Identifying Correlations in Academic Anxiety to Coin the Term "Math-Related Testing Anxiety"

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Abstract

Math anxiety was first defined by Richardson and Suinn (1972) as “feelings of tension or anxiety that interfere with the manipulation of numbers.” Testing anxiety has been proven to produce similar feelings of tension which interfere with an individual's ability to think critically (Putwain & Pescod, 2017). Therefore, in identifying the correlations between math anxiety and testing anxiety, this study aims to coin the term “math-related testing anxiety. “This study researched the effects of math anxiety and testing anxiety for undergraduate, entry-level mathematics students. This was done through an online survey to gather qualitative data and interviews to gather quantitative data.

The study found that the concept of threats from internal and external pressures creates a sense of anxiety (Steele, 2009). This anxiety from threat is produced from the language used to discuss mathematical concepts and testing situations and is heightened based on past experiences with each concept (Richardson & Suinn; Ashcraft & Moore, 2009;). This heightened threat impacts individuals of all ages (Steele). Therefore, this study indicates a basic definition for “math-related testing anxiety” to be "feelings of tension or anxiety that interfere with an individual's ability to effectively perform academically in a testing situation involving the manipulation of numbers and solving of mathematical problems in a wide variety of ordinary life and academic situations." Understanding this definition can help educators in better adjusting their pedagogy to student needs.

Introduction

According to Barta, Eglad, and Barkely (2014), "mathematics is not a subject that is fixed, rigid, and fully developed; it is instead a process that… continues to evolve" (pg. V). However, too often in our contemporary educational system, mathematics is understood and taught exactly in the way Barta, Egland, and Barkely describe. This static understanding of math, when developed at an early age, can eventually develop into a fear of mathematics and testing due to the perceived threat and lack of enjoyment in the subject based on pursuit of a grade (Boaler, 2016). That math aversion extends beyond K12 schools.

The number of student participants in the mathematics major in higher education has remained relatively stagnant over the last 50 years, while other majors such as business, engineering, and psychology, have grown exponentially (Bressoud, 2018; National Center for Education Statistics, 2019). Mathematics seems to be a dying field of study; a need exists in the world for good mathematicians that continues to grow with the development of technology as well as the application in fields such as psychology and physical science (Azeri, 2020; Herbart & Haanel, 1877; Yli-Vakkuri & Hawthorne, 2018). With these identified needs, it is essential to study causes of this decreased appreciation in an essential field.

Given the lack of interest in the field and the impact of pedagogy on student understanding, I hypothesized that the development of anxiety and fear of testing in the subject could impact the way individuals perceived mathematics as whole. The purpose of this study was to identify connections between math anxiety and testing anxiety and to attempt to give foundational direction for the term “math-related testing anxiety” through the means of these connections. The study utilized a literature review, a survey to gather quantitative data, and interviews to gather qualitative data. In identifying these connections between math anxiety and

testing anxiety, the study identified language and pedagogical techniques, which are correlated to heightening anxiety. Research on math-related testing anxiety is essential for understanding pressures that individuals face specifically when taking tests in mathematics, and it can be utilized by teachers, administrators, and individuals who may be experiencing math anxiety and testing anxiety in academic settings. Teachers will be able to make more effective pedagogical choices if they are aware of what triggers anxious feelings in their students.

Furthermore, by coining the term "math-related testing anxiety," I give voice to the diverse needs of students and the negative emotions associated with the testing of mathematics. In validating this anxiety, further research can explore practical steps for individuals experiencing these feelings, which has the potential to positively impact the lives of many people.

Literature Review

Defining Math Anxiety

Math anxiety has been heavily researched within the last century. One of the first and most well-known studies on math anxiety originated with the work of Frank Richardson from the University of Texas and Richard Suinn from Colorado State University (1972). These researchers defined the term "math anxiety," linking the phrase to "feelings of tension and anxiety that interfere with the manipulation of numbers and solving of mathematical problems in a wide variety of ordinary life and academic situations" (Richardson & Suinn, 1972). For the means of this study, "tension" is defined as general perception of involuntary responses and bodily symptoms to a physiological indicator or indicators of anxiety (Putwain & Pescods, 2017). Richardson and Suinn's definition is used by an array of scholars due to its applicability

for individuals of all ages from elementary-aged to college students and working adults. Furthermore, their research focused solely on math anxiety, giving no attention of the influence of testing anxiety or any other academic domains of anxiety.

Ashcraft and Moore (2009) defined math anxiety as “feelings of tension, apprehension, and fear or situation involving mathematics.’ Ashcraft and Moore found a direct correlation between math anxiety and a decline in performance, especially during timed sequences or when an individual is under high-stakes conditions. This effect on performance is consistent as math anxiety can lower both executive functioning and the use of neural resources, which are essential for evaluation of various mathematical computations (Pizzie, Raman, & Kraemer, 2020). Math anxiety is also shown to be more prominent in children with a parent who had higher math anxiety, specifically in same-gender dyads (Casad, Hale, & Wachs, 2015). Macmull and Ashkenazi (2019) have found additional correlations between an authoritarian parenting style and math anxiety, as well as gender and math anxiety with math anxiety being higher in female populations than male populations. Furthermore, when classrooms focus solely on mathematical facts, especially at the elementary age, students are given the impression that these facts are the very essence of mathematics, which leads to comparison in the classroom that can heighten anxiety towards mathematics carried throughout an individual's educational experience (Boaler, 2016; Pizzie, Raman, & Kraemer, 2020).

Anxious feelings are heightened when an individual feels the external pressure of the high-stakes conditions or a timed sequence (Ashcraft & Moore, 2009; Boaler, 2017; Pizzie, Raman, & Kraemer, 2020; Richardson & Suinn, 1972). Contemporary means of testing that include the various factors, such as timed sequences and high stakes conditions, have proved to heighten math anxiety. Therefore, further research should explore whether these "feelings of

tension, apprehension, and fear" (Richardson & Suinn, 1972) are solely due to the mathematics or if the experience of taking a test is a contributing factor.

Defining Testing Anxiety

Spielberger and Vagg (1995) explain how anxiety can fluctuate between a permanent personality trait and an acute state—such as a feeling experienced immediately before an exam. If an individual experiences anxiety as an acute state related to an event, it can affect a student's academic performance temporarily due to the perception of a high-stakes condition (Ashcraft & Moore, 2009). This perception of the situation refers to the anxiety-proneness of an individual and qualifies as associated trait anxiety (Spielberger & Rickman, 1988). Trait anxiety refers to an individual's likeliness to perceive a situation as dangerous or threatening (Spielberger & Rickman, 1988). Differences in trait anxiety reflects the anxiety states which have been experiences in the past and the probability that they will be experienced in the future (Spielberger & Rickman, 1988).

Test anxiety is a situational form of trait anxiety and is defined as "individual differences in the general tendency to appraise performance-evaluative situations, such as examinations, as threatening" (Spielberger, Gorsuch, & Lushene, 1970). Testing anxiety measures two cognitive aspects, worry and test-irrelevant thoughts, as well as the two affective-physiological aspects of tension and bodily systems (Putwain & Pescod, 2017). Worry can be understood as the unconstructive thoughts of failure and its consequences, while test-irrelevant thoughts are distracting thoughts that do not necessarily concern failure (Putwain & Pescod, 2017). Similar to math anxiety, testing anxiety has been proven to negatively impact academic achievement for students of all ages (Steinmayr et al., 2016). Furthermore, high levels of testing anxiety can

interfere with an individual's memory and attention (Owens et al., 2014). This interference impacts students' experiences and academic struggles such as recalling taught material or completing timed tasks (Dutke & Stober, 2001; Richards et al., 2000). In addition, Cipra and Muller-Hilke (2019) found that students with a procedural approach to mathematics have a significantly higher risk of developing anxiety as a trait and risk being less successful academically as "anxiety is a prerequisite for burn-out" (p. 1).

How to Measure Math Anxiety

Richardson and Suinn (1972) developed the Mathematics Anxiety Rating Scale (MARS), consisting of a 98-item scale composed of brief descriptions of behavioral situations that could produce different levels of anxiety. This scale for measuring math anxiety is an agreed upon inventory for assessing math anxiety.

Although math anxiety has been measured as its own field through the MARS scale, the connections between math anxiety and other types of anxiety was first explored through the "Academic Anxiety Inventory," which is a two-part assessment with a series of questions relating to various fields of academic anxiety including testing, writing, science, and math (Pizzie, & Kramer, 2019). This assessment was created to help facilitators determine areas in which students would require extra support, yet it is also a clear tool for outlining the connections between math anxiety and other academic anxiety, specifically testing anxiety (Pizzie & Kraemer, 2019). Consistent with MARS, the AAI measures math anxiety through either yes or no questions or Likert scale responses, which influenced the means of measurement for this study (Richardson & Suinn, 1972; Pizzie & Kraemer, 2019).

How to Measure Testing Anxiety

One process for measuring testing anxiety proposed by Zeidner and Matthews (2005) is known as the S-REF model, which consists of executive processing, self-knowledge beliefs, and maladaptive situation interactions. Executive processes can be initiated by external stimulus such as the reminder of an upcoming test from a peer or teacher or internal stimulus cycles of processing such as thinking about failing an upcoming test (Zeidner & Matthews, 2005). How an individual responds to these stimulations impacts their levels of anxiety. The consequences of negative responses from beliefs a student holds about themselves, such as poor metacognitive processes with self-blame or avoidant behavior, can create or even heighten testing anxiety (Putwain & Pescod, 2017). Therefore, how an individual perceives a situation has a direct effect on the level of worry or tension that they will experience both physiologically and metacognitively. The maladaptive situational interactions part of the S-REF model influences the longevity of testing anxiety in an individual by influencing withdrawal or avoidance of certain situations which have previously been perceived as failures (Zeidner & Matthews, 2005). The combination of these three processes further impacts anxiety and an individual's fixed mindset, influencing negative thoughts and long-term decisions (Putwain & Pescod, 2017; Zeidner & Matthews, 2005).

Connecting Math Anxiety and Testing Anxiety Biologically

According to Von der Embse and Hasson (2012), the effects of testing anxiety are amplified in current students because of how student test data such as chapter exams, quizzes, and even end-of-the-year assessments are utilized for accountability purposes. This connection could be due to the external pressures for achievement or the internal necessity to prove

themselves. This internal motivation could be influenced by stigma pressures, which are especially prominent among minority groups (Steele, 2007). The stigma pressures can be created by factors inside the classroom during a test taking time or factors outside of the classroom such as identity threat or stereotype threat surrounding race or ethnicity, socio-economic status, among other environmental factors (Steele, 2007).

A threat is distinct from a challenge. A challenge is encouraged to achieve learning. A threat causes individuals' sympathetic nervous systems to accelerate cardiac activity, diminishing the release of adrenaline, the blood pressure to rise, and the experience to be perceived as too demanding (Moss, 2016). A challenge does not impact the blood pressure, but the blood flow within the heart is elevated, and an individuals perceived ability to cope either exceeds or approximates the demands of a situation (Moss, 2016; Blascovich & Mendes, 2000). It is essential to address how identity threat influences what an individual may carry into a classroom with them, as this can add to existing anxiety (Steele, 2007). It would follow that a student's academic anxiety impacts group settings or individual tasks such as tests. This impact could be due to an array of perceptions such as avoiding stereotypes, the pressure of a timed activity, or negative work environment (Boaler, 2016; Steele, 2007). Steele clearly outlines that identity threat "isn't a threat that happens just during tests"; it affects young students, working adults, and can be present in any situation, yet its implications and pressures remain (Steele, 2007). The anxiety produced by threats impacts students of all ages, which indicates age is not a factor when considering who has the potential to be impacted by testing anxiety or math anxiety or both. Therefore, any academic anxiety is termed as a threat, and specifically anxiety pertaining to mathematics or testing as it inhibits an individual's perception of their situation because it will be assumed to be too difficult to cope with the given resources.

Connecting Math Anxiety and Testing Anxiety Academically

It is essential to understand how math anxiety and testing anxiety align both biologically and academically as they can be understood as connected but separate entities (Jamieson, 2017). Jo Boaler (2016) expressed the negative impacts of grading on a student's academic achievement and its direct influences on math anxiety by saying "grades and test scores demotivate rather than motivate students" (p. 143). This demotivation is due to the communication of fixed messages, which students attribute to their own worth and changes their motivation from higher learning to working for a grade (Boaler, 2016). When students focus their motivation towards grades, this heightens math anxiety because it becomes easier to lose motivation or excitement surrounding mathematics. Therefore, anxiety is heightened in students when their academic achievement specifically in mathematics is used as a means of accountability or grading. This anxiety has been coined as both testing anxiety and math anxiety on separate accounts (Boaler, 2016).

Homework is a unique tool used in classrooms that unfortunately creates inequities and stress, creating a "null or negative impact on achievement," especially mathematics homework, which tends to require less creative thinking and depends on the redundancy of practice problems (Boaler, 2016; PASA, 2015). This influences the perceptions a student has surrounding mathematics and their mindset when attempting a mathematics test.

Overall, the connections between math anxiety and testing anxiety cannot be ignored, yet the logistics of measuring this connection are enormously complex, as they include attributions for failure and success, math self-concept, perceived self-efficacy, achievement, general test anxiety, and even statistical test anxiety (Bandalos et al., 1995). One way this connection was studied in the past was through structural equation modeling done by Bandalos, Yates, and

Thorndike-Christ (1995). These researchers found that failure and success attributions influence general test anxiety and statistical test anxiety in both males and females, yet the level of worry associated with these attributions varied.

These attributions are varied potentially due to the impact of stereotypes. One stereotype assumes that math is a male field of study, and females would find more success in language or reading studies (Cvencek et al., 2011). The impact of this stereotype has been proven to develop as early as second grade, yet the stereotype is not valid (Cvencek et al., 2011; Steeffens et al., 2010). Implicit Association Tests were used by various researchers as a means of assessing the impact of stereotypes on academic performance (Cvencek et al,, 2011; Steeffens et al., 2010; Nocek et al., 2009). This stereotype has been measured across different countries including Singapore, producing the same conclusions that "non-academic factors such as implicit math self-concepts and stereotypes are linked to students' actual math achievement" (Cvencek et al., 2015).

Another stereotype to be considered is that individuals of Asian descent are assumed to be better at mathematics than whites. Research shows that an awareness of this stereotype was clear in all races, yet adolescents seemed to endorse the stereotype clearly, no matter their cultural affiliation (Cveneck et al., 2014). It is essential to consider the stereotypes that exist surrounding mathematics because of the way stereotype threat affects academic performance and continues to be an issue impacting all individuals and significantly impacting minority students in higher education (Steele, 2007). Currently, an achievement gap exists specifically for women and underrepresented minority groups in science, technology, engineering, and mathematics careers and majors, giving greater power to threats such as stereotypes (Finkel, 2017; Bressoud, 2018; National Center for Education Statistics, 2019). Stereotypes, therefore, impact academic

performance pertaining to tests, homework, and group work (Steele, 2007; Cveneck et al., 2014; Boaler, 2016).

Methodology

Completing this study required several steps. The first step in this research was development of the protocols and approval from the Northwest University Institutional Review Board (IRB). Following approval from IRB, the next step was offering an online survey to all students in MATH 1103 Mathematics for Liberal Arts at Northwest University. This survey was administered using Google Forum and comprised questions to measure both math anxiety and testing anxiety for the individual students. The survey given to the students included questions adapted from the Academic Anxiety Inventory (AAI), intended to assess overall anxiety levels and negative or positive perceptions of math using the Likert Scale process and included simple demographic questions (Pizzie & Kraemer, 2019). The questions utilized for this survey were adapted from questions which had been normed and validated in the original study, *The Academic Anxiety Inventory: Evidence for Dissociable Patterns of Anxiety Related to Math and Other Sources of Academic Stres*s (Pizzie & Kraemer, 2019). This strategy was chosen to ensure all questions in the survey would successfully measure both math anxiety and testing anxiety.

Each question response was attributed to a numerical value from 2 to -2. The question score was determined by the degree of how the individual agrees with questions associated negatively or disagree with questions associated positively regarding testing and mathematics. For the survey questions that attributed a negative connotation to mathematics or testing such as "I feel anxious while studying for a final," a strongly agree response received a numerical point value of 2, while a strongly disagree would receive a value of -2. For the survey questions that attributed a positive connotation such as 'mathematics is very interesting, and I have usually

enjoyed courses in this subject," the numerical point value is opposite. Therefore, a strongly agree response received a value of -2, while a disagree received a 1. An overall "Math-Related Tested Anxiety Score" was calculated by adding all of the values from the questions per participant.

Overall sums and averages from all responses to the online questionnaire were calculated utilizing Microsoft Excel. Calculating the average provides the likely response in the case of a random sample. The sum helps in understanding the difference ranges for the questioned used in the survey. The lower the sum, the more negative responses received to the question. The higher the sum, the more positive responses between 1 and 2, which projects a higher anxiety trend towards the type of question. The sum and average are very similar, yet the sum helps in understanding the discrepancies between the different responses to questions when little difference exists between the averages.

After analysis of all survey responses, three individuals were chosen to participate in an interview based on their past and present experiences with anxiety and mathematics. All interview participants indicated "yes" or "maybe" when responding to a request to participate in an interview. Interviewees with higher math-related testing anxiety scores were invited first. The interviewed individuals were all white females between the ages of 18-20 whose highest level of completed high school math course was Algebra II. Two individuals were homeschooled throughout elementary and secondary school. One individual attended one elementary, middle, and high school, which was a public school.

The interviews were conducted through Zoom video-chat calls over the course of two months with just the researcher and the interview participant. Each participant was asked nine pre-prepared questions pertaining to math and testing anxiety, along with a few extra questions

pertaining to math and testing anxiety as well as a few follow-up questions based on individual interview responses. The data derived from the interviews was utilized to better understand the bridge between math anxiety and testing anxiety by allowing for explanation of personal experiences. Through the sharing of these experiences and feelings, the data helped to reveal clear connections between both forms of anxiety. Therefore, this overall experiment utilized both quantitative research methods through the online baseline survey and qualitative research methods through online video-chat interviews.

The online survey was completed by 21 participants, including 16 females and five males. Fifteen people were between 18 and 20 years old; five individuals were between 21 and 22 years old, and one participant was 24 years old or older. Sixteen participants identified as white; three were two or more races; one individual was Black or African American; and one was Hispanic. When asked about the highest level of high school math completed, 11 individuals answered Algebra II, and four individuals had completed a calculus-level course. Twelve individuals attended public high schools, and nine attended private high schools. Nine individuals attended only one elementary school and 10 individuals attended two to four elementary schools. Eleven attended one middle school, and seven attended two or three middle school institutions. Thirteen attended one high school, and five attended two or three different high schools. One individual was homeschooled throughout elementary and secondary school. One individual was homeschooled through elementary and secondary school but attended a Christian cooperative. Six of the surveyed individuals identified as transfer college students.

Findings/ Results

Each question administered to students was derived from the Academic Anxiety Inventory (AAI) to measure either math anxiety or testing anxiety (Pizzie & Kraemer, 2019). The average and sum were calculated for each question individually to measure the results for all participants and the consistency of anxious feelings affiliated to each question. An individual score was also given to each participant as their "Math-Related Testing Anxiety Score" calculated based on the sum of their response to the questions. The questions were administered to each participant in the order below, and each average and sum are included.

Table 1

Math-Related Testing Anxiety Score Questionnaire Calculated Results

Question	Average Score	Sum
I feel anxious while studying for a final.	0.789474	15
Figuring out mathematical problems does not appeal to me.	0.631579	10
For some reason, even though I study, math seems unusually hard for me.	0.736842	13
I feel anxious while waiting to see my letter grade on a test.	0.947368	18
Mathematics is less important to people than art or literature.	0.052632	1
I feel nervous waiting for a test to be handed out.	1.052632	20

I'm not good at math.	0.631579	12
I feel stressed thinking about a coming exam an hour before it's scheduled to begin.	0.894737	17
Thinking about a coming exam the night before it's scheduled makes me nervous.	1	19
I feel anxious having a test returned.	0.894737	17
I think mathematics is based solely on memorization.	-0.31579	-6
I think counting on your fingers is childish.	-1	-19
I would feel self-conscious or uncomfortable counting on my fingers in a college classroom.	-0.15789	-3
Reviewing study materials the night before an exam makes me feel confident.	-0.73684	-14
Mathematics is enjoyable and stimulating to me.	0.263158	5
I think I could handle more difficult mathematics.	0.052632	1
I feel confident in class waiting for my graded test to be returned.	0.157895	3
I feel confident while studying for a midterm.	-0.05263	-1
Mathematics helps develop a person's mind and teaches him/her to think.	-0.73684	-14

Mathematics is very interesting, and I have usually enjoyed courses in this subject.	0.277778	4

Quantitative Data

In first addressing the finding from the online forum questionaries, the researcher considered the sum and average of each question. “I think counting on your fingers is childish” received the lowest average responses with an average of -1.000 and a sum of -19. Overall, 85.7% of participants either disagreed or strongly disagreed with this question. Of the surveyed individuals, 42.8% either agreed or strongly agreed that they would feel self-conscious or uncomfortable counting on their fingers in a college classroom, which shows that although it is not considered childish in performing the task, an individual may be afraid of how others would perceive counting on their fingers. Therefore, counting on one’s fingers may help to alleviate math anxiety and testing anxiety as a physical and visual way of understanding mathematics outside of the classroom, but anxiety levels could vary within the classroom.

The day of a test specifically had strong correlations on the class survey for raising anxiety, as 71.4% of participants either strongly agree or agree with feeling “stressed thinking about a coming exam an hour before its scheduled to begin.” The statement “I feel nervous waiting for a test to be handed out” resulted in 76.2% of participants ranking either strongly agreed or agreed. This statement received the highest average of 1.052632 and a sum of 20. These negative emotions were shown to exist even before the testing day as 47.6% of individuals strongly agree that “thinking about a coming exam the night before its scheduled makes me nervous” and another 28.6% simply agreed. The negative emotions continue after the test has been taken as 71.4% of individuals strongly agree or agree with the statement “I feel anxious

while waiting to see my letter grade on a test," and 76.2% strongly agreed or agreed about "feel anxious having a test returned." When the question was reversed, 61.9% of participants disagreed with the statement "I feel confident in class waiting for my graded test to be returned." Specifically addressing midterm exams and final exams, 76.2% of participants "feel anxious while studying for a final," while only 28.6% of individuals do not "feel confident while studying for a midterm" and 47.6% of participants felt neutral.

Another theme from the survey was student-perceived lack of enjoyment of mathematics. When asked if "mathematics is enjoyable and stimulating," 61.9% of individuals disagreed, and another 19% answered neutral. The statics were very similar when asked if they could "handle more difficult mathematics" with 66.9% disagreeing and 19% choosing neutral. When asked if mathematics is interesting or if they have enjoyed courses in the subject, 66.7% of individuals disagreed, and another 9.5% chose neutral. Overall, a very negative theme emerged relating to actual student enjoyment specifically affiliated with mathematics. Student appreciation for the subject also varied as 66.6% of individuals agreed that "mathematics helps develop a person's mind and teaches him/her to think." However, 47.6% chose neutral when asked if "mathematics is less important than art or literature," while 28.6% disagreed and 23.8% agreed. Enjoyment or appreciation could also be impacted by an individual's perception of their own mathematical abilities as 61.9% agreed with the question "I'm not good at math" and 23.8% chose neutral.

Overall, the survey data presented clear negative responses regarding mathematics based on the childishness of counting on one's fingers, any language pertaining to testing, and student enjoyment for the subject of mathematics. These negative responses were reaffirmed and explored through the qualitative interviews.

Qualitative Data

To uphold the confidentiality of each interviewed participant, pseudonyms are used for each participant. Sue is a female transfer student who was homeschooled from Kindergarten through eighth grade and attended a Christian homeschool cooperative in high school. Kara is a female, first-year student who attended public school throughout primary and secondary school. The third interview participant, Emily, is a first-year female who was homeschooled until college. All three participants identify as white and were between the ages of 18 and 20 years old at the time of the research.

When asked "do you remember a time when you were told not to count on your fingers" Kara and Emily explained that they could not remember a time when they were told not to count on their fingers and that they are confident in counting on their fingers to this day, even in higher level mathematics. Sue reflected on how she was told not to count on her fingers when she was a young child, but she opted to learn American Sign Language to be able to count on her fingers more subtly because it helped her to understand and be more comfortable in a math setting.

Understanding the "multidimensionality" of mathematics, originally developed by Boaler (2016), helps students to learn in different ways including visually. When asked "do you believe mathematics to be a visual field of study," the interviewed individuals had mixed responses on their own personal beliefs yet, all three concluded that their mathematical endeavors are more successful when they visually understand. Sue and Emily mentioned that visual learning feels slower, and Kara mentioned how she needed to write out a problem on paper to understand because it is much harder to simply complete in her head.

Throughout the various interviews performed, a consistent negative affiliation to any timed mathematical activity appeared, which aligns with prior research about "speed solving"

(Pizzie et al., 2020; Ashcraft & Moore, 2009; Richardson & Suinn, 1972; Boaler, 2016). When asked specifically about any connection to math anxiety or testing anxiety, Sue identified her negative affiliations to be based on prior experience with timed tests in mathematics specifically because "it makes me feel as though I cannot give my best because of the need to perform under pressure." When asked to identify the first time the interviewed individuals experienced a negative experience specifically associated with math, all three females explained situations involving pressure to preform by either a timed assignment or test as well as pressure created by an experience with the teacher. Kara specifically expressed how state testing produces negative affiliations with both mathematics and testing, raising anxiety.

Negative emotions towards math have repeatedly been shown to be amplified on a test day. Kara expressed how tests make her feel as though she will not do as well as she could have if it were simply a lesson or homework. These negative feelings are slightly amplified because it was a math class particularly when compared to a history class.

The interviewed individuals gave mixed responses about their own perceived math abilities, as Emily agreed that she is "just bad at math" because some parts make absolutely no sense while two interviewees disagreed. They outlined other obstacles that create anxious feelings surrounding math such as dyslexia, giving them confidence that they can complete the mathematical task with extra time or effort.

Discussion

A clear theme from the results of this experiment related to how students perceive counting on their fingers. It became clear that participants in this survey no longer consider counting on their fingers to be a childish endeavor nor a sign of mathematical competence. However, it still carries a negative correlation as many students agreed that they would feel self-

conscious or uncomfortable counting on their fingers in a college classroom. According to Boaler (2017), mathematics is best understood as a visual study and is best learned when an individual can visualize what they are being taught. Although it could be foundational in alleviating anxiety through aiding in visualizing mathematics, this alleviation could be due to the physical distraction, which is cultivated though counting on one's fingers (Crollen & Noel, 2015). It cannot be denied that this "hand interference" is helpful in the development of counting and arithmetic throughout an individual's lifespan (Crollen & Noel, 2015; Lafay et al., 2013; Boaler, 2016). Being able to count on our fingers does not necessarily impact the actual mathematical procedures when attempting to complete a test, yet it does seem to add external pressures due to fear of judgment from peers for most students especially in a college classroom.

Fear of judgment from peers is exactly what Steele (2007) is referring to when outlining identity threat and stereotype threat. These threats exist in all academic circles and even outside of academic circles as they are "a broad fact of life," yet their impact on a student in a math classroom and during testing is clearly impactful (Steele, 2007). Threat was a clear impact on math anxiety and testing anxiety not only by the response to counting on one's fingers, but also in the way students interpret timed activities in math and testing in general.

Any questions pertaining to tests such as "thinking about a coming exam the night before" or "I feel anxious having a test returned" showed high percentages of negative affiliations. In fact, the statement "I feel nervous waiting for a test to be handed out" received the highest average of 1.052632 and a sum of 20, the most consistently high numerical responses representative of negative emotions. Kara identified that her negative perceptions of math influenced the way they perceive math tests in general. This shows that the threat created through math testing carries different weight than other academic testing due to the perceived threat of

math itself. Clearly, most participants see testing as a threat, which inhibits individuals from performing at their best. Furthermore, when a student views both mathematics and testing as a threat, their body will not be able to perform at its best, and their overall academic performance would be directly impacted.

In exploring how this threat applied to mathematics and testing developed, the clear impact of speed-solving activities and timed test was insurmountable. Research has shown the benefits of understanding mathematics visually, yet students had mixed reactions to understanding mathematics visually because usually makes them feel slower in their understanding (Boaler, 2016). Students feel pressure to complete mathematical endeavors in a short amount of time, but the aim seems to be only completion with no intentions for actual learning. Timed activities and testing in elementary and secondary mathematics classrooms created a sense of threat pertaining to mathematics and testing for many contemporary students, which produces a sense of incompetence, tension, and anxiety for any math-related testing experience.

As math anxiety and testing anxiety directly impact a student's math-related testing experience due to the impacts of threat developed by past experiences developed in elementary and secondary school, there seems to be clear reason to understand the term "math-related testing anxiety." Data gathered in this study indicates a definition of math-related testing anxiety could be the following: "feelings of tension or anxiety that interfere with an individual's ability to effectively perform academically in a testing situation involving the manipulation of numbers and solving of mathematical problems in a wide variety of ordinary life and academic situations." Much of this definition is derived from Richardson and Suinn's (1972) definition of math anxiety along with the addition of the direct threat created by the addition of a testing

situation. Other math-related testing factors that were not specifically measured through the survey or interviews but are necessary to mention include culture, gender, and grading. Exploring how culture, gender, and grading impact academic anxiety is essential to understand the impacts of threat in the classroom and how teachers can attempt to help remedy this threat specifically regarding math-related testing situations.

In first addressing grading, the pressure created through the modern grading systems add levels of threat to a student's academic experience (Boaler, 2016; Kohn, 1999; Jaschik, 2009; Schinske & Tanner, 2017). Academic grades and test scores do not motivate students to learn and have the potential to contribute a lack of deep learning in academics (Boaler, 2016; Schinske & Tanner, 2017). As students fix their motivation towards grades, their learning loses its depth as it develops dependency on speed and accomplishment leading to a lack of visualization (Boaler, 2016). This spiraling effects a student's perceived threat attributed to math and math-related testing, which was clearly expressed through the results of this experiment as over 75% of students expressed anxious affiliation with any questions pertaining to grading (Steele, 2007).

The stereotype that males are better at mathematics while females are better at reading and writing could pose as an added threat to math-related testing anxiety (Steele, 2007; Szczygiel, 2020). Research shows that this stereotype threat clearly impacts an individual's negative affiliations with mathematics, especially for females in the United States and begins developing in elementary school (Seffens et al., 2010; Cvencek et al., 2011). Surprisingly, all three interviewed individuals expressed no concern about this threat as females participating in mathematics. The impact of gender stereotypes specifically on math-related testing anxiety is less clear as the research, and the results from this experiment were inconclusive.

Another threat that has the potential to impact math-related testing anxiety pertains to culture. Stereotype threat of Asians being assumed to be better at mathematics impacts individuals of all cultures but undermining the success of individuals simply based on their race (Steele, 2007). Although the measurement of culture in its relations to math-related testing anxiety was not measured in depth through this study, its impact has the potential to correlate directly to higher levels of anxiety due to its possible impact of perceived threat. Gaps exists in the achievement scores and have been directly correlated to the way students learn mathematics in ways that they "see as relevant to their identities and communities" (Barta et al., 2014; Finkel, 2017). Students perceived threat of mathematics could also be connected to the lack of cultural context in instruction which continues to drive stereotype threats in early aged classrooms (Barta et al,, 2014). Other areas that could be explored in the future could include the way math-related testing anxiety is perceived across different cultures. Whether differences occur does not undermine the impacts that anxiety has on an individual's academic performance especially in math-related testing situations.

Understanding the way that math anxiety and testing anxiety are connected in mathematical testing situations is essential for the development of effective future pedagogy. Various resources have been outlined which aid either math anxiety or testing anxiety individually such as expressive writing for math anxiety or computerized adaptive testing specifically for testing anxiety (Park et al., 2014; Fritts & Marszalek, 2010). Nonetheless, the greatest indicator for student success seems to be traced clearly to teaching quality, as it "significantly enhances student motivation especially in mathematics courses at the high school level" (Ruiz-Alfonzo et al., 2021). Therefore, the greatest remedy we can offer to students who

identify with math-related testing anxiety is to strive to employ the best teaching quality (Finkel, 2017).

Great educators need to improve teaching quality by taking on the role of learner and be willing to adapt their pedagogical practices according to the needs of their students. According to Finkel (2017), programs implemented for in-service and pre-service teachers that specifically focus on structures and pipeline elements which would need to be altered in contemporary school systems would help to bridge the gap specifically for women and underrepresented minority groups in mathematics. Above all, the way teachers assess mathematical understanding cannot solely be dependent on traditional testing as this is clearly connected to heightened math-related testing anxiety. There is an array of other possibilities for assessing mathematical understanding such as common performance tasks, student-designed projects, and even group tests (Boaler, 2016). According to Boaler (2016), "one of the greatest gifts you can give to your students is your knowledge, ideas, and feedback on their mathematical development when phrased positively with growth messages." Teaching quality includes an understanding of ways to alleviate anxiety through diverse forms of testing and positive feedback, knowledge, and ideas.

Limitations

It is important to note that this experiment was conducted in a small, Christian university affiliated with the Assemblies of God denomination in Washington State. The questionnaire was completed by 21 participants, with 76.2% being Caucasian, 71.4% being between 18 and 20 years old, and 76.2% being female. Therefore, the results of this questionnaire are not conclusive of a whole population, rather they operate as a research tool that can help us to see connections between math anxiety and testing anxiety based on responses from students who were actively

participating in a higher education math course. Furthermore, MATH 1103 Mathematics for Liberal Arts at Northwest University is a course, which is created for students to complete the mathematics elective for their graduation requirement. There were few students who participated in this study who are choosing to continue their study of mathematics throughout their higher educational experience. The three individuals who participated in the qualitative interviews were three white females which gives little room for diversity in the perspectives being taken. Again, it needs to be emphasized that the responses are not conclusive of the whole population.

This study was conducted by one researcher, and the calculations for individual Math-Related Testing Anxiety scores were calculated by one individual. Although each calculation was meticulously double checked, there is room for minor error in score calculations.

The COVID-19 pandemic exerted a tremendous impact on students across the globe, and its impact on this study cannot be ignored. This study was conducted only months after the first lockdown in Washington State; therefore, students who participated in this study were experiencing class in a HyFlex model, which means that for half of the classes throughout the course of their semester. Students were expected to participate in in-person courses initially and on Zoom for the latter part of the year. The implications for online course work should be studied further based on the impact from the pandemic, yet the stress many students experienced throughout the time this study was conducted cannot be ignored. This is a study that attempted to measure correlation between two different kinds of anxiety, which is tremendously impacted by stress. Therefore, this stress could have had further implications than what was measured by this study.

Another limitation of the COVID-19 pandemic was forcing all qualitative interviews to be conducted through Zoom. It is important to note that this could have impacted the response

that participants felt comfortable telling due to their comfortability in being recorded over a video-chat.

It should also be considered that participants were informed of the purpose of the study which was to identify possible connections to math anxiety and testing anxiety. Therefore, participants' conclusions regarding math-related testing anxiety could have been influenced more by participation in the study rather than personal experienced correlations between the two concepts.

Conclusion

The purpose of this study was to identify clear connections between math anxiety and testing anxiety and to attempt to give foundational direction for the term "math-related testing anxiety" through these connections. The connections emerged from detailed research, quantitative online forum classroom research, and qualitative interviews. Research on math-related testing anxiety is essential for understanding pressures that individuals face specifically in math-related testing situations and can be utilized by teachers, administrators, and individuals who may be experiencing anxiety in academic settings. The results can be used to advance research in the future surrounding math-related testing situations in hopes of eventually developing clear pedagogical practices that can be implemented in classroom curriculum to achieve the best student learning environment and attempt to close achievement gaps (Finkel, 2017).

Overall, it was found that there are various factors that clearly overlap between math anxiety and testing anxiety illustrated by the fact that the very verbiage of "testing" itself raises anxiety specifically when connected to mathematics. When in a math-related testing situation,

students may feel threated by an array of internal and external motivations such as self-worth, stereotypes, or grading.

According to Steele (2007), “unless you make people feel safe from the risk of [threat] identity predicaments in identity-integrated settings, you won't succeed in reducing achievement gaps or in enabling people from different backgrounds to work comfortably and well together.” Therefore, it is essential that we continue to identify, understand, and research the ways that threats impact math-related testing situations because it is key in ways we can reduce achievement gaps specifically in math related fields (Steele). Classroom learning is significantly impacted by an individual’s perceived threats which are not verbally expressed in a normal classroom (Boaler, 2016; Steele). As educators, we must be willing to strive to emulate the highest teaching quality for our students to feel valued in the ways that we communicate assessment and feedback.

Although it cannot be deemed its own term without further experimentation with larger numbers of people in more diverse settings, “math-related testing anxiety” reflects the clear connections between math anxiety and testing anxiety and could significantly impact an individual’s academic experience.

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Appendix

The questions included in the MATH 1103 Mathematics for Liberal Arts class at Northwest University Google Forum, which asked participants to rate the statements from “strongly disagree” to “strongly agree”:

1. I feel anxious while studying for a final.
2. Figuring out mathematical problems does not appeal to me.
3. For some reason even though I study, math seems unusually hard for me.
4. I feel anxious while waiting to see my letter grade on a test.
5. Mathematics is less important to people than art or literature.
6. I feel nervous waiting for a test to be handed out.
7. I’m not good at math.
8. I feel stressed thinking about a coming exam an hour before it’s scheduled to begin.
9. Thinking about a coming exam the night before its scheduled makes me nervous.
10. I feel anxious having a test returned.
11. I think mathematics is based solely on memorization.
12. I think counting on your fingers is childish.
13. I would feel self-conscious or uncomfortable counting on my fingers in a college classroom.
14. Reviewing study materials the night before an exam makes me feel confident.
15. Mathematics is enjoyable and stimulating to me.
16. I think I could handle more difficult mathematics.
17. I feel confident in class waiting for my graded test to be returned.
18. I feel confident while studying for a midterm.

19. Mathematics helps develop a person's mind, teaching him/her to think.
20. Mathematics is very interesting, and I have usually enjoyed courses in this subject.

The demographic questions included the following:

a. Name
b. Are you willing to possibly participate in a one-on-one interview depending on your response to this survey?
c. Do you wish to be followed up with your math-related testing anxiety score based on this survey?
d. Gender
    a. Male
    b. Female
    c. I prefer not to answer this question.
e. Age
    a. 18-20 years old
    b. 20-22 years old
    c. 22-24 years old
    d. 24+
f. Race
    a. Hispanic
    b. American Indian or Alaska Native
    c. Asian
    d. Black or African American

    e. Native Hawaiian or Other Pacific Islander
    f. White
    g. Two or more races
    h. Prefer not to respond

g. How many different schools did you attend in elementary school? Middle School? High School?
h. Highest level of high school math
i. High School affiliation (private or public)
j. Are you a transfer student?

The questions asked in the individual qualitative interviews were as follows:

1. Tell me about a time you felt successful in a math setting or about a positive experience you have had with math.
2. How do you feel about the gender stereotype that males are better at math and females are better at reading and writing?
3. Can you identify the first time you remember a negative experience specifically associated with math? Please describe this experience in detail.
4. How do you normally prepare for any academic test?
5. Do you prepare for math tests differently than other academic tests?
6. Do you think your perceptions for math are due to the way you were taught?
7. Do you believe that you are naturally "just bad at math"?
8. Do you believe mathematics to be a visual field of study?

9. Do you remember a time when you were told not to count on your fingers? How old were you?