model, the regression analysis results indicated that math anxiety was a significant predictor of math self-efficacy, ($b = -0.63, SE = 0.12, t(264) = 14.84, p < .001$). Step 2 showed that math self-efficacy was a significant predictor of expected grade, ($b = 0.34, SE = 0.11, t(264) = 3.19, p < .01$). In Step 3, math self-efficacy (mediator), controlling for math anxiety, was a significant predictor of expected grade, ($b = -0.26, SE = 0.12, t(264) = -2.15, p < .05$). Step 4 also revealed that after controlling for the mediator (math self-efficacy), math anxiety was still a significant

predictor of expected grade, ($b = 0.10, t(264) = -4.43, p < .001$). A Sobel test was conducted and found partial support for the mediation in the model ($Z = -2.68, p = .007$). Approximately 14% of the variance in expected grade was accounted by the predictors ($R^2 = 0.14$). As such, math self-efficacy partially mediated the relationship between math anxiety and expected grade.

Discussion

The purpose of this study was to examine the relationship between math anxiety and math self-efficacy of undergraduate business students in prerequisite mathematics courses. Self-efficacy theory (Bandura, 1986) provided a theoretical perspective to understand the value of being self-efficacious when engaging in mathematical learning and problem-solving tasks. This study contributes to previous literature by providing evidence that the factor of math anxiety relates

negatively to math self-efficacy and expected grade in prerequisite business math courses. Additionally, this study provides initial evidence of math self-efficacy as a mediator of the relationship between math anxiety and expected grade.

Math Anxiety and Math Self-Efficacy

The findings of this study confirmed the inverse association between math anxiety and math self-efficacy, even after controlling for demographic variables. This finding is consistent with previous studies (Akin & Kurbanoglu, 2011; Pajares & Graham, 1999) that found that when students have high math anxiety in their courses, they also experience lower levels of self-efficacy. Studies have shown that experiencing high degrees of math anxiety in their courses can damage students' self-esteem and confidence when completing mathematical problems, tests, and homework assignments, which can inhibit students' learning potential (Ho et al., 2000; Gresham, 2004). However, business students who reported low math anxiety also indicated having high math self-efficacy. According to Bandura's self-efficacy theory, students with high math self-efficacy are better able to tackle difficult mathematical problems and also perform better in mathematics courses (Bandura 1986; Zimmerman et al., 1992). As such, students who report having low math anxiety and high math self-efficacy are more likely to put more efforts in mathematical learning behaviors such as completing exercises and homework assignments and practicing problems before course assessments (Akin & Kurbanoglu, 2011; Jameson & Fusco, 2014). Students with high math self-efficacy are also known to be more self-motivated and better able to perform well in mathematics courses than those with low math self-efficacy (Recher et al., 2018).

Math Self-Efficacy and Demographic Variables

Additionally, the examination of the demographic variables of this study confirmed that high school GPA and expected grade in class positively related to math self-efficacy. Student success factors such as high school GPA and expected grade in mathematics courses are important factors of math self-efficacy because if students are self-efficacious in their mathematics performance, students may be able to achieve and maintain academic success (Cooper & Robinson, 1991; Ramos Salazar, 2018). Moreover, students' generation status also positively related to math self-efficacy. Whether students are first, or second, or third generation can impact the mathematical background of students and the type of preparation received in high school, and the degrees of confidence in the mathematical problem-solving process. For instance, a first-generation student

might deal with additional educational barriers such as socio-economic challenges, societal expectations, and academic support, which can hinder their completion of mathematical courses (Garriott et al., 2013). Also, students with parents who have completed a high school and/or college degree may have educational advantages given the expectation to complete college, and the parental support along the educational journey (D'Allegro & Kerns, 2010; Garriott et al., 2013). Thus, these demographic factors contribute to our understanding of business students' math self-efficacy.

Math Self-Efficacy by Major

This study also found that math self-efficacy differed by students' business major. In particular, math-based majors such as finance, economics, and accounting indicated higher levels of math self-efficacy than other business majors. This finding is consistent with a prior study by Hackett (1985) that found that college students with high mathematics self-efficacy are more likely to choose undergraduate majors with mathematical components, and students with low mathematics self-efficacy are more likely to choose non-mathematics related majors. Additionally, when comparing students majoring in finance over other majors, finance majors tended to exhibit higher degrees of motivation and course performance in mathematics, and this can attribute their higher degrees of math self-efficacy (Shotwell, 1999). Another study also found that students in economics are more likely to perform well in mathematics because about a third of the students switched to economics from another math-intensive major such as engineering, math, or physics (Mumford & Ohland, 2011). Because these students are majoring in business which requires higher degrees of mathematical proficiency, students in these majors may be more confident about the mathematic problem-solving process. Students in finance, for example, must regularly use mathematical methods to solve financial problems. Additionally, confidence in mathematics is needed for accounting because students must learn how to develop effective budgets, audit financial accounts, and pass the certified public accountant (CPA) exam. Economics students with high math self-efficacy may also be at an advantage to understand advanced mathematical economical models.

However, this study found that non-mathematics majors such as marketing, computer information systems, and management reported the lowest levels of math self-efficacy. Moreover, students with non-mathematically based majors such as management and marketing may not feel confident in their ability to solve mathematical problems, especially in mathematical courses. Students in these majors might suffer from low math self-efficacy. A previous study by Fullerton and

Kendrick (2013) found that a national sample of advertising students reported holding negative attitudes toward mathematics, and they reported having low degrees of confidence when completing mathematical problems in statistics courses. Additionally, Ganesh et al. (2010) found that marketing undergraduates tend to be mathematically deficient than other math-based business majors. Students that select non-mathematical majors might have chosen those majors due to their lack of initial confidence in mathematics, and they may prefer to solve societal and technological problems over mathematical problems. However, because mathematics prerequisites courses are required across the business curriculum across the United States, non-mathematics business majors are required to take these courses, even if they might not feel highly confident in solving mathematical problems. As such, these students might need further mathematical preparation and confidence-building drills to build these students' math self-efficacy.

Math Anxiety and Expected Grade in Business Math Courses

The current study also found that math anxiety was inversely related to students' expected grade in business math courses. Previous studies have also noted an inverse correlation between math anxiety and mathematics course performance in college students (Ashcraft & Kirk, 2001; Hendy et al., 2014; Liew et al., 2014; Llabre & Suarez, 1985). Students who suffer from high math anxiety levels are less likely to receive higher grades in mathematics courses such as algebra and calculus (Llabre & Suarez, 1985). For example, a study of business and economics students found that students who are mathematically anxious are less likely to perform well on basic elementary arithmetic problems, which include simple addition, subtraction, multiplication, and division problems (Standing et al., 2006). Additionally, part of the reason students may expect to earn lower grades when experiencing math anxiety is the avoidance of mathematics activities altogether, such as the avoidance of trying out mathematical problems, poor preparation in studying for mathematical tests, and putting less effort on mathematical assignments (Llabre & Suarez, 1985; Resnick et al., 1982). Additionally, students with high math anxiety are also more likely to score poorly on mathematics tests, which can explain why students might expect lower grades in mathematics courses (Liew et al., 2014).

As such, this study has replicated previous findings; however, using a sample of business students who take mathematics prerequisites. Studies have demonstrated that business students tend to experience mathematical anxiety, when solving mathematical problems and

calculating formulas, and completing mathematical assessments (Sizoo et al., 2008; Standing et al., 2006; Tasari et al., 2012), and this study has provided evidence that business students' math anxiety is inversely related to their expected grade in mathematics prerequisite courses. Students who score low in math anxiety also report expecting higher grades in prerequisite mathematics courses, and vice versa. Previously, Ma (1999) conducted a meta-analysis that examined 26 studies and explained that students with low math anxiety may be more likely to earn higher grades and to perform better in mathematics courses in comparison to students with high math anxiety levels. Thus, business students with little to no math anxiety are more likely to expect and earn higher grades in comparison to students with high levels of math anxiety.

Mediating Role of Math Self-Efficacy

This study explored the mediation role of math self-efficacy on the relationship between math anxiety and expected grade in business math courses. Findings from this study found partial mediation support for math self-efficacy on the inverse relationship between math anxiety and expected grade. Consistent with Bandura's (1986) self-efficacy theory, self-efficacy can serve as a mediator among math anxiety constructs relevant to course performance outcomes such as expected grade. Previous studies have also found that math self-efficacy serves as a mediator among student's anxiety and higher levels of academic performance in mathematical tests and mathematical problem solving (Fast et al., 2010; Pajares & Miller, 1994; Randhawa et al., 1993). Math self-efficacy, or the confidence in performing mathematical tasks, can be influenced by math anxiety and in turn, can positively relate to expected course grade performance (Maddux & Stanley, 1986; Zarch & Kadivar, 2006). If students experience math anxiety, but also feel highly self-efficacious about mathematics, this can serve as a buffer that can reduce the negative effects of math anxiety and may result in higher expectations on course grades and course outcomes. Additionally, students who have low mathematics self-efficacy and elevated levels of mathematics anxiety may expect lower grades in business mathematics courses. Thus, math self-efficacy might play a role in students' math anxiety and course grade expectations.

Interventions to Reduce Mathematics Anxiety

As this study suggests a negative relationship between mathematics anxiety and course performance for students majoring in business, a discussion of interventions aimed at reducing this form of anxiety is warranted. With implications to practice and given the

inverse relationship between mathematics anxiety and expected grade, informing instructors of business math courses of these techniques and strategies may provide students with material that may reduce their mathematics anxiety. It is suggested that doing so may then result in a subsequent increase in performance.

Although focused on a population of children aged 5 to 17 years old, in their review of the existent literature regarding mathematics anxiety interventions, Balt et al. (2022) determined that mathematics anxiety interventions primarily fell into two categories: interventions that target mathematical abilities and interventions labeled as cognitive-behavioral. Interventions aimed at mathematical ability attempt to break the cycle of poor mathematical performance through mathematics skill development in an effort to increase mathematical self-efficacy, while reducing mathematics anxiety (Balt et al., 2022). Strategies in this category included the incorporation of recreational and digital-based mathematics games (Alanazi, 2020; Huang et al., 2014), cooperative learning (Lavansani et al., 2011; Mehdizadeh et al., 2013), and adaptive mathematics training (Jansen et al., 2013; Rauscher et al., 2017). Cognitive behavioral interventions aimed at reducing mathematics anxiety included cognitive behavior therapy (Asanjarani & Zarebaramabadi, 2021; Karimi & Venkatesan, 2009), coping techniques such as mindful breathing and self-regulation (Collingwood & Dewey, 2018), and reflectively writing about feelings of mathematics (Hines et al., 2016; Ruark, 2021).

With regard to the university age population, Nunez-Peña et al. (2015) investigated the effects of a formative assessment system on reducing mathematics anxiety. This intervention involved providing students with error feedback on assignments conducted throughout a core psychology course. These authors determined that the “perceived usefulness of the feedback” (Nunez-Peña et al., 2015, p. 80) predicted the final exam score, thus suggesting the viability of this technique in reducing mathematics anxiety. Samuel and Warner (2021) implemented and studied a combined mindfulness and growth mindset intervention within a required first-year statistics course with 40 first-year, first semester students. Results of this pilot study indicated that this type of intervention reduced mathematics anxiety while also increasing mathematics self-efficacy (Samuel & Warner, 2021).

While these studies convey the effectiveness of these strategies and techniques, future studies may look at combining interventions for their usefulness in reducing mathematics anxiety. Replication studies may also be conducted, with focus given to courses in business mathematics. Moreover, interventions found worthwhile at the K–12 levels may also be implemented

at the university level to determine the utility of these strategies and techniques for reducing mathematics anxiety with this mature population of students.

Limitations and Future Directions

There are several limitations in this study, and these can be used to guide future research. First, the findings of this study are not generalizable because of the adopted cross-sectional approach. To overcome this, future researchers need to conduct longitudinal research toward the beginning, middle, and end of mathematical courses, to determine if math anxiety remains constant in its inverse relationship with math self-efficacy. Findings using longitudinal methods can also be used to determine causal links among the variables of this study. Second, this study relied on self-reports of students’ math anxiety and math self-efficacy. One problem with self-reports is that students might face social desirability bias when completing self-reported questionnaires. To address this, future researchers may need to confirm self-reports with follow-up surveys and interviews, to confirm the validity of responses. Third, this study did not examine other specific performance outcome measures other than expected grade. However, future researchers may include additional performance outcome measures such as test performance and homework performance.

Implications and Conclusion

Several implications can be derived from this study. First, because there was a negative relationship between mathematics anxiety and mathematics self-efficacy, mathematics and business educators can benefit from understanding this association. Business students who suffer from mathematics anxiety in mathematics prerequisite courses, might also have low math self-efficacy. Mathematics educators who teach business students might not be used to teaching non-mathematics majors, and might not understand the higher degrees of mathematics anxiety that some of these students might face, and how this relates to their math self-efficacy and their expected grade in mathematics courses. To alleviate the mathematics anxiety, mathematics educators may consider including math anxiety reduction interventions such as journaling and reflecting about the mathematical problem-solving process.

Additionally, because math self-efficacy differed by major, this has implications to business and mathematics educators. By examining students’ business major, educators might be able to better identify students who might be less self-efficacious in the mathematical problem solving process. Once these students are identified, educators can place more efforts such as providing additional tutoring and additional practice questions to ensure these students are successful in these

courses. Another effective approach to increase students' math self-efficacy may be to introduce a variety of easy, moderate, and difficult questions until students master the material in order to build confidence when completing mathematical tasks. Finally, because math self-efficacy served as a partial mediator of the inverse relationship between math anxiety and expected grade, this finding has potential theoretical implications. Researchers may continue to examine the mediation role of math self-efficacy, and examine whether it impacts the relationship between math anxiety with another performance outcome such as test performance, final course grade, and undergraduate grade point average.

In conclusion, this was the first study to examine math anxiety, math self-efficacy, and expected grade using a business student sample in mathematics prerequisite courses. The findings of this study understand the inverse relationship between math anxiety and math self-efficacy among business students. The study also found that math anxiety was inversely related to students' expected course grade in mathematics courses. Additionally, students' math self-efficacy differed by business major. Finally, the study found that math self-efficacy served as a partial mediator of the relationship between math anxiety and math self-efficacy. With these findings in mind, mathematics educators may be equipped in understanding business students' math anxiety and math self-efficacy in their mathematics courses to stimulate their students' course performance.

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