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Expressive Writing as an Intervention for Math Anxiety in Middle School Students

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Introduction

There is an increasing call for students to pursue college degrees and careers in science, technology, engineering, and mathematics (STEM). The demand for STEM occupations is growing, yet the number of students choosing STEM fields is declining. This may be due to the fact that many science, technology, and engineering endeavors rely heavily on the application of mathematics, and as a result, many students are veering away from math-related subjects (Beilock & Maloney, 2015; Luttenberger et al., 2018). As pressure and mandates continue to be placed on educators to develop math-competent individuals who can meet increasingly more rigorous standards at earlier grade levels, the unintended side effect among students with math anxiety may be the continued dislike and avoidance of the subject. The problem compounds as students encounter more complex math in middle school, high school, and college, lowering performance and increasing avoidance (Beilock & Maloney, 2015; Hirvonen et al., 2012). Yet, math anxiety does not simply disappear after high school and college. Hart and Ganley (2019) demonstrated that mild to moderate math anxiety was prevalent for the majority in a sample of 1,000 surveyed adults.

Math anxiety can originate as early as elementary school, and if left unchecked, may compound over time. By the time students with math anxiety choose college majors and careers, they tend to avoid fields that are based on math. It is estimated that as many as four out of five students in community college and one out of four students in four-year programs suffer from math anxiety (Beilock & Willingham, 2014). The end result is a significant lack of professionals in science, technology, engineering, and math (STEM) fields, such that Beilock and Maloney (2015) called it a "STEM crisis" and suggested math anxiety is to blame (p. 5). The historical view has been that many students with math anxiety do not lack in actual skill, but that their poor

math performance can be attributed to their avoidance of the subject altogether (Tobias, 1987; Tulock, 1957). Recent studies have examined the relationship between numerical processing ability and the subsequent onset of math anxiety. Findings have suggested that a deficit in what is described by Dehaene (1997) as "a direct intuition of what numbers mean" (pg. 5), commonly referred today as "number sense" (pg. 5), is not only related to lower math performance, but may be a factor in the later development of math anxiety (Lindskog et al., 2017). Further, Moscoso et al. (2020) suggested a strong correlation between higher levels of math anxiety and less acute number sense. Because numerical intuition begins developing in infancy, addressing the ability early on may be key to mitigating and preventing the onset of math anxiety (Xu et al., 2005).

Attempting to address math anxiety by the time a student is in college may be too late. What is needed is more understanding of the original causes of math anxiety and practical strategies to prevent, reduce, and remove the factors that contribute to its effects. Although it is often difficult to pinpoint a single event or issue that initiates math anxiety, it is known that both cognitive and social factors work in conjunction to start and perpetuate the problem. Genetic predisposition, whether as an actual math-learning disability, a weakness in spatial reasoning, or a tendency to worry, is believed to contribute, along with parental and teacher influences and the nature of learning math itself (Eden et al., 2013; Finlayson, 2014; Geary et al., 2017). Further research indicates that teachers' classroom management and instructional practices are an integral part of the math anxiety equation. Deieso and Fraser (2019) suggested that when the quality of the learning environment decreases, negative attitudes towards math and math anxiety increase. Because math anxiety has such an impact on students across a broad spectrum of grade levels, today's educators are tasked with how best to understand, mitigate, and prevent math

anxiety (Bosmans & De Smedt, 2015; Jameson & Fusco, 2014; Maloney & Beilock, 2012; Novak & Tassell, 2017).

Math Anxiety

Math anxiety can be defined as "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (Richardson & Suinn, 1972, p. 551). It is distinct from both general anxiety and test anxiety, though there are common characteristics among them. Math anxiety is more than just nervousness regarding math, it is a complex condition that involves social, cognitive, and physical factors (Ashkenazi & Denan, 2017; Ramirez et al., 2018). Attitudes, ideas, stereotypes, learning issues, and behaviors that adversely affect how a student learns and experiences mathematics create a perfect storm that causes significant physiological responses.

Teachers and Parents Influence Math Anxiety

It has long been known that teachers have considerable influence on the development of math anxiety in students. An unwillingness to repeat an explanation for a concept, a negative attitude toward a student asking a question, a heavy reliance on repetition and drills for instruction, or a personal struggle with math anxiety (particularly for female elementary teachers) have been shown to instigate math anxiety in students (Jackson & Leffingwell, 1999; Ramirez et al., 2013; Ramirez et al., 2018; Stent, 1977).

It appears that female students of female teachers are particularly vulnerable to developing math anxiety (Chernoff & Stone, 2014). Negative emotions and attitudes associated with math unwittingly exhibited by a math-anxious female teacher can be adopted by her female students. This includes stereotyped beliefs regarding girls and mathematics (Gunderson et al., 2012).

But the responsibility does not fall on teachers alone. Parents influence their children to have math anxiety as well. Parents with math anxiety who demonstrate negative feelings for, or voice negative opinions of math, contribute to and can worsen math anxiety in their children (Casad et al., 2015; Maloney et al., 2015; Soni & Kumari, 2017). The issue of stereotypical ideas of girls and math is also present in parents, namely, mothers. Tomasetto et al. (2015) suggested that a mother who does not think her daughter can succeed in math as well as boys creates the same belief in her daughter.

However, parents and teachers can also be instrumental in both preventing and reducing math anxiety. When parents engage in positive math conversations with their children, less math anxiety results (Soni & Kumari, 2017). In the classroom, less emphasis on time, a positive mindset, feedback, and flexible problem-solving techniques can help mitigate and reduce the onset of math anxiety (Chernoff & Stone, 2014; Núñez-Peña et al., 2015; Ramirez et al., 2016). A positive attitude toward one's own ability to learn and do math can also have a significant impact for avoiding and overcoming math anxiety. Self-efficacy in math has been suggested as one of the most prominent factors in the development of math anxiety (Jameson, 2014). Justicia-Galiano et al. (2017) agree that math self-efficacy, along with working memory, are influential in how math anxiety affects performance. As teachers work to counter math anxiety and its effect on student learning and achievement, these findings warrant consideration.

Expressive Writing

A relatively new approach used to address math anxiety is expressive writing. Expressive writing has been shown to be effective for reducing math anxiety in college and high school students (Hines et al., 2016; Maloney et al., 2014; Park et al., 2014). Expressive writing is an exercise in which an individual writes for a specified period of time for one or more instances

about his or her emotions and thoughts associated with a stressful experience or situation (Smyth & Pennebaker, 2008; Travagin et al., 2015). It often involves writing about feelings connected to a traumatic, hurtful, or stressful experience or situation (Pennebaker & Beall, 1986). The length of time spent writing can vary. However, expressive writing appears to have positive benefits regardless of the length of time and the number of writing occurrences. Perhaps one of the most compelling examples of the effectiveness of expressive writing comes from Burton and King's "Two-minute miracle" (2008), in which only two expressive writing sessions of two minutes each showed significant improvements in health for undergraduate participants.

Travagin et al. (2015) demonstrated that participation in expressive writing resulted in significant improvement in overall school performance for adolescents, and especially for adolescents with psychological problems. Expressive writing has also been shown to help middle school students reduce peer-related anxiety when used with a cognitive focus and improve their self-concept as they transition to high school (Facchin et al., 2013; Travagin et al, 2016). In addition, expressive writing has been shown to be a successful intervention in lowering math anxiety in college and high school students. Park et al. (2014) and Hines et al. (2016) found that expressive writing helped to reduce math anxiety's influence, resulting in better performance on math tests for college and high school students. This may be attributed to the effect expressive writing has on working memory resources. Studies have suggested that expressive writing can activate brain processes associated with working memory–cognitive functions that math anxiety inhibits (Alparone et al., 2015; Kellogg et al., 2010; Passolunghi et al., 2016).

Theoretical Orientation

Perhaps what makes expressive writing effective at reducing the effect of anxious thoughts and creating objectivity is that it also allows for a mental re-framing of a stressful

situation. Alparone et al. (2015) suggested that when expressive writing is employed, a true change in cognition occurs regarding the source of stress or anxiety, and outlook improves. This may also explain how expressive writing has helped delinquent adolescents increase their belief in their resilience to be successful after their detention (Greenbaum & Javdani, 2017). Expressive writing promotes behaviors related to resiliency that improves self-efficacy (Schumann & Sibthorp, 2016; Tavil, 2014). Expressive writing may serve as an opposing force to math anxiety because it increases self-efficacy. Thus, self-efficacy provides a theoretical basis for the current math anxiety intervention. When an individual engages in expressive writing, self-reflection and metacognition occur as the individual writes about anxious, stressful, or hurtful feelings and emotions related to an experience or situation. The placement of feelings on paper provides the individual a more objective viewpoint that helps reduce the effects of the negative emotions that typically arise from a hurtful experience (Kellogg et al., 2010; Klein & Boals, 2001). Because expressive writing helps mitigate such adverse emotions, it may prove to be effective, much like a positive stimulus that can reduce the effects of a negative one (Miller, 2016). The nature of expressive writing that promotes metacognition and addresses emotional influences on learning may prove to be an essential factor for math anxiety due to its positive impact on self-efficacy.

Methodology

A pretest-posttest control group design with random assignment was used to investigate the effectiveness of expressive writing on the math anxiety scores of middle school math students in East Texas. The study examined two research questions: Is there a significant difference between the mean math anxiety scores of middle school students who participate in an expressive writing activity and those who do not participate while controlling for pre-existing

math anxiety? Is there a significant difference between the mean math anxiety scores of male and female middle school students while controlling for pre-existing math anxiety?

The population for this study consisted of 800 students in grades seven and eight from a public school in East Texas. Each of the 40 students (10 males and 30 females) from the sample of seventh-grade students was randomly placed in either the treatment group (n = 18) or the control group (n = 22). Participants in both groups completed pretest and posttest surveys that collected demographic information and included the Modified Abbreviated Math Anxiety Scale (mAMAS) created by Carey et al. (2017). During the study, participants in both groups completed math journals each night for two weeks. The math journals for participants in both groups contained questions asking for the date, number of homework problems assigned, and the due date. The journals for the treatment group included an additional prompt that asked the student to write for at least one minute about how they felt about math that day.

Collected data were analyzed using the Statistical Package for the Social Sciences (SPSS) (Green & Salkind, 2017). Two one-way Analysis of Covariance (ANCOVA) tests were conducted at the .05 significance level.

Findings

Results for Research Question One

Research question one investigated the effect of expressive writing on math anxiety scores according to the group. The dependent variable, math anxiety score (adjusted means), was compared on each level of the independent variable, group (control–no expressive writing, treatment–expressive writing). The one-way ANCOVA showed the result was not significant $F(1, 37) = .064$, $p = .802$, $\eta^2 = .002$. There was not a statistically significant difference in adjusted mean scores between the treatment group and the control group.

Results for Research Question Two

The second research question investigated the effect of expressive writing on math anxiety scores according to gender. The dependent variable, math anxiety score (adjusted means), was compared on each level (male and female) of the independent variable, gender. A one-way ANCOVA determined there was no statistically significant difference between the adjusted means scores according to gender $F(1, 37) = .484$, $p = .491$, $\eta^2 = .013$.

Discussion

This study investigated the effectiveness of an expressive writing intervention on the math anxiety scores of middle school students. An experimental, control-group design with random assignment and pretest and posttest was utilized to investigate the differences in math anxiety scores of students who participated in expressive writing and those who did not while controlling for pre-existing math anxiety. This study also examined the impact of gender on math anxiety levels while controlling for pre-existing math anxiety.

Research indicates that math anxiety affects students' learning, achievement, and later career goals (Chang & Beilock, 2016; Ramirez et al., 2016; Suárez-Pellicioni et al., 2016). By the time students have entered middle school, many, both male and female, have already acquired math anxiety from their parents and teachers, who themselves have math anxiety (Ganley and Lubienski, 2016; Hill et al., 2016; Maloney & Beilock, 2012). However, females appear to be especially susceptible due to stereotypical beliefs of society and the home. The literature suggests that mothers impose, however unwittingly, stereotyped ideas and attitudes regarding math onto their daughters (Casad et al., 2015; Tomasetto et al., 2015). Once students reach middle school, the negative impact of math anxiety is pronounced. These are the years when girls' performance in math begins to decline compared to boys (Gibbs, 2010).

The middle school years are also those in which mathematical concepts become more abstract. Some researchers have found significant connections between abstract concepts and working memory differences between males and females. They have suggested that males utilize visual-spatial working memory processes that support abstract thinking more than females, and these differences become more pronounced in the presence of math anxiety (Ganley & Vasilyeva, 2014). Thus, the numerous factors of the math anxiety equation combine to create an exodus of young adults (especially females) from math and math-based college majors and professional careers. The result is a shortage in society and the workplace in STEM careers and a pronounced gender gap in those areas (Beilock & Maloney, 2015; Goetz et al., 2013; Moakler and Minsun, 2014).

Much of the research has focused on examining the problem of math anxiety, its effect on students, and particularly female students, who experience greater levels of math anxiety even when their performance is equivalent to male student performance (Devine et al., 2012). Other research has uncovered evidence of math anxiety's impact on the brain, in regions of pain and fear, as well as working memory (Suárez-Pellicioni et al., 2016). Math anxiety is a complicated construct comprised of social, emotional, and cognitive elements (Ashkenazi & Denan, 2017; Ramirez et al., 2018). The multi-faceted complexity of math anxiety makes it a difficult problem to solve.

The goal of this research was to add to the body of knowledge by building on previous work investigating expressive writing as a potential intervention for math anxiety. Park et al. (2014) used a single, seven-minute expressive writing activity with college students just prior to a math test. Their results suggest a significant decrease in math anxiety levels for participants who completed the activity compared to participants in the control group who sat quietly for the

same amount of time prior to the test. Hines et al. (2016) implemented a three-day-long study in which high school students wrote for fifteen minutes each day about non-emotional topics (no expressive writing control group) or they wrote about their feelings regarding math (expressive writing treatment group). Their results indicate a decrease in math anxiety levels for participants in both groups, suggesting that feelings may come into play even in writing about neutral topics, and thus some anxiety may be released.

Expressive writing is grounded in the same theoretical framework as math anxiety that includes self-efficacy and social learning theory (Franceschini et al., 2014; Miller, 2016). This may explain why previous research has shown a significant impact on reducing math anxiety. Other research involving expressive writing has demonstrated that it may be more effective for males than females (Kirk et al., 2011; Klein & Boals, 2001). In addition, the literature calls for more research on expressive writing, and in particular with middle school students (Hines et al., 2016; Suárez-Pellicioni et al., 2016; Travagin et al., 2015).

Very few, if any, previous studies have been conducted that examine the use of expressive writing for math anxiety in middle school students. This current research was conducted to help fill the gap in the literature. The study included volunteer participants in the seventh grade from a public middle school in East Texas. Participants were randomly assigned to either the control group or the treatment group. Both groups took the Modified Abbreviated Math Anxiety Scale (mAMAS) as a pretest and posttest survey. During the study, all participants completed a math journal each night for two weeks. Journals for both the control and treatment groups contained three benign questions that asked for each day's date, the number of homework problems assigned for that day, and the due date for the homework, if any. The journals for the treatment group contained a fourth question that asked each participant to take at least one

minute and write how they felt about math for that day. The posttest was administered the day after the final day of student journaling.

Research question one addressed the impact of expressive writing compared to no expressive writing on math anxiety scores for middle school students. No significant results were found between the adjusted mean scores of participants in the control group (no expressive writing) and participants in the treatment group (expressive writing). The research failed to reject the first null hypothesis. This suggests that the expressive writing intervention did not significantly lower the math anxiety scores during the period of the study. These findings do not align with other existing research. However, a suggestion from Travagin et al. (2015) indicated that expressive writing might be counterproductive for middle school students unless conducted over an extended period of time and have a spacing of greater than one day in between writing instances. The current study was conducted over two weeks and involved a brief writing session of at least one minute that occurred each day of the study. The results show that the two-week time period did not have a significant effect on math anxiety levels. In addition, it is unclear from the literature what amount of writing time is most effective for expressive writing. Significant results have been found with single and multiple writing sessions lasting as few as two minutes and as long as fifteen minutes (Burton & King, 2008; Hines et al., 2016; Huang & Mayer, 2016; Park et al., 2014). However, these studies involved high school and college-age participants rather than middle school participants. Travagin et al. (2015) indicated that there might be benefits of expressive writing for adolescents, yet it was not definitive. The insignificant finding in this current study may be a result of the short amount of expressive writing time provided in the intervention. Further, middle school students might act differently than high school and college students, which may also explain the non-significant results of the current study.

The second research question addressed any differences between the adjusted mean scores according to gender. The results were not significant, and the research failed to reject null hypothesis two. Although the differences in adjusted mean scores between males and females were not statistically significant, it may be interesting to note that the number of female volunteer participants was three times the number of male participants. This result is in agreement with the literature that demonstrates how females experience more math anxiety than males (Dowker et al., 2016; Ferguson et al., 2015; Goetz et al., 2013; Stoet et al., 2016). The gender demographics of this study may add support to the premise that females suffer from math anxiety to a greater extent than males, and the difference is evidenced as early as middle school. The findings of the current study contradict literature, which proposes that expressive writing is effective for reducing stress and anxiety for both adolescent males and females (Horn et al., 2011; Shen et al., 2018). Boals (2012) noted that expressive writing could introduce anxious thoughts for individuals who are not experiencing stress or are not writing about a significantly stressful situation. However, Travagin et al. (2015) suggested that expressive writing may have either positive or negative effects on adolescents, depending on how they can manage and regulate negative emotions elicited by expressive writing. The results of this research indicate that expressive writing may not have had an effect at all. In all groups (control, treatment, male, and female), the adjusted mean scores were lower than the mean pretest scores.

Implications

This study adds to the growing body of knowledge of math anxiety and provides a response to the call for research for the use of expressive writing with middle school students (Suárez-Pellicioni et al., 2016; Travagin et al., 2015). The current research is perhaps the first study to investigate the use of expressive writing as an intervention to reduce math anxiety in

middle school students. The use of expressive writing, specifically for math anxiety, has only begun to be researched, and there are few other known studies that have been conducted. In those that have, however, the participants were college and high school students (Hines et al., 2016; Park et al., 2014). Thus, the findings of the current research are valuable for researchers and educators.

The literature is still unclear on which math anxiety interventions are most effective. Foley et al. (2017) called for more research to discover ways to reduce math anxiety's negative impact on learning and performance in the classroom. The results of the current study suggest that expressive writing may not be useful for some students of adolescent age, contradicting other literature that suggests that expressive writing may have benefit for all students (Hines et al., 2016; Shen et al., 2018).

This study also has implications for society. There still exists a shortage of individuals of both sexes in science, technology, engineering, and math (STEM) fields (Beilock & Maloney, 2015). There is an even greater lack of females in these areas that is attributable to the issue of math anxiety and stereotype threat (Maloney et al., 2013). The problem of math anxiety has been shown to manifest at early ages, with a significant decrease in female performance evidenced by the time students enter middle school (Gibbs, 2010). The non-significant results of the current study suggest that expressive writing may not be effective for reducing math anxiety among female or male middle school students.

Recommendations for Future Research

Several avenues of research related to the current study are recommended. This study was conducted at a single middle school. Thus, a larger study involving several schools that use

different teaching methods may prove useful. Boaler (2014), Greenwood (1984), and Ramirez et al. (2018) contended that teaching methods had been shown to be a contributing factor to the cause and continuance of math anxiety. Therefore, more research involving varied teaching methods is recommended.

Another suggestion for future research includes working memory. Studies indicate that not only does math anxiety hinder working memory, but it appears to target visual-spatial working memory processes. According to Maloney et al. (2012), there is a distinct difference in the use of visual-spatial memory processes between males and females. Interventions that target visual-spatial learning may prove useful in adding to the body of knowledge in math anxiety and in math anxiety in females.

Finally, more research in the use of expressive writing is also recommended. Travagin et al. (2015) posited that varied writing times and greater spacing between sessions might alter how effective expressive writing is for adolescents. Since the current study is one of the first to utilize expressive writing for math anxiety in middle school students, more research is needed. Writing sessions of varying lengths spread out during a school year may yield different findings. Previous math anxiety studies involving college students utilized expressive writing just before a math test (Park et al., 2014). This strategy would also be a valuable avenue to explore with middle school-aged students. More research on the effectiveness of expressive writing for math anxiety in middle school students may provide deeper understanding of how math anxiety impacts middle school students and particularly female students.

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Appendix

Results for Control and Treatment Groups $F(1, 37) = .064$, $p = .802$, $\eta^2 = .002$

Results for Male and Female $F(1, 37) = .484$, $p = .491$, $\eta^2 = .013$

Table 1. Findings for one-way ANCOVAs between groups ($p < .05$)

Group	*N*	Pretest Mean Score	*S.D.*	Posttest Mean Score	*S.D.*	Adjusted Mean Score	*S.E.*
Control	22	25.18	7.17	23.09	7.48	23.511	.820
Treatment	18	26.22	7.67	24.33	7.85	23.820	.907
Male	10	23.50	7.88	21.00	8.06	22.911	1.221
Female	30	26.37	7.12	24.53	7.33	23.896	.700