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Expressive writing interventions for pre-service teachers' mathematics anxiety

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ABSTRACT

Many pre-service teachers suffer from mathematics anxiety, which hinders their mathematics learning. This can cause a deficit in their mathematics content knowledge, which must be addressed to become effective mathematics teachers. The present study explored whether positive expressive writing was better at mitigating pre-service teachers' mathematics anxiety than general expressive writing. Expressive writing is emotional writing, which was shown to be successful in medical fields to reduce anxiety and more recently in the field of education. In contrast, research on positive expressive writing has recently shown beneficial results for treating test anxiety. Therefore, the potential for positive expressive writing in reducing mathematics anxiety was examined in this mixed methods study involving 27 pre-service teachers enrolled in a hybrid (i.e., half of the instructional time was in-person, while the other half was online) mathematics for teachers course. Participants were randomly assigned to one of three writing groups (positive expressive, expressive, and neutral) and completed pre- and post- measures of mathematics anxiety using the abbreviated mathematics anxiety rating scale at time 1 (beginning of course), time 2 (mid-term examination), and time 3 (final examination). In addition, participants completed a measure of their mathematics ability at the beginning of the course and then proceeded to engage in the three types of writing at the beginning of each of the nine consecutive classes. Although results did not show a significant difference between the three writing groups (positive, expressive, and neutral) and mathematics anxiety, there was a significant relationship between pre-service teachers' mathematical ability and measure of mathematics anxiety taken at the mid-term examination. This strong negative relationship demonstrated that pre-service teachers with low mathematics ability have high mathematics anxiety. Valuable insights were gained into mathematics anxiety effects on pre-service teachers, as well as contextual factors in terms of writing.

Keywords: expressive writing, positive expressive writing, mathematics anxiety, pre-service teachers

INTRODUCTION

Pre-service teachers are responsible for teaching the next generation of leaders. These leaders will require strong skills in the areas of critical thinking, problem solving, and communication to forage ahead into new frontiers in science, technology, engineering, and mathematics (STEM) that are necessary to solve New World problems (Breiner et al., 2012; Xie et al., 2015). A National Council of Teachers of Mathematics (2018) discussion paper emphasized the importance of strong competency in mathematics for students who will work in STEM fields. This competency will enable students to navigate future demands in the workforce. Mathematics can be conceptualized as the underlying component to STEM given that technology, engineering, and science rely heavily on mathematical concepts. Subsequently, students with deficits in mathematics and by extension, deficits in all STEM domains, are likely to experience difficulty in pursuit of STEM careers such as health care, where during the COVID-19 storm between 2019 and 2022, society was made aware, first-hand, of a shortfall of skilled workers in health care. The barrier preventing people from entering careers in health care is predominantly due to a deficit in mathematics (Jarvis et al., 2015). The importance of STEM careers and the integral connection of mathematics necessitates building a stronger student population equipped with understanding in mathematics beyond what is required in basic daily mathematics skills. Graduating students with high competency in mathematics becomes problematic given that pre-service teachers who graduate to become teachers, have a deficit in mathematics themselves and these future teachers, shape the next generation of scientist, technologist, and healthcare workers (Mewborn, 2001; Wu, 2009).

The issues raised above were drawn from research published in 2001, 2009, and more recently in 2015 (Hine, 2015); all revealing that pre-service teachers have continued to struggle with mathematics. Unfortunately, little is written in this field undoubtedly for many reasons, one of which may be because it is difficult for pre-service teachers to self-report low competency in mathematics

given that they should be highly competent in mathematics to be effective teachers (Wu, 2009). This goal towards developing competency in mathematics is compounded given that many pre-service teachers have mathematics anxiety (Baloglu & Kocak, 2006; Bessant, 1995; Hembree, 1990; Novak & Tassel, 2017). This deficit in mathematics becomes more alarming given that teachers with low ability or who are anxious in mathematics are likely to pass their anxiety to their students. Subsequently, these teachers become ineffective in teaching children the depth and breadth of mathematics that is required in the curriculum (Luttenberger et al., 2018).

Mathematics anxiety has been shown to be a factor influencing teachers' inability to develop competency in mathematics (Hembree, 1990; Novak & Tassell, 2017). Too often pre-service teachers leave teacher training programs without any intervention addressing their anxiety or their own mathematics ability, which hinders their effectiveness as mathematics teachers. As careers in the STEM fields advance, so to must students' mathematics abilities. For that to happen, we must address teachers' shortfall in mathematics ability and one strategy is to address their mathematics anxiety (Finlayson, 2014; Foley et al., 2017).

Mathematics anxiety refers to an individual's apprehension and fear that arises when he or she is asked to perform a mathematics task (Ashcraft, 2002). Mathematics anxiety affects individual's achievement in mathematics by causing a cognitive disruption to his or her working memory (Maloney & Beilock, 2012; Passolunghi et al., 2016; Shi & Liu, 2016) or an affective disorder which results in emotional and physiological effects such as rapid heartbeat, sweating, and nausea (Liebert & Morris, 1967; Lyons & Beilock, 2012; Park et al., 2014; Pizzie & Kraemer, 2017). Both of these dimensions can hinder an individual's ability to perform a mathematical task or computation, which in the case of pre-service teachers, can affect their ability to learn mathematical content knowledge which precedes learning about the pedagogical approaches to teaching mathematics (Thames & Ball, 2010). Basically, teachers must be competent in mathematics content before they learn mathematics pedagogy (Ball et al., 2008; Hine, 2015; Senk et al., 2012).

One method to reduce mathematics anxiety is through writing, in particular, expressive writing. Expressive writing is writing one's thoughts and feelings about a stressful or traumatic event without the usual concern for writing conventions (Pennebaker, 2004; Pennebaker & Beall, 1986). Expressive writing has been investigated in the medical field with success in anxiety and mood disorders patients (Baikie et al., 2012; Burton & King, 2008), as well as in psychiatry where patients suffering from trauma have experienced positive health results (King & Miner, 2000). Expressive writing has also been studied in the context of test anxiety as an effective intervention (Doherty & Wenderoth, 2017). Recently, the use of *positive* expressive writing as a strategy to reduce testing anxiety has also shown beneficial results (Shen et al., 2018). Positive expressive writing refers to writing that focuses on intensely positive experiences or situations in one's life (Burton & King, 2008; King, 2001). This is in contrast to expressive writing, which directs the individual's attention to general experiences and feelings which are often negative, while neutral writing guides the individual to write factually without emotional response. Despite the use of expressive writing and positive expressive writing in medical research and psychological fields, there is scant research on expressive writing in the education field, in particular, its use with pre-service mathematics teachers as a treatment for mathematics anxiety.

Purpose

Hence, the purpose of this study was to determine whether positive expressive writing is more beneficial than expressive writing at alleviating mathematics anxiety in pre-service teachers. Given the previous medical studies cited above, success treating mathematics anxiety using expressive writing and the recent successful research study by Shen et al. (2018) with positive expressive writing working as a treatment strategy for test anxiety, this study considered the possibility of different forms of writing having an impact on pre-service teacher's mathematics anxiety.

LITERATURE REVIEW

Theory of Mathematics Anxiety

The theory underpinning mathematics anxiety has been studied for several decades. Hembree (1990) conducted pivotal work in the 90's synthesizing research in this field showing the link between high mathematics anxiety and low mathematics performance, which can ultimately cause the individual to avoid mathematics. Hembree (1990) showed a strong relationship between mathematics anxiety and mathematics avoidance at the pre-college level. Despite these findings, Hembree (1990) concluded that treatments, such as behavioral-cognitive therapy were effective in reducing mathematics anxiety returning the individual's performance level to the equivalent of an individual with low mathematics anxiety. Stemming from Hembree's (1990) research, researchers have continued to examine different theories explaining mathematics anxiety (Ashcraft & Faust, 1994, 2002; Ashcraft & Krause, 2007; Ramirez et al., 2018). These theories have focused on three major determinants of mathematics anxiety which are described as: cognitive/affective factors (Ashcraft & Krause, 2007; Maloney & Beilock, 2012; Passolunghi et al., 2016), social factors (Jakobsson et al., 2013, Ho et al., 2002), and genetic factors (Wang et al., 2014); each of these factors help to solidify a research framework for mathematics anxiety. Another factor proposed most recently was that of *missed opportunity* (Brewster & Miller, 2020).

Anxiety due to

> "*missed opportunity* would account for individuals who measure high in other academic domains but display evidence of mathematics anxiety because they missed (for any reason) opportunities to learn mathematics" (Brewster & Miller, 2020, p. 7).

Missed opportunity could also occur due to low mathematics content knowledge by the teacher which impedes his or her teaching practice causing the teachers' students to miss necessary mathematical knowledge for future learning. Given the impact of mathematics anxiety on student learning, it is imperative that pre-service teachers with mathematics anxiety be provided with intervention strategies to alleviate their mathematics anxiety so they can focus on the content and pedagogy to become effective mathematics teachers (Finlayson, 2014; Novak & Tassell, 2017).

Pre-Service Teacher's Mathematics Ability

Pre-service teachers who struggle with mathematics tend to have high mathematics anxiety combined with lower mathematics achievement scores (Linsell & Anakin, 2012; Novak & Tassell, 2017). Pre-service teachers' deficit in mathematics was highlighted in a US educational policy paper that advocated a need for pre-service teachers to improve their mathematical content knowledge but also, in understanding the importance of learning about mathematics anxiety, its effect on their learning, and their teaching ability. This call for addressing pre-service teachers' deficit in mathematics was made in response to the growing demand for graduates in the STEM fields (Beilock & Maloney, 2015). If pre-service teachers' deficit in mathematics is not addressed, they are likely to enter the teaching profession and research has shown that teachers with poor content knowledge are less effective in helping their students achieve in the mathematics classroom (Hill & Schilling, 2008; Rowland & Ruthven, 2011).

The deficit in pre-service teachers' mathematics ability is possibly the effect of negative past experiences in the mathematics classroom which can have long lasting effects. Studies have shown that pre-service teachers who experienced difficult and troubling experiences in learning mathematics carry those experiences with them (Bekdemir, 2010; Vinson, 2001; Wilson, 2013). As Bekdemir (2010) reported in an extensive study with 167 pre-service teachers, whose prior mathematics learning was marred with unfavourable memories and also had an increased level of mathematics anxiety, attributed their deficit directly to negative past experiences. Subsequently, pre-service teachers' increase in mathematics anxiety impaired their ability to learn new concepts in mathematics that was necessary to achieve a firm grasp of mathematics content knowledge which made it difficult, perhaps even impossible to understand the pedagogy of mathematics (i.e., how to teach mathematics).

When teachers are left to struggle with mathematics, they tend to adopt an algorithmic approach to solving mathematics questions which involves memorizing the steps to solve mathematics questions without really understanding the meaning behind the steps (Reid & Reid, 2017; Thames & Ball, 2010). The memorization of algorithms is not how mathematics should be taught or learned (Ball et al., 2005). Teachers must develop a deeper conceptual understanding of mathematics to truly understand mathematical concepts and to be effective mathematics teachers (Ball et al., 2008).

Pre-service teachers' deficit in mathematics could also be a result of mathematics anxiety which may be attributed to missed opportunities to learn foundational concepts in mathematics in their own kindergarten to grade 12 schooling given that pre-service teachers could otherwise be classified as high achieving students (Brewster & Miller, 2020). It is therefore reasonable to surmise that pre-service teachers who do not receive intervention in mathematics may become teachers who have deficits in mathematics who then influence the next generation of students. This potentially causes a downward spiral where the teaching and learning of mathematics weakens every couple of decades between the time a student with poor mathematics skills becomes the teacher with poor mathematics skills who subsequently affects the next generation of students and teachers. An intervention is critical to prevent the potential of a downward spiral. Interventions such as mindfulness (Brunyé et al., 2013; LaGue et al., 2019), mastery-based teaching (Furner & Gonzales-DeHass, 2011), anxiety reducing computer-based programs (Huang & Mayer, 2016), and expressive writing have shown some impact on breaking the cycle. Given that expressive writing has had positive change in reducing anxiety in the medical field, it is possible that when used in the education field, similar results may be achieved.

Park et al. (2014) initiated research in the context of higher education utilizing expressive writing as a treatment strategy for 80 college students reporting mathematics anxiety. The experimental group were asked to write about their thoughts and feelings related to the emotional stressor caused by their mathematics examination that was to be written in the next few minutes. The control group were asked to sit and wait in anticipation of the mathematics examination. Findings revealed that students with high mathematics anxiety in the control group scored worse on the mathematics examination than students with low mathematics anxiety. Following the intervention, scores on the mathematics examination from the highly anxious mathematics students in the expressive writing group revealed a significant gain in their mathematics performance. This was indicative of a reduction in anxiety as a result of the expressive writing freeing up working memory reducing the difference between highly mathematics anxious students and low mathematics anxious students' performance on mathematics examinations. When students were able to express their worries, thoughts, and feelings prior to the administration of the mathematics examination, their performance improved which was aligned to Park et al.'s (2014) hypothesis. It is also important to note that these researchers reported that expressive writing by participants in the low mathematics anxiety group did not alter those students' performance results. The significant findings by Park et al. (2014) in support of expressive writing as an intervention to alleviate mathematics anxiety in highly mathematics anxious individuals set the foundation for this study. In addition, we extended this area of inquiry by investigating the impact of *positive expressive* writing as a more beneficial intervention for reducing mathematics anxiety than *expressive* writing in the context of pre-service teachers' learning of mathematics. Positive expressive writing directs the individual's attention away from feelings of stress and anxiety toward positive feelings and situations.

CONTEXT

This study was implemented in a bachelor of education program where students were studying to be teachers in kindergarten to grade six. A compulsory component of the program was a 10-lesson (three-hour classes each week), mathematics for teachers' course, which is a pure mathematics course focused on foundational concepts in mathematics and taught by modelling the

pedagogy pre-service teachers would learn about in the subsequent mathematics methods courses. In the first half of the course, pre-service teachers learned how to use base 10 blocks to model addition, subtraction, multiplication, and division and learned about other strategies to conceptualize these operations (e.g., addition or multiplication by decomposition of numbers, zero pairs to model subtraction of negative numbers). Students were then led to examine patterns in mathematics to discover common algorithms used in mathematics (e.g., to divide, just flip and multiply). Other manipulatives (e.g., fraction strips, decimal squares) were used to explore operations with fractions and decimals. Following five, three-hour lessons, students wrote a mid-term examination which has proven to be a stressor for the pre-service teachers given their deficit in mathematics. The second half of the course focused more on inquiry-based learning to discover concepts related to: two- and three-dimensional objects, angles, parallel lines, Pythagorean theorem, and foundational concepts in statistics. For example, students investigated the concepts of a circle and discovered the relationship between the circumference and diameter, as well as discovered the formula for area and circumference of a circle. The second half of the course is typically reported to be less stressful for pre-service teachers even though students wrote a final examination following the tenth lesson. Students do not use calculators in the course or on examinations and are required to explain the evolution of formulae before using them.

The research questions posed in this study were:

1. To what extent does positive expressive versus expressive writing have on reducing pre-service teachers' mathematics anxiety?
2. How does pre-service teachers' mathematics ability relate to mathematics anxiety?
3. To what extent did pre-service teachers engage in the journal writing?

METHOD

The proposed study employed a mixed methods research design involving surveys and journals. A 25-item, anxiety survey known as the abbreviated mathematics anxiety rating scale (referred to as A-MARS, SMARS, or RMARS) was used to measure anxiety at three intervals: pre-test, post-test1 (before mid-term exam), and post-test2 (before final exam) (Alexander & Martray, 1989). A-MARS is a self-administered questionnaire with a 5-point Likert-type response scale (e.g., "1=not at all, 2=a little, 3=a fair amount, 4=much, and 5=very much) with a minimum score of 25 and a maximum score of 125. It has a test-retest reliability coefficient of 0.86 and a 0.93 correlation with the MARS instrument (Richardson & Suinn, 1972).

A second instrument, a 26-item, self-assessment of mathematics ability, was used as a proxy measure of pre-service teachers' mathematics ability. We chose not to use a standardized assessment of mathematics given that testing pre-service teachers in mathematics, the field in which many have a deficit (Bekdemir, 2010), was likely to lower their self-confidence and heighten their mathematics anxiety which would counter the purpose of the study in reducing mathematics anxiety. Students responded on a 4-point scale with: 1=not sure at all how to even start this question, 2=if I got an answer, I'm not too sure it would be correct, 3=I think I know how to answer this question but I might make a mistake, and 4=I know the correct answer and I could teach someone how to answer the question.

The qualitative component of the study was the intervention in the form of journal writing as a means of reducing anxiety. Pre-service teachers engaged in the three forms of writing: positive expressive writing, expressive writing, and neutral writing (control group). Students were randomly assigned to one of the three groups and given a journal with a prompt pasted in the journal. At the beginning of each class, starting at lesson 2, students wrote a response to the prompt, for 10 minutes in their journal. 10 minutes was chosen as adequate time for students perform the writing task, which was supported by previous research conducted by Ramirez and Beilock (2011).

The mixing of the quantitative and qualitative methods provided a more innovative means of engaging in this research, where the research questions could tap into the complexity of mathematics (Creswell et al., 2011). As a construct, mathematics anxiety is multidimensional and complex in its effect on an individual's cognitive, emotional, and affective dimensions, thus research questions on mathematics anxiety must take this into account.

Participants

The participants were 27 pre-service teachers who were registered in a bachelor of education program completing a hybrid mathematics for teachers course during the peak of COVID-19. The hybrid model of instruction involved half of the class in-person and the other half, online. Students would rotate from being in-person to online following each lesson.

All participants provided informed consent prior to the start of the first class. On the first day of the 10, three-hour classes, pre-service teachers were asked to complete a self-assessment of mathematics ability and a mathematics anxiety survey. Throughout the next nine lessons, pre-service teachers were randomly selected to one of three groups to engage in the three different forms of writing for 10 minutes at the beginning of each class. The writing prompts used in this study were based on Pennebaker's (1997) expressive writing paradigm (Baikie et al., 2012; Pennebaker & Chung, 2007), and focused on

(i) writing about thoughts and feelings of the most intensely positive experience (positive writing),

(ii) writing about thoughts and feelings regarding the mathematics class (expressive), and

(iii) without writing about your feelings and emotions related to yesterdays' tasks, write about what you did such as activities or tasks that you performed, who you saw, the duration, etc.

A copy of the complete writing prompts can be found in **Appendix A**. Following the writing on the last class, journals were collected (pseudonyms were used to track pre-service teachers to their self-assessment of mathematics and anxiety surveys).

Table 1. Alpha coefficient, mean scores, and standard deviations from the self-reported survey of mathematics anxiety (n=27)

	Alpha	Mean	Standard deviation
Pre-anxiety survey	0.97	2.78	0.886
Post-anxiety survey (mid-term)	0.97	2.78	0.919
Post-anxiety survey (final)	0.98	2.58	0.984

Data Analysis (Quantitative)

The quantitative data was analyzed using descriptive and inferential statistical techniques. Descriptive statistics included frequency, percent, mean, and standard deviation for all scale items, as well as cross tabulations to examine characteristics in each of the three writing groups. Inferential statistics included an analysis of variance (ANOVA) to compare mean scores in each of the three writing groups crossed with mean scores on the mathematics ability survey and three anxiety surveys. A correlation analysis was also used to examine the relationship between mathematics ability and anxiety. To determine whether the intervention (writing) reduced anxiety, a one-way between groups analysis of covariance (ANCOVA) was performed to compare the effectiveness of the different writing tasks on reducing mathematics anxiety. The independent variable was the type of intervention which was either positive expressive writing, expressive writing, or neutral writing and the dependent variables were the post anxiety survey at time 1 completed prior to writing the mid-term and post-anxiety survey at time 2, completed prior to writing the final examination. Participants' scores on the pre-anxiety survey, completed at the beginning of the course, and self-reported mathematics ability also completed at the beginning of the course were used as the covariates for this analysis.

Data Analysis (Qualitative)

Qualitative analysis consisted of analysing content from pre-service teachers' writing journals (Creswell, 2014; Merriam & Tisdell, 2015). A deductive approach was used to read pre-service teachers' writing journals to identify emerging themes and patterns as the researcher became familiar with the data set (writing journals).

Qualitative data analysis was initiated by reading and re-reading students' journals. Following this, Saldaña's (2013) method of process and pattern coding for analyzing data was used. The a priori codes from Park et al. (2014) (i.e., anxiety, cause, and insight-think or know) were applied during the initial reading. Next, process coding was used to develop codes, arising from the data through reading and re-reading of the transcripts. Park et al.'s (2014) codes were indicative of emotional processing (e.g., worry, negative thought, etc.) which occurred during their participant's writing process (Klein & Boals, 2001). Two additional codes were identified during the analysis in this study:

(i) positive emotion and

(ii) did not follow the writing prompt.

Next, pattern coding which comprises a systematic categorizing of excerpts from the journal writing was used to categorize the initial codes. This process allowed for reflection and to critically analyze the data collected (Saldaña, 2013) as concepts and relationships began to emerge.

FINDINGS

Findings Quantitative

Descriptive

The alpha coefficient for the mathematics ability survey was 0.90 indicating high reliability (Warrens, 2015). The mean score for the mathematics ability survey was 2.7 (recall: 1=not sure at all how to start this question; 4=I know the correct answer and could teach someone how to answer the question) (*SD*=0.50) indicating that students were not overly strong in mathematics and given that adults tend to overestimate their abilities (Bench et al., 2015), it is likely that pre-service teachers' mathematics ability was lower than what is reported in this study. When focusing on individual items where the majority of pre-service teachers had a mean score of two or less indicating that they did not know how to start the question or were really uncertain whether they could accurately perform the calculation, these items included: relationships and calculations involving a circle, expressing a decimal as a fraction in lowest form, writing an algebraic expression, describe the Pythagorean relationship, creating a table of values for a linear relationship, identifying the degree and coefficient of a polynomial, and calculating surface area of a composite figure.

In regard to the self-reported survey of mathematics anxiety, the alpha coefficient, mean scores, and standard deviations are shown **Table 1**. The alpha coefficient indicates the survey had high reliability and the alpha coefficients were aligned with the coefficient of the original survey of 0.93 (Alexander & Martray, 1989). The mean score of the pre-survey of mathematics anxiety was 2.78 (on the 5-point scale where 5=very much anxiety) and more specifically, 41.6% of participants reported little or no mathematics anxiety (mean score of one or two) and 58.3% reported having between a fair bit of anxiety up to very much anxiety. There were only three items, where students had a mean score of 3.9 or 4.0 (4.0 being the highest mean score). These items surveyed level of anxiety in:

(i) taking an examination in a math course (73.1% responded with 4 or 5),

(ii) thinking about an upcoming math test 1 hour before (69.2% responded with 4 or 5), and

(iii) being given a surprise quiz in math (69.2% responded with 4 or 5).

Table 2. Mean score (SD) for group X mathematics ability, pre-anxiety survey, mid-term anxiety survey, and final examination anxiety survey

		Anxiety survey		
Group	Math ability	Pre	Mid-term	Final
Positive expressive	2.41 (0.35)	2.97 (.89)	2.85 (1.03)	2.71 (0.99)
Expressive	2.78 (0.34)	3.03 (0.86)	2.84 (0.69)	2.55 (0.86)
Neutral	2.97 (0.67)	2.19 (0.73)	2.61 (1.11)	2.43 (0.98)

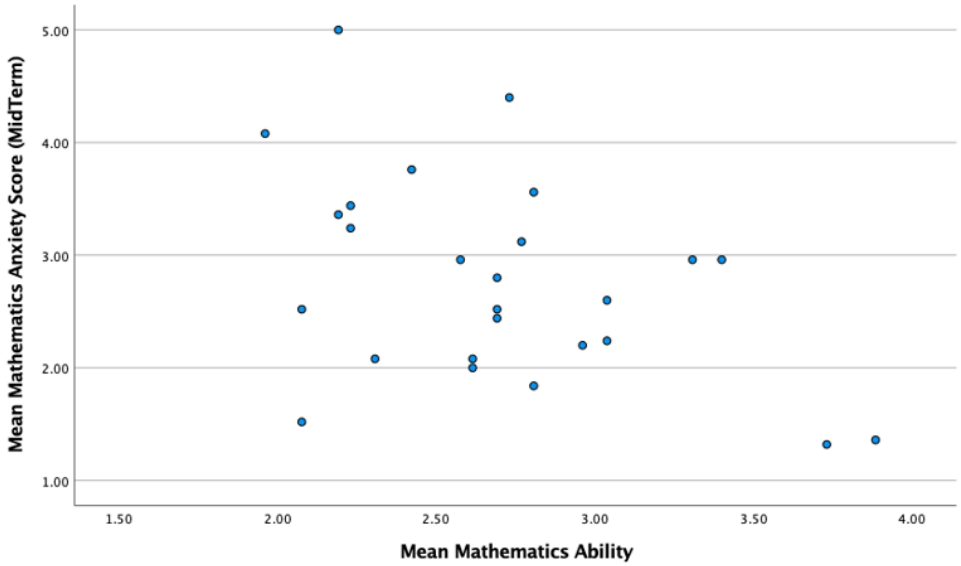

Figure 1. Mathematics ability X mathematics anxiety (mid-term examination)

A cross tabulation was performed to obtain an overview of pre-service teacher characteristics in each of the three writing groups based on their self-reported mathematics ability as well as their measures of anxiety taken before the intervention, before the mid-term examination, and before the final examination. **Table 2** displays the mean scores and standard deviations in each group.

Inferential

ANOVA revealed that there were no significant differences in mean scores (p<0.05) based on the writing groups and the four measures shown in **Table 2**. To examine the impact of the writing intervention on reducing anxiety, a one-way between groups ANCOVA was performed. Preliminary analyses were conducted to ensure assumptions of normality, linearity, homogeneity of variances, homogeneity of regression slopes, and reliability of covariates were met.

While controlling for proxy measures of mathematics ability and mathematics anxiety, there was no significant difference between the three writing groups on the post measure of anxiety taken at the mid-term, F(2, 21)=0.61, p=0.56, partial eta squared=0.055; M_{PE}=2.53 (SD=0.29), M=2.86 (SD=2.9), M_N=3.05 (SD=3.6)[1] and at the post measure of anxiety taken at the final examination, F(2, 21)=0.32, p=0.70, partial eta squared=0.033; M_{PE}=2.41 (SD=0.324), M_E=2.55, (SD=0.32), M_N =2.87 (SD=0.40). There was a significant relationship between the mathematics ability score and the mean post-anxiety survey written before the mid-term F(2, 21)=6.37, p=0.02, explaining 23.3% of the variance. A further examination of this relationship using a correlation analysis revealed a strong negative relationship, r=-.45, whereby pre-service teachers reporting low mathematics ability had high mathematics anxiety as measured before writing the mid-term examination (**Figure 1**).

Findings Qualitative

The qualitative findings summarized in this section are organized based on the three writing groups. Excerpts from participant journals are used to illustrate the emerging themes. The lived and learned experience of students are embodied in their dialogue around their perceptions and experiences with mathematics anxiety and how, at times, they coped with it.

Expressive writing group

The 10 pre-service teachers in the expressive writing group provided 90 samples of writing over the nine lessons. The data analysis began with the use of a priori codes of: anxiety, cause, and insight (Park et al., 2014). Initial findings revealed that out of the 90 writing samples, participants used words or phrases indicative of one of the three initial codes: 74 used *anxiety*, 54 used *cause*, and 52 used *insight* which provided evidence of emotional processing. Out of the 90 writing samples *cause* and *insight* words were included in the 74 writing samples therefore 74 out of 90 writing samples disclosed the use of anxiety and anxiety-related words such as: stress or worry. This focus on pre-service teachers' writing provided evidence of emotional disclosure consistent

[1] PE=Positive expressive writing; E=Expressive writing; & N=Neutral writing

with anxiety. Samples of pre-service teachers' writing under the anxiety code include, "there are only a few days left, but I am very worried about my final outcome," said participant "CACA" and "I am anxious today," stated participant "BEDE". The next code examined was *cause* which was indicated using words such as *because* and *hence*. 54 of the 90 writing samples referenced the *cause* code. Examples included: "I find this is putting a lot of extra stress on me because sometimes I will do everything right but lose marks for forgetting something little," said participant "CAED". The last code, *insight*, was represented by participants who indicated a deeper understanding of their emotion or situation. An example of this type of writing was written by participants "HASA" and "ANBR" who stated, "I am worried that because the tests are timed I might have less time because sending the picture will take time as well," and "I know when I am quizzed and tested that my abilities are not accurate due to the amount of anxiety I have."

In analyzing the data set further by reading and re-reading the journals, additional codes emerged which further categorized the data. The codes that emerged were:

(i) positive self-talk and

(ii) did not write according to prompt.

The first code was positive self-talk where 27 out of the 90 writing samples included this code. Examples of positive self-talk from the participant's writing were: "I need to do some studying to brush up on my skills, but I feel pretty confident that I will do well. Really, all I need to do is write the test and as long as I do that I am golden," said "LOCH". Another participant "ANBR" stated, "I seem to understand the concepts we have discussed in last class and feel relatively ready to tackle today's class," and participant "BEDE" stated, "If I sit down and really think about things I can work it out. For the first time in my life–math makes sense!"

Another writing code focused on writing that detoured from the writing prompts. In this case, 13 of the 90 writing samples revealed writing that did not follow the writing prompt. Instead, they drew pictures such as butterflies or wrote formulas for the imminent mathematics quiz or examination. Writing that detoured from the writing prompt also focused on an additional stress that was brought on due to the online learning component (i.e., half of the students were online and half in-person). Some participants' comments, such as, participant "ANBR" wrote, "Learning math online does seem to play a large part in my stress so I am grateful to be able to come to class," another participant "CACA" said, "learning online is definitely not one of my stronger times in my education so when combined with math it held extra weight on my stress, I think that the stress I was feeling played a large part in clouding my understanding and knowledge of some of the processes leading me to make those mistakes," and participant "LOCH" said, "Online makes learning difficult."

When further synthesizing the data, categories emerged from the writings. Anxiety, cause, and insight were categorized under emotional processing which occurred in 74 of the 90 writing samples. Positive self-talk and did not write according to the prompt remained as distinct categories. Next, the analysis of the positive writing group was conducted which identified connections and consistent threads woven between the expressive writing group and the positive writing group.

Positive expressive writing group

There were 10 pre-service teachers in this writing group who wrote for the nine days which provided 90 writing samples for analysis. The following four code categories were used to analyze the positive writing group:

(a) forthcoming fun events,

(b) family,

(c) positive memories, and

(d) did not write according to prompt.

Examples of writing about forthcoming fun events included: "We are honestly more like sisters than friends, so getting to see her is a big deal," stated "CAGL," and "I received a text notifying me that I had my second vaccine booked for today. I am so happy about this because it means I can visit my family back home this summer," expressed "RASW," and "I am excited for a fun relaxing/relaxing weekend. It is my friend's birthday this weekend so I will be celebrating that on Saturday," wrote "TACA". The writing under this code occurred in 14 of 90 writing samples.

The second code that highlighted writing about family was found in 19 of the 90 writing samples. Writing under the code of family included: "Most of my family is scattered around the world, so I always have an excuse to travel to go visit them," wrote "RASW", "One of the best experiences of my life has been going to my uncle's cottage on a lake every summer," expressed "ANEW", and "Something that has brought me extreme happiness into my life is the birth of my nieces. They have brought so much joy to my life," noted "DIDO". Last, the code, positive memories, was found in 35 of the total 90 writing samples. Writing examples of positive memories included: "I play basketball for the university so it would be the moment when we won …," expressed "TRPA" and "One intensely positive experience in my life was is getting my dog," described "MABE".

Also in the positive writing group, there were 22 out of 90 writing samples where students did not follow the prompt at some point in their writing, by writing statements such as, "I am not sure what to write today," declared "MAFR", and "for some reason, trying to think of a positive experience today stumps me," expressed "CAST". Two of the 10 pre-service teachers who did not follow the prompt wrote mathematical formulas for the upcoming test.

As analysis proceeded with this positive expressive writing group, categories emerged with the combining of forthcoming fun events, family, and positive memories incorporated under the category of positive emotion. The findings revealed with this new category showed that 68 of the 90 positive expressive writing group were included in this category. The *did not write according to prompt*, remained as a distinct category. Following this analysis, the neutral writing group was analyzed.

Neutral writing group

The neutral writing group consisted of seven participants writing for nine consecutive days with 63 writing samples for analysis. This group was asked to write as factually as possible about events that occurred yesterday in their lives without any feelings or emotions and as objectively as possible. These writings were analyzed to determine whether the participant followed the prompt as directed or to see if feelings and emotions entered into their writings. The codes employed were neutral writing (writing according to prompt) and *did not write according to prompt*. Examples of neutral writing included: "Yesterday I went to the gym. I lifted for two hours then I went to a friend's house to eat," wrote "DEDA" and "Yesterday I woke up before my 11:30 class," stated "JORO". Although 44 out of the 63 writing samples wrote as directed, all of the seven participants used writing which consisted of writing which did not follow the prompt, such as explicitly describing emotions and feelings (emotional processing and emotional expression) during their writing intervention. 19 out of 63 writing samples revealed pre-service teachers not writing according to the prompt. This resulted in 19 out of the 63 writing samples describing the pre-service teachers' emotions. Therefore, the resulting analysis categorized the code *did not write according to prompt* into two categories: positive emotion and negative emotion. From these findings 17 out of 19 writing samples disclosed negative emotions and only two out of the 19 writing samples had pre-service teachers' disclosing positive emotions. Additionally, one of the seven participants drew formulas on the last day of class prior to the examination. The writing content focused on positive emotions which conveyed emotions such as happiness or excitement or negative emotion such as anxiety and stress. Some examples of this group's writings were: participant "JETE" wrote, "I got up and had a bit of a breakdown and feel overall gross and anxious" and participant "RWSD" declared that, "I started a bit of homework when I got home in hopes of relieving a little bit of stress".

Comparison of Themes between Groups

Following analysis of the three writing groups: expressive, positive expressive, and neutral, themes emerged which were common to all groups. The themes that emerged were: emotional processing, did not write according to prompt, social connections, and school/work. Each of the groups had pre-service teachers who revealed words and thoughts in their writing consistent with emotional processing (Klein & Boals, 2001; Rameriz et al., 2014). Pre-service teachers in all three groups disclosed their emotions by writing about positive emotions (e.g., happiness or excitement) using such words as; "happy" and "excited" or negative emotions (e.g., feeling anxious or stressed); using words such as; "nervous" or "worried" whether or not they were in a writing group asked to express these emotions.

The majority of the expressive writing group provided emotional disclosure as directed by the prompt. In this writing group, 74 out of 90 writing samples consisted of writing using emotional processing using the codes of (anxiety, cause, and insight). In comparison, 68 of 90 writing samples in the positive expressive writing group wrote using words or thoughts aligned with emotional processing, therefore a higher percentage of pre-service teachers in the expressive writing group wrote expressively in comparison to the positive writing group. A smaller percentage of the neutral writing group wrote as directed by the prompt than either the expressive writing group or the positive expressive writing group.

For the pre-service teachers in the positive writing group, 22 out of 90 writing samples did not write according to prompt, while 13 out of 90 in the expressive writing group did not write according to prompt. For the neutral writing group 19 out of 63 did not follow the writing prompt by writing using positive or negative emotion. Also included in this theme were mathematical formulas and abstracting sketches (e.g., doodling) with the majority of formulas being written just prior to an examination.

Social connections with family, friends, and pets was another consistent theme connected through the three groups of writing. The final theme found consistently across groups was writing which focused on and discussed school and work.

DISCUSSION

The discussion section has been organized according to the three questions posed in the study and synthesizes findings from the qualitative and quantitative data presented above.

To What Extent Does Positive Expressive Versus Expressive Writing Have On Reducing Pre-service Teachers' Mathematics Anxiety?

The primary purpose of this research was to examine the impact of expressive versus positive express writing on reducing pre-service teachers' mathematics anxiety. Although we were optimistic that the effect would be positive and aligned with the work of Park et al. (2014), it was not. There was no significant difference in mathematics anxiety as measured on the anxiety survey (AMARS) taken before the mid-term and again before the final examination while controlling for pre-measures of anxiety and mathematics ability. There are a couple explanations as to why our findings were counter to previous research.

First, it is possible that the duration of the writing was too long. In our study pre-service teachers wrote for 10 minutes. This duration of writing is contrasted with other studies that had participants write for 20 minutes to improve working memory (Klein & Boals, 2001), 10 minutes to improve performance on a mathematics exam (Ramierz & Beilock, 2011), and seven minutes to reduce mathematics anxiety (Park et al., 2014). It is feasible that there is an optimal amount of time participants should engage in writing to reduce anxiety. This finding is expanded upon in response to the third question posed in the study.

Second, it is also possible that the context of the study was too different from Park et al. (2014) who used 80 students from a Midwestern university in an experimental setting in contrast to a real-world classroom setting in which this study took place. Another defining difference in this study and Park et al.'s (2014) was that this study took place just over a year into a global

pandemic, which may have heightened the general anxiety level of the pre-service teachers in addition to their mathematics anxiety and perhaps overriding their focus.

Last, the all-female pre-service teachers were instructed by a female instructor who would describe herself as highly skilled in mathematics knowledge and pedagogy and having no mathematics anxiety. Therefore, there was no transmission of mathematics anxiety similar to what was found in Beilock et al.'s (2010) study of younger girls which may explain why the writing had little impact on reducing mathematics anxiety. It is probable that the female instructor as a role model of confidence and competence in mathematics teaching may have influenced and inspired the pre-service teachers by helping to change their beliefs that women and girls are capable of learning mathematics, thus increasing their self-efficacy.

How Does Pre-Service Teachers' Mathematics Ability Relate to Mathematics Anxiety?

In this study, there was a significant relationship between pre-service teachers' mathematics ability and measure of mathematics anxiety taken at the mid-term exam which is aligned with the early work of Ashcraft (2002) and Foley et al. (2017). This relationship was not the same when considering the measure of mathematics anxiety taken at the final examination. Reasons why the relationship was not the same for both post measures of anxiety are possibly because anxiety was alleviated through instructional practices and familiarity of expectations in the course. To expand further on this point, the goal of each lesson was to teach mathematical concepts by modelling accurate pedagogy. Therefore, if the mathematics is taught well and students can learn the concepts, it is likely that anxiety will be reduced because they are more confident and the daily quizzes, where most pre-service teachers were successful, provided reassurance that they were learning the concepts. Further, it seems reasonable that mathematics anxiety would not be erased in five weeks given its complex, interacting factors (Luttenberger et al., 2018) and that pre-service teachers would still have anxiety when measured before the mid-term given that for many, they would not have written an examination in mathematics for many years. Second, they probably had some degree of uncertainty in what to expect on the mid-term despite having sample quizzes each lesson.

Therefore, our research examining the relationship between pre-service teachers' mathematics ability and mathematics anxiety is aligned with the work of Linsell and Anakin (2012) and Novak and Tassel (2017) revealing a strong negative relationship where pre-service teachers with low mathematics ability have high anxiety. Our study extends the body of research by adding that when pre-service teachers are given the opportunity to explore foundational concepts using manipulatives and taught with accurate pedagogy, they can learn. This finding affirms previous research (Brewster & Miller, 2020), connecting missed opportunity to learn mathematics in pedagogically appropriate ways creates anxiety. It is important that future research examine this relationship further by interviewing participants about their mathematics anxiety and to what extent, the instructional practices used in a course alleviated or heightened their anxiety.

To What Extent Did Pre-service Teachers Engage in the Journal Writing?

Students in all writing groups were not consistent in following the directions provided by the writing prompt for their group. 13 out of 90 writing samples from the expressive writing group, 22 out of 90 in the positive writing group, and 19 out of 63 in the neutral writing group, deviated from the writing prompt directions. These findings revealed that almost one-quarter of the positive expressive writing group did not engage in the positive writing intervention as directed. The lack of adherence to the writing protocol may have had significant effect on the outcome of this study. Reasons as to why pre-service teachers did not write according to prompt may be due to excessive time and/or the prompts were too monotonous given that they did not change from day to day.

The duration of the writing task was set at 10 minutes in this study because our study aligned closely with the 10 minutes used by Ramirez and Beilock's (2011) experimental study. This timing is contrasted to the 20 minutes used in a health context study (Baikie et al., 2012), which may have warranted additional writing time to overcome emotional trauma. The seven-minute writing time used by Park et al. (2014) was also considered, but these researchers did not provide a rationale for the reduced writing time; hence we opted to provide a slightly longer period to allow participants to gather their thoughts and then engage in the writing process. We posit that there is an optimum duration for writing and more research is needed to identify this duration to capitalize on reducing anxiety given that more time to write may have influenced pre-service teachers' tendency to write off-topic.

It is possible that pre-service teachers might have written to the prompts if they were provided with a different prompt each day that was still aligned with the type of writing. Changing up the prompts may trigger more positive experiences and subsequently, more engaged writing that could reduce anxiety.

CONCLUSION

The current findings did not reveal a significant difference between the positive and expressive writing groups based on results from the mathematics anxiety survey at post-test 2 (i.e., mid-term examination) and post-test 3 (i.e., final mathematics examination). It is likely that the duration of writing, context of study, and competency of the female instructor may have contributed to the absence of a significant finding. However, a significant relationship between pre-service teachers' self-assessment of mathematics ability and level of mathematics anxiety measured before writing the mid-term examination was found. This relationship was not found prior to the final examination possibly due to competent instructional practices in that the instructor was an expert in mathematics pedagogy (and assessment) and subsequently was able to provide lessons that allowed students (including low ability students) to understand the material which would lower their anxiety. Second, students' familiarity with course expectations may have also lowered their anxiety possibly because they were able to learn the material presented in each lesson and thus became confident knowing that what they learned is what would be assessed on the final examination. The

findings also demonstrated a strong negative relationship between pre-service teachers' low mathematics ability and high mathematics anxiety (i.e., measured prior to writing the mid-term examination), as well as support for previous research that missing the opportunity to learn foundational mathematics is an important factor influencing the level of mathematics anxiety.

This study revealed important insights into the effect mathematics anxiety has on pre-service teachers. Although the findings were not as conclusive as anticipated, they provide insight into contextual factors of writing as an intervention to reduce anxiety. Although not considered a variable in this study, it is also important to recognize that the quality of teaching can be a factor in reducing or creating mathematics anxiety and is subsequently, important to document in future studies. Similarly, the extent of the gap between what participants' currently understand in mathematics and what they need to learn is likely to have some effect on participants' anxiety level; the greater the gap, the greater the anxiety. In this study, the gap could be described as moderate and therefore, participants' anxiety might not have been as elevated as in other studies which is also likely to impact the outcome of future studies.

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Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

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APPENDIX A

General Instructions That Will be Given by the Course Instructor Before Beginning the Journal Writing

Each of you have received a journal with writing instructions inside. Each day at the beginning of class, starting at the second class and continuing until the last class, you two will be asked to write in your journal for 10 minutes according to the directions given inside. Please put the date at the top of the page. Your writing will be completely confidential. Your writing over these nine weeks can be a continuation from the class before, much like a novel or a completely new writing each day much like a short story. The only rule is that once you begin writing, you continue until time is up. Thank you for your interest in this research and your assistance with this project

Positive writing prompt

Please take the next 10 minutes to write as openly as possible about your thoughts and feelings about the most intensely positive experience in your entire life or any extremely important positive experience or issue that has affected you and your life. In your writing, I want you to really let yourself go and explore your emotions and thoughts around this positive experience. Please try to be as open as possible as you write about your thoughts at this time. You may write about the same general issues or experiences on all days of writing or about different topics each day. All of your writing will be completely confidential. Don't worry about spelling, grammar, or sentence structure. The only rule is that once you begin writing, you continue until the time is up.

Expressive writing prompt

Please take the next 10 minutes to write as openly as possible about your thoughts and feelings regarding the mathematics class that you are about to have. In your writing, I want you to really let yourself go and explore your emotions and thoughts as you are getting ready to start the mathematics class. You might relate your current thoughts to the way that you felt during other similar situations at school or in other situations in your life. Please be as open as possible as you write about your thoughts at this time. You may write about the same general issues or experiences on all days of writing or about different topics each day. All of your writing will be completely confidential. Don't worry about spelling, grammar, or sentence structure. The only rule is that once you begin writing, you continue until the time is up.

Neutral prompt

Please take the next 10 minutes to write as factually as possible about the activities and events that occurred in your life yesterday. Please describe in a non-emotional manner what you did yesterday, such as activities or tasks that you performed. For example, you might start when your alarm went off and you got out of bed. You could include the things you ate, where you went, which buildings or objects you passed by as you walked from place to place. I am not interested in your emotions or opinions, rather I want you to try to be completely objective. Feel free to be as detailed as possible. However, the most important thing is for you to describe what you did as accurately and as objectively as possible.