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"I Can Math!": Reducing Math Anxiety and Increasing Math Self-Efficacy Using a Mindfulness and Growth Mindset-Based Intervention in First-Year Students

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ABSTRACT
Math anxiety is a debilitating problem that affects many community college students. Neuropsychological research suggests that negative rumination when anticipating math situations substantially exhausts working memory load, contributes to execution anxiety, which interferes with learning and performance. Studies have shown that improving the psychological experience in the classroom could have a positive impact on students' academic achievement. However, there is little to no research employing interventions designed to specifically address anticipation and execution math anxiety in community college students. The current research investigated the effect of embedding a combined mindfulness and growth mindset intervention within a required first-year, two-semester developmental statistics course. Results from this mixed methods pilot study indicate that this new combined approach not only reduced math anxiety, but had also increased math self-efficacy in a sample of college students. Replication of the research is warranted in order to substantiate the preliminary results.

Academic achievement in math is an issue of great concern to educators and cognitive psychologists alike. Mathematical anxiety, a negative emotional response when encountering math problems to solve (Richardson & Suinn, 1972), affects many students in all academic levels. For many community college students, this self-doubt about math achievement becomes a self-fulfilling prophecy even for those who are otherwise excelling in their areas of concentration. Anxiety associated with math situations could result in negative academic consequences for students, and decreased interest in math-related fields. Researchers (Beilock & Maloney, 2015) have argued that in order to increase student retention in math courses and student interest in pursuing STEM disciplines, efforts must be made to mitigate math anxiety. Neuropsychological research has revealed that math anxiety can be literally painful. In fact, according to Lyons and Beilock (2012b), increased levels of math anxiety within highly math-anxious individuals produce visceral pain sensations, which is evidenced by heightened neural activity in the bilateral dorsal-posterior insula region in the brain. Furthermore, this neural mechanism is activated particularly when students are *anticipating* math situations and contributes to anxiety when students are *executing* math problems (which is implicated in the subcortical right caudate and left hippocampal regions – a separate brain network responsible for cognitive management and motivation during tasks) (Lyons & Beilock, 2012a). For many students, simply anticipating a math situation (i.e. walking into their math classroom, hearing the instructor announce the beginning of class, waiting for exam packets to be distributed) can produce a great deal of stress and negative thoughts related to the inability to solve problems. This disruptive thinking contributes to anxiety the working on mathematical content. Thus, the extent to which math-

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anxious students could regulate their negative emotions related to math could either trigger or mitigate anxiety when working on problem sets or exams. Therefore, the researchers suggest that interventions be designed and implemented to address reducing negative emotions associated with math during the anticipatory phase in an effort to minimize execution anxiety. However, there is minimal research employing such interventions in the classroom to help alleviate math anxiety throughout the class session – at both the anticipation, and execution of mathematical materials. The current research administered a combined mindfulness and growth mindset intervention within a statistics classroom in an effort to reduce math anxiety in first-year students at a community college.

Working memory, the cognitive system primarily associated with conscious processing of memory for ongoing tasks, has limited capacity (Baddeley, 1986; Prinz, 2012). Therefore, negative rumination about failure on math problems substantially exhausts working memory load (LeFevre, DeStefano, Coleman, & Shanahan, 2005), and interferes with academic performance (Ashcraft, 2002; Ashcraft & Kirk, 2001; Mattarella-Micke, Mateo, Kozak, Foster, & Beilock, 2011; Suárez-Pellicioni, Núñez-Peña, & Colomé, 2016). *Mindfulness*, the contemplative practice of non-judgmental, intense, and intentional focus on the present moment, involves deep breathing and meditation techniques (Kabat-Zinn, 2003; Kabat-Zinn & Hanh, 2009; Williams & Kabat-Zinn, 2011). Since mindfulness also relies on working memory usage in an effort to devote full attention to a task, it disrupts rumination (Lu, 2015), and thus the practice of mindfulness is incompatible with anxiety. Mindfulness-based practices can help to ensure that valuable working memory storage is not consumed by anxious thoughts of failure; but is available for the present task. In clinical psychology, mindfulness has been recognized as an effective intervention developed for people with depression (Brown & Ryan, 2003; Lu, 2015), social anxiety (Hayns, 2011), and binge eating disorders (Telch, Agras, & Linehan, 2001). Beyond psychiatric applications, the mindfulness approach has been adapted and applied in broader contexts, including the military (Stanley, Schaldach, Kiyonaga, & Jha, 2011), correction facilities (Himelstein, 2011; Samuelson, Carmody, Kabat-Zinn, & Bratt, 2007), and recently, in educational settings (Mapel, 2012; Powietrzynska, Tobin, & Alexakos, 2015; Tobin, Powietrzynska, & Alexakos, 2015; Wilson & Dixon, 2010). Researchers and educators have found mindfulness as a reliable method in reducing math test anxiety via renewing working memory (Bellinger, DeCaro, & Ralston, 2015; Shapiro, Brown, & Astin, 2011). Implementing a mindfulness-based technique helps students self-regulate their behavior by diverting attention from their anxiety to orienting their concentration to completing the problems at hand.

According to Sternberg, “The traditional model [of fixed abilities] may be a cause of rather than a potential answer to educational problems, in particular, and societal problems, in general” (1998, p. 15). The literature on math achievement formerly espoused the idea that mathematical understanding is merely an innate cognitive ability. Fixed mindset, the belief that intellectual ability is a dispositional attribution (Dweck, Chiu, & Hong, 1995), had previously been the dominant theory that heavily influenced educational policies. Research indicates that math anxiety develops in students because of the ways in which mathematics is packaged to them, not necessarily as a function of content difficulty (Williams, 1988). Instructors and students who adopt fixed mindsets perceive mistakes as failures, and tend to pursue performance-oriented goals (e.g. focus on performance on future exams, or passing the class) (Rattan, Good, & Dweck, 2012). This results in students avoiding challenges and interest in learning from mistakes, as their failure strongly implies that their intelligence is inherently limited. Statements that make direct associations with mistakes and intelligence (e.g. *I made this mistake because I am stupid*, or *I will never understand math*) are common among students who embrace a fixed mindset. Therefore, it is essential that educators attune students to the idea that success in math is achieved by maximizing effort, using appropriate strategies, embracing challenges and welcoming feedback from others (Chen et al., 2018). This notion is grounded on the principle of *growth mindset* (Dweck, 2007), which is an incremental theory of intelligence, which argues that skills and abilities could be developed through hard work and perseverance. Cultivating a growth mindset culture in the classroom focuses on building upon and nurturing ability; and success is based on goal mastery, and increasing developmental skills (Dweck et al., 1995; Yeager & Dweck, 2012). Moreover, mistakes are not perceived as failures, but are reframed as problems that require different strategies, and through this process, knowledge is enriched. Therefore, statements by growth mindset students typically reference lack of effort, or misapplication of a strategy (e.g. *I failed the exam because I didn't study for it*, or *I failed because I consistently used the wrong formula*). In a growth mindset environment, mastery-goal orientation substantially contributes to general academic resilience (Aronson, Fried, & Good, 2002; Dupeyrat & Mariné, 2005) and specifically, mathematical resilience (Johnston-Wilder, Clare, Brindley, & Garton, 2015).

In addition to math anxiety, the extent to which college students believe they are confident in executing math-related problems could affect their level of engagement in class, and motivation to persist over the course of the semester. According to Bandura, Adams, and Beyer (1977), self-efficacy, or the degree of self-confidence an individual has regarding his or her ability to be successful at a particular task, is inversely related to anxiety (Bandura, 1977). Regarding math anxiety, this self-evaluation of competence provides students with the ability to maintain control over their learning environment. Therefore, increased efficacy in math can temper negative effects of math anxiety (Galla & Wood, 2012). It is widely documented in the literature that self-efficacy is one of the strongest predictors for academic achievement and resilience (Cassidy, 2015; Martin & Marsh, 2006), as opposed to innate ability. Students with growth mindsets tend to have more self-efficacy than students with fixed mindsets, and thus, show higher incidences of academic persistence.

Recommendations have been made for instructors to investigate students' math histories (Tobias, 1990) and provide psychological interventions (Spitzer & Aronson, 2015) to counteract negative experiences in an effort to promote academic mental health. Self-affirmation interventions have demonstrated to be generally effective in reinforcing self-worth (Aronson, Cohen, & Nail, 1999; Steele, 1988), and attenuating stress in situations that present a threat to students' identity (Creswell et al., 2005). In fact, research by Cohen, Garcia, Apfel, and Master (2006), a self-affirmation intervention was found to substantially reduce stress, and increase academic performance in African-American students over the course of the term compared to students who did not receive treatment, and compared to their European-American peers. Furthermore, the intervention, which involved students reflecting on personal values important to them, served as psychological support and contributed to academic resilience, despite poor performance at the beginning of the term. As a result of the intervention, ethnic disparity (with GPA as an outcome) was reduced by 40% after the first term, and by 30% two years later. In math and STEM-related academic contexts, female students' performance is typically threatened by increased anxiety of confirming the stereotype in relation to their gender identity compared to their male peers (Steele, 1997; Steele, Spencer, & Aronson, 2002). Studies (see Martens, Johns, Greenberg, & Schimel, 2006) have shown that implementing a self-affirmation intervention provides a buffer against the effect of the stereotype threat, resulting in increased math performance in female students.

However, Wood, Perunovic, and Lee (2009) have criticized the effectiveness of such interventions. In their experiment, for participants with low self-concepts, repeating value self-affirmations (e.g. "I am a lovable person," p. 861) was counterproductive and actually resulted in lower self-esteem, as the affirmation did not align with the participants' low self-perceptions. In considering growth mindset theory, the results of the research by Wood et al. (2009) is not surprising, as the statement, "I am a lovable person" (p. 861) refers to an inherent personality characteristic, and reinforces a fixed mindset. Therefore, participants with low self-esteem would not find value in stating a fixed mindset affirmation, but would perhaps benefit from stating the growth mindset alternative: *I am capable of loving others/being loved*. Nonetheless, the utility of employing an intervention with repetitive growth mindset affirmations in an effort to reduce math anxiety in college students has been largely unexplored in the literature.

Academic responsibility is only one of a number of contextual factors that contribute to stress and anxiety in first year undergraduate students. Stressors related to college life (new environment, adjustment to schedule and courses, test anxiety, lack of consistent social support from family) is correlated to increased clinical symptoms of anxiety and depression (Bewick, Koutsopoulou, Miles, Slaa, & Barkham, 2010). Previous research has shown that social and environmental psychological interventions in the classroom have been quite successful to alleviate academic anxiety (Cohen et al., 2006; Spitzer & Aronson, 2015). In particular, mindfulness interventions (Bellinger et al., 2015) have been shown to be beneficial for college students in high-stakes math situations (e.g. exams). However, there is little to no research investigating the effect of mindfulness interventions and growth mindset-based interventions on general math anxiety and math self-efficacy in college students. The current pilot research was conducted to determine the extent to which administering a combined mindfulness and growth mindset intervention within a math classroom could reduce general math anticipatory and execution anxiety, and increase math self-efficacy in college students. Furthermore, it seeks to investigate the effectiveness of this combined intervention in a sample of first-year community college developmental math students, a population that is quite vulnerable to academic adversity.

Method

The present research study investigated the effects of a combined mindfulness and growth mindset intervention in first-year community college students taking a statistics course. Two central research questions under investigation in the current study examined the following:

(a) What effect does implementing a combined mindfulness and growth mindset intervention have on community college students taking a year-long statistics course?
(b) How was the mindfulness and growth mindset-based intervention received by student participants?

These research questions warranted the use of an embedded-experimental mixed method design (Creswell, Klassen, Plano Clark, & Smith, 2011), in which embedded data is secondary to primary data, and can be collected and analyzed before, during, or after the research process. In the current research, quantitative data were collected and analyzed, which were supplemented by qualitative data collected from a focus group in an effort to corroborate quantitative findings and reception of the intervention. The primary focus was to examine pretest-posttest dependent measures of perceived math anxiety as a function of the treatment, while the secondary focus examined the students' reception and view of the intervention.

The hypotheses for the present research study were the following:

(a) Math anxiety will significantly decrease from pretest to posttest in students receiving the intervention over the course of the first semester compared to the control group.
(b) Math anxiety will significantly decrease from pretest to posttest in students receiving the intervention over the course of the entire year compared to the control group.
(c) Math self-efficacy will significantly increase from pretest to posttest in students receiving the intervention within a year-long statistics class.

Experiment 1

Method

Participants

At Stella and Charles Guttman Community College statistics is a required first-year math course. This course is taught either in one semester for students who are proficient in math (*Statistics*), or stretched over the course of one year in two semesters (*Statistics A* in the fall semester, and *Statistics B* in the spring semester) for students who require remediation and more support in math. Two sections of a Statistics A course (Cohorts 1 and 3) taught by the first author, were recruited for the study in the 12-week, Fall 2017 semester. Both cohorts were matched based on students' scores on the mathematics placement exam (<57), which is the criterion for placing into the Statistics A course.

On the first day of the semester, the second author announced to students in Cohort 1 and 3 that their classes were recruited to participate in a research study investigating math anxiety and math confidence. Students were informed that participation was voluntary, and that there were no consequences for nonparticipation. The initial sample consisted of 40 first-year/first semester students in the two classes (19 females and 21 males; mean age = 17 years, 11 months), who volunteered to participate in the research study. One cohort would receive the intervention, and the other would serve as the control group (no intervention).

Procedure

Mindfulness and growth mindset intervention

Cohort 3 was randomly selected to receive the mindfulness/growth mindset intervention, which began on the second day of class. The intervention procedure proceeded as follows. The instructor gave definitions, and showed videos related to mindfulness and principles of growth mindset theories (these were only shown on the first day of the intervention, the second day of the semester). In order to address anxiety and negative thoughts during the anticipation phase, at the start of each class session (beginning on the second day of the semester and thereafter), the professor rang a chime once, and led the class through a 1-minute deep breathing exercise (10 deep breaths). Students were asked to close their eyes, focus only on the present moment while breathing, and not to think about what occurred before class, or what they anticipate would happen after the deep breathing session. Students were reminded that this exercise was voluntary: however, if they decided not to participate, that they should not distract those who were engaged. Then, both the professor and students recited five positive affirmations about mathematics aloud in unison (e.g. "*I am capable of understanding math*," "*I expect to make mistakes today, and then learn from those mistakes*"), which were developed by the authors based on growth mindset principles. See Appendix 1 for the complete list of positive affirmations. After the recitation was completed, the professor then proceeded with the lesson planned for the day. To address execution anxiety, the intervention continued with the professor a) prompting students to be actively engaged in the present moment throughout class time, and to take deep breaths when feeling anxious; b) reinforcing effort, endurance, and openness to feedback; and c) offering verbal praise frequently to create a culture of positivity, effort and endurance. Any negative comments about math were reframed into positive statements to redirect students to endure (e.g. if a student said, "I give up, this is too hard," the instructor would respond with, "Let's just focus on the first problem, and work through it step by step using the procedure"). Fixed mindset comments from students were reframed into growth mindset ones by the instructor (e.g. if a student said, "I don't know why I keep making the same mistake for every problem,") the instructor would respond with, ("Take a look at the strategy that you used for each problem – did you use the appropriate formula? It's okay to make mistakes now so you can learn from them"). When appropriate, the student was reminded of the affirmation that applied to the situation (e.g. "Remember, *I expect to make mistakes today and learn from those mistakes*"). In addition, when students arrived at incorrect answers, correctly executed parts were acknowledged by the professor. To mitigate any instructor anxiety or unconscious negative attitudes prior to starting class, the instructor also engaged in the deep breathing and stated the positive statements along with the students during every class session. On exam days, the class engaged in the intervention, beginning with the deep breathing exercise. However, since many of the affirmations are not applicable (e.g. *"I expect to make mistakes today and then learn from those mistakes,"* or *"Today's lesson might be challenging, but I'm up for the challenge"*) the positive affirmations were changed to *"I know I am capable of doing well on this exam!"* and *"I've got this!"*

The control group (Cohort 1) received standard instruction without the intervention throughout the semester.

Dependent measures

Quantitative data collection

Two online anonymous surveys assessing math anxiety and math self-efficacy were administered to consenting students from both Cohorts 1 and 3 at two time periods: on the first day of classes in the Fall 2017 semester, and during the last week of classes in the same semester. In an effort to preserve anonymity and to track pretest-posttest surveys, each student was asked to enter their individual randomly generated, 8-character alphanumeric code that was emailed to them in advance of the first day of classes.

Math anxiety assessment

Math anxiety was measured using the Revised Math Anxiety Rating Scale (RMARS; Alexander & Martray, 1989), which is one of the most widely used abbreviated version of the 98-item Math Anxiety Rating Scale (MARS; Richardson & Suinn, 1972). The RMARS is a valid and reliable instrument (Bowd & Brady, 2002; Plake & Parker, 1982) that assesses students' self-perceived anxiety to various math situations (i.e. anticipating a scheduled math test). As opposed to the unidimensional MARS, the 25-item revised version is a multidimensional construct that examines math anxiety on three subscales: Mathematics Test Anxiety (items 1–15), Mathematics Course Anxiety (items 16–20), and Numerical Task Anxiety (21–25). Items are rated on a 5-point Likert scale to indicate levels of anxiety ranging from 1 (*not at all*) to 5 (*very much*).

Math self-efficacy assessment

Math self-efficacy was measured with the revised Math Self-Efficacy Scale (MSES; Betz & Hackett, 1993), a 34-item highly valid and reliable instrument that examines students' confidence in their ability to perform math problems. Students rate their self-perceived confidence in their ability to solve math problems commonly found on standardized math tests, complete real-life math tasks (e.g. balancing a checkbook), and succeed in various college courses that require math knowledge (e.g. biochemistry, economics, statistics). Items are rated on a 10-point Likert scale ranging from 0 (*no confidence at all*) to 9 (*complete confidence).*

Qualitative data collection (focus group)

On the last day of classes, a randomly selected group from the treatment group (n = 4) participated in a focus group interview. The semi-structured interview lasted for approximately 20 minutes. Guided questions asked participants to reflect on their math anxiety levels over the course of the semester, their confidence in math over the course of the semester, whether they have used positive affirmations prior to the intervention, and elements they liked and did not like about the intervention. For this study, we wanted to determine emergent themes based on their reflections on the intervention, and the extent to which their self-perceived anxiety and competence to be successful in math had changed over the course of the semester.

Results and discussion

Quantitative analyses

For the intervention cohort, all students (N = 20) consented to participate at the beginning of the semester. Only 17 students completed both pre- and post-surveys, yielding an 85% response rate. For the control cohort, of all students (N = 20) who consented to participate at the beginning of the semester, only 15 students completed both pre- and post- surveys, yielding a 75% response rate.

Sample characteristics

Data were entered and analyzed using SPSS. Since the sample size was < 30, we conducted an analysis to test that the assumptions of normality were met. A Shapiro-Wilk test indicated that both the pre- and post-test RMARS scores were approximately normally distributed for both Cohort 1 and Cohort 3 (p's > .05). A visual inspection of the histograms, normal Q-Q plots and box plots also confirm these results. Since there were no violations of normality in the distribution, we proceeded to analyze the data using parametric tests.

Preliminary analysis (RMARS)

A preliminary analysis was conducted to test the assumption that the RMARS pre-test scores were not significantly different between the intervention (Cohort 3) and control (Cohort 1) groups. An independent-samples t-test indicated no significant differences between Cohort 3 (M = 2.93, SD = .833) and Cohort 1 (M = 2.68, SD = .741), t (30) = −.880, p = .386.

Within-groups analysis (RMARS)

Of particular interest was the investigation of the math anxiety measure at the beginning of the semester compared to the end of the semester for each group. A paired sample t-test was conducted for the control group, but no differences were found between the pre-test scores (M = 2.68, SD = .741) and post-test scores (M = 2.42, SD = .598). For the intervention class, we tested the hypothesis that the mindfulness/growth mindset intervention decreased math anxiety over the course of the semester. A paired sample t-test indicated that for the intervention group, math anxiety scores decreased at post-test (M = 2.31, SD = .797) compared to the pre-test scores (M = 2.93, SD = .833), t (16) = 2.825, p = .012, d = .686, a medium effect size. Figure 1 illustrates that overall, although students in the class section who received the intervention reported higher anxiety levels at the beginning of the semester (compared to the control group), they had reported substantially low levels of anxiety at the end of the semester.

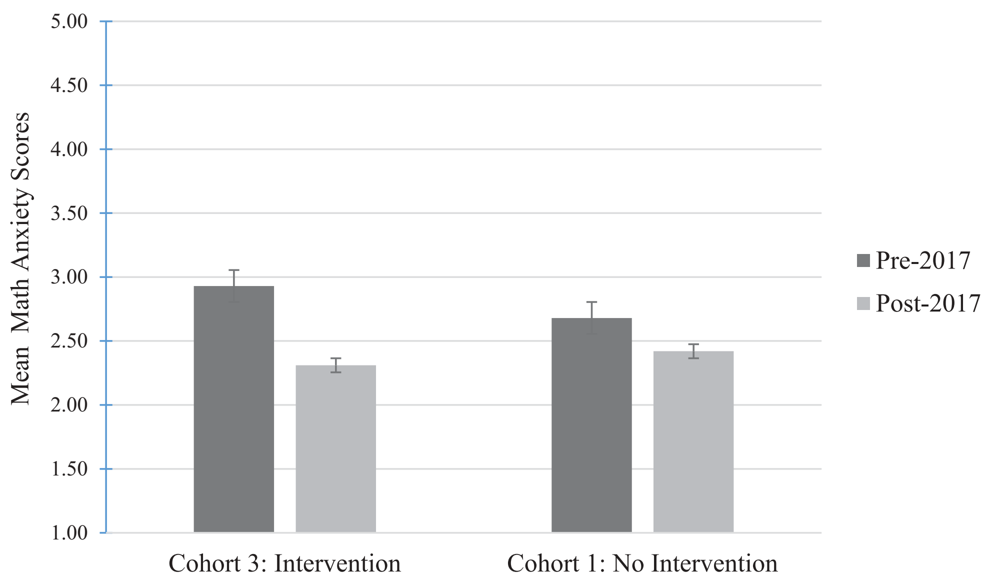

Figure 1. Mean pre- and post- math anxiety scores in fall 2017 semester: Cohort 3 (intervention) vs. Cohort 1 (no intervention).

Between-groups analysis (RMARS)

A follow-up analysis was conducted to determine whether the post-test scores for the intervention group (Cohort 3) were significantly different compared to the post-test comparison group (Cohort 1). An independent samples *t*-test revealed no differences between these groups, $t\ (30) = .419$, $p = .679$. Although Cohort 3 revealed considerable decrease in math anxiety over the course of the semester, this difference was not significantly different compared to Cohort 1.

Preliminary analyses (MSES)

Overall MSES pre-test scores were analyzed to test the assumption that there were no differences between the intervention (Cohort 3) group and the control (Cohort 1) groups. An independent-samples *t*-test confirmed no significant differences between Cohort 3 ($M = 5.14$, $SD = 2.53$) and Cohort 1 ($M = 5.28$, $SD = 2.14$), $t\ (30) = .171$, $p = .865$.

Within-groups analyses (MSES)

Pre- and post- overall math self-efficacy scores were analyzed for both groups. A paired sample *t*-test was conducted, and no differences were found for the control group when comparing their pre-scores ($M = 5.28$, $SD = 2.14$) to their post-scores ($M = 6.00$, $SD = 2.20$), $t\ (14) = -1.058$, $p = .308$. For the treatment group, no differences were found for overall math self-efficacy scores at post-test ($M = 6.27$, $SD = 2.65$) from pre-test ($M = 5.14$, $SD = 2.53$), $t\ (16) = -1.930$, $p = .072$.

Qualitative analysis (focus group)

The qualitative data was analyzed using thematic content analysis (Braun, Clarke, Hayfield, & Terry, 2019), which yielded five themes that were related to the participants' reflection on elements of the intervention method, and the effectiveness of the intervention on math competence. The themes included: 1) instructor authorizing and participating in intervention, 2) deep breathing is a calm, fresh start to class, 3) saying the affirmations makes you believe them, 4) sense of control, and 5) routine.

Instructor's role in authorizing and participating in the intervention

Participants expressed that the instructor's role in facilitating the intervention was extremely important. Students found it valuable that the instructor facilitated the intervention, reminded students about the purpose of the intervention, and also participated in the deep breathing exercise and stated the positive affirmations along with the class. One student remarked, "And when your professor comes in and says, 'Try this thing, and this is what I'm recommending.' And she says it with you, with so much belief. It makes you feel good."

Deep breathing is a calm, fresh start to class

When asked about what they felt about the deep breathing exercise at the beginning of each class session, many participants made statements that the mindfulness deep breathing exercise was a refreshing way to begin the class. One student expressed how the deep breathing disrupted his thinking about stress, which describes the cognitive processing on working memory when one engages in mindfulness:

> I think those ten deep breaths calms, calms you down to get up again, and increases your speed actually, because once you're calmed down, your brain is in the right place. Because that's one thing I feel, that rather than thinking about stress, why not just do the work? Because thinking about it, you're just wasting your time, rather than doing the work.

Another student commented about the refreshing nature of the mindfulness exercise:

> It's a bit refreshing because it's the last class of the day, so automatically you are tired. You're tired, you know, because these classes, these quizzes … It's just, it's a nice to refresh yourself before doing the subject that probably all of us consider the toughest, and one that we're all the most scared about.

Saying affirmations made it easier to believe them

When asked about their impressions about the positive affirmations they had to recite, many participants reported that saying the affirmations aloud had great impact on their beliefs in the statements. An example of this is the following statement:

> And also when you can see that you're learning more, you're doing well, those positive affirmations make sense. Because you're saying them and you're doing well as well. So that makes you believe more and want to say them even more, and with more passion.

Sense of control

Some participants remarked that the mindfulness and growth mindset approach gave them a sense of control, and that they did not feel stressed or overwhelmed when working on multiple-step problems or problem sets. One student stated:

> Like, I feel like when she gives us, like, those packets, like, I feel like I could do it. Because we take it, like, one step at a time, which is what I really like. Like every step of the way we do the breathing and affirmations. So it helps, to focus on different parts. And when we all put them back together, it doesn't feel like – it doesn't overwhelm you.

Routine

Since the intervention was done every class session, many comments were made about the impact of the habitual practice of the intervention. Students made the following statements about this theme: "And I think, like, the positive statements are good, because even if, like, you don't believe it, you still going to start to believe it, because you say it every day – like *everyday* – in your head."; and "Yeah it started to grow on us."

The quantitative data analysis reveal that students receiving the embedded intervention reported decreased math anxiety over the course of the semester. Furthermore, qualitative data from the focus group indicated that the routinized practice of the intervention with the professor helped in managing internal and external stressors in relation to the math class over the course of one semester. To test the hypothesis regarding the year-long impact of the intervention on students, including any challenges related to the intervention, the experiment continued for the spring 2018 semester.

Experiment 2

Method

Participants

Due to attrition from the fall semester (i.e. students failing the course, or leaving the college for various reasons), Cohorts 1 and 3 sections were collapsed into one section for the spring 2018 semester for Statistics B. There were a total of 16 students (six females and 10 males; mean age = 18 years) in the single class section, and all 16 students re-consented to participate in the experiment. With the integration of the two sections, Cohort 3 students (n = 8) continued to receive the intervention for a second semester, and Cohort 1 (n = 8) students received it for the first time.

Quantitative data collection

All students (N = 16) were asked to complete the math anxiety (RMARS) and math self-efficacy (MSES) assessments at the beginning and at the end of the spring 2018 semester in an effort to obtain pre-test and post-test scores.

Intervention

The mindfulness/growth mindset intervention was implemented for the single class section, as detailed in Experiment 1.

Qualitative data collection (focus group)

As with Experiment 1, a randomly selected group of students from the treatment group ($n = 4$) participated in a focus group (students receiving intervention for two semesters: $n = 3$; students receiving intervention for one semester: $n = 1$). The students in Cohort 3, who were randomly selected for this interview, were a different set of students from Experiment 1. They were asked questions about whether the mindfulness/growth mindset intervention had an impact on math anxiety and math confidence. They were also asked to reflect on which aspects of the intervention worked well, and which aspects needed improvement. As this was the second focus group, we wanted to determine if any new themes had emerged as a result of receiving the intervention only during the second semester of the course (Cohort 1), or over the course of the entire year (Cohort 3). Furthermore, we were interested in identifying if there were any emergent themes that were consistent with what found in the previous semester.

Results

Response rates

There was a total of 16 students in the statistics class for the spring 2018 semester (Cohort 1: $n = 8$; Cohort 3: $n = 8$). For both the math anxiety assessment (RMARS), all 16 students completed both pre- and post-surveys, yielding a 100% rate. For the math self-efficacy assessment (MSES), all 16 students completed both pre- and post-surveys, also producing a 100% response rate.

Year-long analyses

We were particularly interested in the year-long effect of the intervention for those students who experienced it from the Fall 2017 semester to the spring 2018 semester. An analysis was conducted to examine our directional hypothesis that math anxiety decreased over the course of the year for groups of students from each cohort.

Sample characteristics

Pre-2017 and post-2018 RMARS scores were approximately normally distributed for students initially from Cohort 1 and Cohort 3 in the Fall 2017 semester (p's > .05). Histograms, normal Q-Q plots and box plots confirm normality so we proceeded to analyze the data using parametric tests.

Within-groups analysis (RMARS)

Math anxiety data responses revealed no differences were found for the Cohort 1 students, who had only received the intervention in the second semester, t (7) = .381, p = .715. However, for the Cohort 3 students, who had received the intervention for two semesters, the paired t-test revealed that anxiety was considerably reduced when comparing pre- scores (M = 2.61, SD = .702) to post- scores (M = 1.91, SD = .644), t (7) = 2.494, p = .041, d = .88, a large effect size (see Figure 2).

Math self-efficacy (MSES)

In examining the overall math self-efficacy, no differences were found for the year-long pre-test/post-test scores from the control group, t (7) = 1.899, p = .099, nor for the intervention group, t (7) = 1.690, p = .135. Although this result was not significant, we decided to run an *a posteriori* analysis on a particular

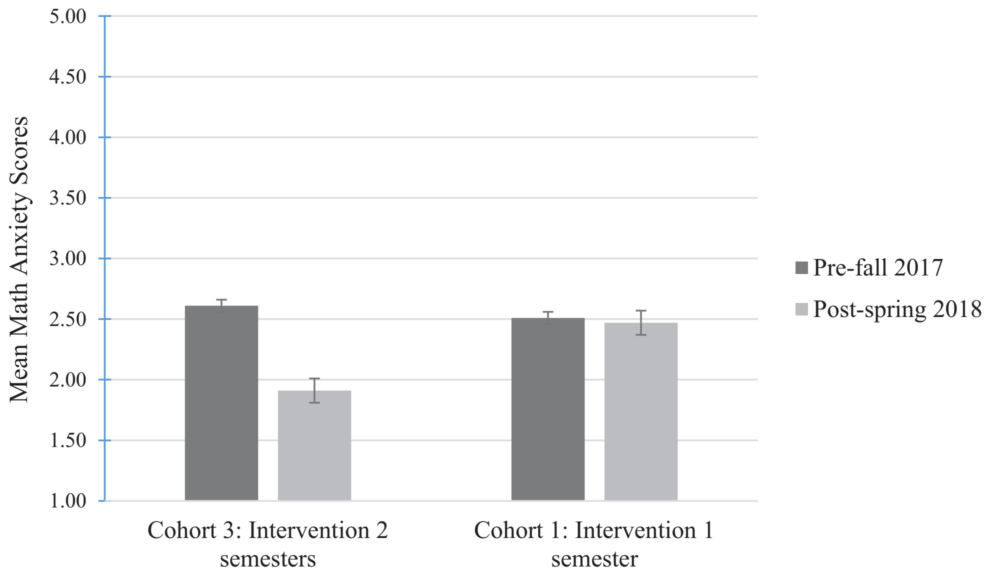

Figure 2. Mean pre-fall 2017 and post-spring 2018 math anxiety scores in a year-long statistics course: Cohort 3 (intervention for 2 semesters) vs. Cohort 1 (intervention for 1 semester).

question: *item 21*, an item on the *school subjects* subscale. Item 21 asks respondents about their confidence in earning an *A* or *B* as a final grade in statistics; thus, we determined further investigation was appropriate. Given that the students were taking a statistics course, it was important to examine whether students' (from Cohort 1 or Cohort 3) self-efficacy had changed over the course of the year for this particular class. A Shapiro-Wilk test was conducted and indicated that both the pre- and post-test scores for Cohort 1 were found to be non-normal (p = .18). Further inspection found that both distributions were kurtotic (−1.481; SE = 1.481 for both pre- and post-scores) but within the range with regards to skewness. However, distributions for Cohort 3 were normally distributed (p's > .05). A Wilcoxon signed-rank test indicated that confidence in statistics increased substantially for students who receive the intervention for two semesters when comparing Fall 2017 pre-scores (*Mdn* = 2.00) to Spring 2018 post-scores (*Mdn* = 5.00), $T = 3$, $z = -2.263$, $p < .05$, r = −.57, a large effect size. Even more interesting is that a similar trend was found for students initially in Cohort 1 who had only received the intervention in the second semester. Confidence in statistics increased from Fall 2017 pre scores (*Mdn* = 2.00) to Spring 2018 post scores (*Mdn* = 5.00), $T = 2$, $z = -1.930$, $r = .48$, also a large effect size. Figure 3 illustrates the within-data comparison of both cohorts.

Although significant within-group scores were found for both cohorts, post- math self-efficacy scores did not significantly differ between Cohort 3 (*Mdn* = 5.00) and Cohort 1 (*Mdn* = 5.00), U = 27.00, $z = -.531$, *ns*, $r = -.13$.

Qualitative data (focus group)

The focus group interview was conducted after the intervention was completed. As with Experiment 1, thematic content analysis was used to analyze the qualitative data. The thematic content analysis yielded four themes that were related to the effectiveness of the intervention, and participant receptivity of the intervention. Of note were two themes related to the dependent measure in the quantitative data – *low math test anxiety* – a new emergent theme compared to the previous semester:

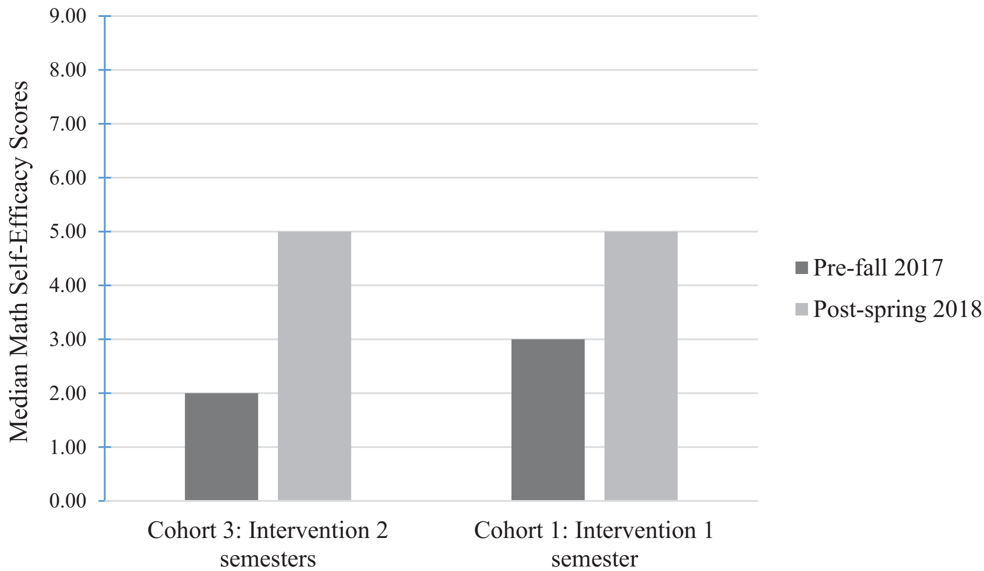

Figure 3. MSES Item 21 (*confidence in statistics*): Median pre-fall 2017 and post-spring 2018 math self-efficacy scores in a year-long statistics course.

Low math test anxiety

Students reported having lower math test anxiety as a result of the intervention, which supports the quantitative data. When asked about their perceptions about the deep breathing exercise, one student remarked:

> Math is not a problem to me, but when it comes to like tests, I'm not good with tests. So that's when anxiety comes in, and it's just like my brain goes, 'Whoo' … so it's just like I only do the deep breathing when it's time to take tests, like whenever I'm taking a quiz, test, it's just like I have to.

Confidence in math

Students made many statements about how the intervention increased their confidence in math. When asked about what they felt about saying the positive affirmations, one stated the following:

> I feel like it improved my confidence in math. I still like the positive sayings to help me get through the class. But stats I'm very confident with myself. Like anything you give me in stats I know I'm going to get it done like I'm very confident to the point that … I really love stats. I don't know and it's surprising to me because I used to hate math … and like now … I like something to challenge my brain, and I like stats because it challenges me.

It is also important to note that two other themes that emerged were the same as those identified at the end of the previous semester – *calm start to class, and routine.*

Calm start to class

When asked about the deep breathing exercise, students made comments stating how the activity created a calm setting at the beginning of class. One student responded:

> … because it's the first thing we do every class … so it helps us break in and ease like whatever's going on at home or whatever happened prior. It's like, 'Ok, now you're in a math class, try to relax and try to get through this' so it really helps calm your other thoughts and stuff and focus on math.

Routine

Participants were asked about the routine nature of the intervention. In particular, students made statements about the effects of saying the positive affirmations every class session: "Since you're saying it [consistently] every single day, you're going to remember it and since you remember it you feel like it's actually true."

They were also asked a probing question about the extent to which they found intervention frustrating to participate at times. Some stated that the routine made it difficult to engage in the intervention on days when they were not in the mood (*"Sometimes it's too repetitive, it's like can we just get to the lesson?"*); however, there was consensus among the participants that this frustration happened infrequently – that they generally enjoyed participating in the intervention, and found it helpful.

Since the data was obtained from a different randomly selected group of students compared to the first semester, it is remarkable that the themes *calm start to class, and routine* remained consistent across semesters. These themes appear to be central attributes of the intervention that students deemed effective.

Discussion

The present research is the first of its kind to address both anticipation and execution math anxiety by embedding a combined mindfulness and growth mindset intervention in a mathematics classroom. First, a semester-long analysis was conducted to examine the effect of the intervention in a standard course section period. Results suggest that students who received the intervention reported lower math anxiety scores and increased math self-efficacy scores by the end of the semester. The qualitative data supports this finding, with students expressing that the intervention helped class begin class with a fresh start and gave them a boost of confidence throughout each class session and over the course of the semester. The year-long findings produced similar results: math anxiety declined in students who received the treatment over the course of the entire year. Although the analysis did not produce significant gains in overall math self-efficacy, the particular question (item 21) assessing *confidence in statistics* revealed that students reported a surge in confidence over the course of the year, which was later confirmed by the qualitative data from the focus group interview. A possible explanation for the non-significant finding in overall math self-efficacy may be related to the characteristics of the students in this particular sample, and the nature of the questions that were asked. Students in the sample are first-year students, who are required to take statistics in their first semester at Guttman Community College. The items within the Math Self-Efficacy Scale assess students' perceived performance on math problems related to everyday life, college-level problems, and their confidence in math-related subjects. Perhaps the items in the MSES asking about confidence in math problems that were specifically related to algebra (e.g. *how long it would take to travel from Columbus to Chicago driving at 55 mph?*), or questions asking them about their confidence in math-related college subjects other than statistics (e.g. *zoology, biochemistry*) were not as salient to them in the context of the statistics course. Nevertheless, whether students received the intervention for two semesters, or only experienced it the second semester, both reported a significant increase in their confidence in statistics (Item 21). In examining the within-groups pre- to post-data, students who had received double the treatment experienced a greater increase in confidence in statistics (a median increase of three points) by the end of the year compared to students who received the treatment only once (a median increase of two points).

The themes from the focus group at the end of the spring 2018 semester substantiated the dependent measures from quantitative data in which students felt "less anxious" and "confident." Furthermore, the other 4 themes were themes also found from the first focus group at the end of the Fall 2017 semester (instructor's role in authorizing and participating with class makes a difference, deep breathing is a calm, fresh start to class, routine, and sense of control). For students, the intervention was especially effective when it was routinely implemented, with the instructor providing a directive for students to participate, with the instructor participating along.

The pilot research was conducted to determine if the intervention was effective on a smaller scale before replication and expansion to other courses. Although normality assumptions were met and medium to large effect sizes were found, limitations of the present research include the small sample size ($N < 30$) at recruitment in the Fall 2017 semester, and subsequent attrition in the spring 2018 semester. Therefore, we reserve caution in generalizing significant findings of the intervention to other statistics and math courses. Replication of this pilot research with a large sample size is warranted in an effort to increase both power and ecological validity.

Student retention is a critical goal for community colleges, and remains to be one of the predictors of an academic institution's sustainability and success. For first-year students who do not place in credit-bearing math courses, passing developmental math courses is a graduation requirement. Persistence, resilience, and successful completion of these courses are essential to ensure that these students stay on track to graduate. However, math anxiety, a psychological contextual barrier that affects many students, is negatively correlated with high-stakes mathematical performance (Ashcraft & Krause, 2007; Richardson & Suinn, 1972). Examining the underlying mechanisms that generate math anxiety and how anxiety manifests in students when they are in the math classroom is crucial before designing interventions. In educational contexts, symptoms of math anxiety in students seemingly occur only when students are presented with math problems (e.g. students reporting that they "blank out" when taking an exam). However, psychophysiological research suggests that the same areas of the brain that are activated when experiencing physical pain are also activated when students are anticipating a situation that involves math. This anticipatory anxiety causes them to think negatively about their mathematical ability, is more severe than execution anxiety, and occurs long before students are asked to work on actual math problems. Tackling this problem warrants addressing both anticipation and execution anxiety phases in math situations with an approach that is easily accessible to students.

Math anxiety presents an obstacle to learning and persisting in many STEM-related subjects, which could have profound academic consequences for community college students. The current pilot research study used a mindfulness and growth-mindset self-affirmation approach within a community college classroom environment in a sample of students taking a two-semester developmental statistics course. The intervention was particularly designed with the intention to assist in regulating math anxiety and increase self-efficacy in first-year students. Mindfulness was implemented at the beginning of the class in an effort to reset the classroom energy, create a fresh start, with emphasis on leaning in to the present moment to minimize apprehension. Growth mindset affirmations were then stated aloud so that students could reprogram fixed mindset thinking related to math before math problems were presented to them. Furthermore, mindfulness and growth mindset thinking and behavior were reinforced throughout the class session to sustain the relief of anxiety during the execution phase. With the medium to large effect sizes, the classroom intervention was more effective for the students receiving the intervention for two semesters than for those receiving the intervention for one semester. As the results indicate, routine application of the intervention with instructor participation created a transformative experience for these students, as they began to make positive associations with math, causing reduced anxiety and a boost of confidence in doing math problems.

Future research seeks to replicate the study to confirm the validity of the findings in statistics courses with different instructors. Additionally, student exam grades will also be assessed to determine if the intervention contributes to increased student performance. Another objective is to examine the extent to which the results are generalizable to various STEM courses (e.g. quantitative reasoning, economics, and information technology) that have been stigmatized by students as being extremely difficult. In these new contexts, the elements of the methodology (e.g. positive affirmations) would be customized for each individual course.

Furthermore, it would also be informative to assess the extent to which the intervention was a transformative experience for the participating instructors with regards to anxiety reduction and increased confidence as they teach students. For instance, research suggests that students can internalize math anxiety displayed by their own teachers, resulting in poor math achievement (Ramirez, Hooper, Kersting, Ferguson, & Yeager, 2018). Pre-service teachers who reported experiencing negative behaviors displayed by their math teachers revealed that these behaviors were seemingly based on their teachers' frustration toward their students' math anxiety (Jackson & Leffingwell, 1999). Math scores in female students also tend to be substantially low if they were taught by highly math-anxious female teachers (Beilock, Gunderson, Ramirez, & Levine, 2010). Therefore, instructors who teach math courses should also be mindful that their own conscious and unconscious expressions of anxiety could negatively affect students, and should consider valid techniques for their own professional development.

Institutional efforts to increase students' academic achievement by primarily focusing on developing and modifying educational programs without consideration of also addressing psychosocial issues is highly problematic. According to Pedrelli, Nyer, Yeung, Zulauf, and Wilens (2015), the onset of some mental health issues tend to appear in the early college years, and symptoms are exacerbated by financial difficulties, family obligations, and stressors associated with academic life related to fear of academic failure. In fact, national data from the Center for Collegiate Mental Health indicates that since 2013, anxiety has remained as the highest ranking concern for college students (Center for Collegiate Mental Health, 2017; see also 2015–2018 reports). Furthermore, preliminary results from a recent report by the City University of New York (Freudenberg, Watnick, Jones, & Lamberson, 2018) have identified that mental illness is the most pressing concern that students attending public colleges in New York City face. Wellness centers and other clinical initiatives have been established in many colleges to ameliorate mental health issues affecting students. However, students who typically utilize these services are either less likely to find therapy stigmatizing, or have been referred by a concerned instructor. One way to address academic-specific anxiety is to incorporate psychological techniques that have been proven to be successful into the classroom setting. If replication studies with a larger sample size validate the pilot study findings, the innovative approach in the current research could have far-reaching implications. Although the intervention should not be considered as a substitute for clinical counseling, it does carve out time and space in the classroom in which students can relieve stress, focus on the present moment, and minimize constant rumination on anticipating failure in their math class. Addressing stigma as a barrier to psychiatric treatment has been quite difficult for clinicians (Sibicky & Dovidio, 1986); however, students who are reluctant to seek clinical help for math anxiety could find some therapeutic value in a technique that is embedded within instruction. For short-and long-term academic periods, the intervention used in the present research was an effective, yet inexpensive method for the sample of students taking the statistics course. Math can be a difficult subject, and for many students, negative associations with math have been reinforced for many years, causing debilitating anxiety. Modifying the psychological experience in the math classroom by providing support targeting anxiety during the entire class session with an approach that promotes positive thinking, capability to learn, and the importance of effort could help to build mathematical resilience in first-year community college students.

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Appendix 1. Daily Growth Mindset Positive Affirmations

On non-exam days:

(1) Professor Samuel believes I can understand today's lesson.
(2) I am capable of understanding math.
(3) Today's lesson might be challenging, but I'm up for the challenge.
(4) I expect to make mistakes today, and then learn from those mistakes.
(5) Math is beautiful when I see how it all fits together.

On exam days:

(1) I know I am capable of doing well on this exam!
(2) I've got this!