The Impact of Math Anxiety on Health-Related Quality of Life and Functional Impairment

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Abstract

First discussed in 1954 by Sister Mary Fides Gough, math anxiety is a topic that has been gaining more attention in recent years. Current literature focuses heavily on the intersection of math anxiety and education, yet scant research assesses the impacts on daily life. This study addressed this gap by using an embedded quantitative correlational survey with descriptive open-ended questions to identify the correlation (if any) between math anxiety and health-related quality of life (HRQOL) and/or functional impairment. The study adopted Beck's general theory of anxiety (BGTA) as a framework. The survey consisted of three established measures—the AMAS, SF-36, and SDS—administered to 113 participants. Results indicate that math anxiety and HRQOL have a negative correlation, while math anxiety and functional impairment have a positive correlation. Based on findings, this study recommend that future research should establish a consistent framework (e.g., BGTA) as well as intervention strategies that addresses HRQOL and functional impairments (e.g., cognitive behavioural therapy). Finally, this study recommends that future practice should view math anxiety as a mental health issue and treat it as such.

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CHAPTER ONE: INTRODUCTION

Math can be a challenging subject, with most people knowing somebody who starts feeling anxious or panicky when in situations that require the use of mathematics or who avoids math-based situations (Janakiram, 2017). The feelings of fear, tension, and apprehension can be indicators that the individuals are experiencing math anxiety (Ashcraft, 2002). Math anxiety is a mental-health concern that is prevalent in K-12 school settings, with as many as 17% of students experiencing it on a spectrum (Luttenberger et al., 2018). Math anxiety triggers a threat response in the brain that leads individuals to have decreased working memory, increased attentional bias, and even experience a pain response (Artemenko et al., 2015). Such reactions impact individuals' abilities to regulate their emotions as well as behaviours in a math setting, which can cause a visual display that most would recognize as math anxiety (crying, avoidance, disengagement, etc.; Jansen et al., 2013).

It has been established that math anxiety negatively impacts mathematics performance in academic settings (Beilock et al., 2010; Çiftçi, 2015; Jansen et al., 2013; Lyons & Beilock, 2012; Maloney, 2012; Schmitz et al., 2019). This study sought to understand the relationship between math anxiety, Health-Related Quality of Life (HRQOL), and functional impairment. HRQOL is defined as an individual's perceived physical and mental health over time (Skevington et al., 2004). Functional impairment refers to the limitations a mental or physical health challenge imposes on people's daily lives (Ustün, 2009).

This introductory chapter includes the problem and purpose of this investigation. It also includes the theoretical framework that guided the study, the research questions that framed the investigation, and important terms. Limitations are provided to clarify how any conclusions that were drawn from this investigation may be reasonably generalized to other contexts.

Background of the Problem

Math anxiety is a topic that has recently been discussed more heavily in the media (Janakiram, 2017). Math anxiety, however, is not new. It has been around for many years and was first referred to as “Mathemaphobia” (Gough, 1954). Around the same time, Dreger and Aiken (1957) published a study also addressing this phenomenon but instead referred to it as “number anxiety.” It was not until 1972, however, that the term “math anxiety” was used in the literature and a specific definition provided: “a feeling of tension and anxiety that interferes with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations” (Richardson & Suinn, 1972, p. 551). Richardson and Suinn (1972) not only provided both the term and definition that is still used today but they also developed a Math Anxiety Rating Scale (MARS). The scale allowed them to assess the impacts of math anxiety on students and to investigate if students’ struggles in a math classroom were due to math anxiety or some other cause (Richardson & Suinn, 1972). This standardized definition and tool allowed researchers to better identify and study math anxiety. The effectiveness of this tool has been further built upon and studied since then.

Math anxiety symptoms have been separated into four different categories: first, the way that math anxiety impacts an individual’s thoughts. Math anxiety causes students to have negatively biased thoughts towards math, typically due to their role models or negative self-talk (Beilock et al., 2010). Very closely related are the impacts that math anxiety has on an individual’s emotions. Math elicits a highly emotional response in math-anxious individuals that can be exhibited in numerous ways (Jansen et al., 2013). Third, math anxiety can even cause physical symptoms, most commonly at the neurological level, such as the impacts on threat and pain, working memory, and attentional bias (Maloney, 2012). Finally, math anxiety can impact individuals’ behaviours; this is most commonly exhibited as avoidance, causing them to make different life choices that will result in them being put in fewer potential math situations (Ahmed, 2018).

The greatest impacts on math functioning are through the neurological changes to the brain and the avoidance behaviour that individuals present (Ahmed, 2018; Lyons & Beilock, 2012). Addressing the issue of augmented behaviours leading to avoidance is the most visible impact on math functioning, and easiest for teachers or observers to notice. Those who experience math anxiety are far less likely to take math courses, put themselves in math situations, or spend any unnecessary time on math work (Huang et al., 2018). This decreased exposure to math leads these individuals to have less experience with the subject, which increases anxiety and causes a spiral effect as this increased anxiety makes them less likely to be able to participate in future math activities, which in turn will cause more anxiety and so on (Maloney, 2012). Avoidance, however, is not the only reason that individuals who experience math anxiety struggle with their math functioning; the greatest barrier is the changes math anxiety has at the neurological level (Lyons & Beilock, 2012).

Math anxiety impacts the brain in three different ways: threat and pain response, working memory, and attentional bias. First, students who experience high levels of math anxiety find that their emotions are grounded in a threat response when presented with math, as well as a very real sensation of pain (Lyons & Beilock, 2012). Second, math anxiety also has an impact on working memory (Klados et al., 2015). Finally, math anxiety also causes an attentional bias (Rubinsten et al., 2015). The combination of an attentional bias as well as the impacts that math anxiety has on working memory also led to poor number and/or spatial awareness skills (Georges et al., 2016).

These three impairments of math anxiety on math functioning in turn lead to a decrease in academic achievement by individuals struggling with math anxiety. On average, math anxiety causes students to achieve 27% lower on academic mathematical tasks than their peers who do not struggle with math anxiety (Çiftçi, 2015). This lower achievement is not just due to math anxious students struggling with their math fluency (understanding of the concepts); it also reflects their inability to represent or display their knowledge on assignments/tests due to avoidance and impairments in working memory (Çiftçi, 2015).

"Quality of life" is an inclusive term used to describe and measure, often through surveys, many different subjective and objective aspects of a person's life (Felce, 1997). This study specifically examines HRQOL, which is used as a measure to better understand the effects of health issues on individuals by looking at the impacts on a person's daily functioning and lifestyle (Cella, 1995). When assessing HRQOL, there are two main domain categories: physical health and mental health (Ware & Sherbourne, 1992). Physical health covers physical functioning, physical role, bodily pain, and general health; in contrast, mental health encompasses vitality, social functioning, emotional role, and mental well-being (Ware & Sherbourne, 1992). The use of HRQOL allows the study to identify the impacts of math anxiety that are experienced through thoughts, emotions, behaviours, and physically.

When assessing HRQOL, specifically in how it relates to anxiety disorders, a functional impairment assessment is also conducted (Barrera, 2009; Huppert et al., 2009; Rapaport et al., 2005; Romera, 2011). Functional impairment is a component of clinical significance, which is a criterion for establishing a diagnosis for a mental disorder as outlined by the Diagnostic and Statistical Manual of Mental Disorders – 5th edition (DSM-5; Ustün, 2009). Functional impairment means limitations in the social and occupational areas of a person's life, and the

DSM-5 broadens this explanation to also include impairment in other forms of functioning (Ustün, 2009). Functional impairment is seen through the way math anxiety impacts people's behaviours as well as cognitive functioning. Research has identified a decreased level of math exposure in math-anxious individuals due to avoidance, which is best represented by the lack of math-anxious individuals pursuing Science, Technology, Engineering, or Math (STEM) careers (Ahmed, 2018). The impacts math anxiety has on the brain through a threat and pain response, working memory, and attentional bias provide a possibility that there is functional impairment. This study investigated the relationship between math anxiety, HRQOL, and functional impairment.

Statement of the Problem Context

Research on math anxiety has focused primarily on the math classroom. There is limited information on the effect of math anxiety in settings outside of the classroom. Ahmed (2018) identified the impacts math anxiety had on an individual's life choices (rather than just the academic impacts) by addressing the difference in careers between math-anxious individuals and their peers. Math-anxious individuals are seven times less likely to pursue a career in the STEM field than their peers (Ahmed, 2018). Other studies have addressed, within academic/classroom settings, the thoughts, emotions, and behaviours of math-anxious individuals (Beilock et al., 2010; Casad et al., 2015; Çiftçi, 2015). These studies, expanded on in Chapter 2, support the notion that math anxiety impairs an individual's academic achievement. I have found no studies that have investigated how math anxiety impacts an individual's HRQOL and if the anxiety is associated with functional impairment. Studies, however, have shown a connection between a math learning disability and functional impairment (Ashcraft et al., 2007) as well as anxiety disorders and functional impairment, which suggests that the same could be true for math anxiety (McKnight, 2016). This study proposes to address this gap in the literature.

Purpose of the Study

This embedded quantitative correlational study with descriptive open-ended questions was structured to examine the relationship between math anxiety and HRQOL and if it contributes to any functional impairments.

Research Questions

- RQ1: Is there a relationship between math anxiety and HRQOL in postsecondary students?
  - H1: Math anxiety is negatively correlated with HRQOL in postsecondary students.
- RQ2: Is there a relationship between math anxiety and functional impairments in postsecondary students?
  - H2: Math anxiety is positively correlated with functional impairment in postsecondary students.

Importance of the Study

This study was designed to fill a gap in the literature, which will allow its findings to be beneficial both academically and within the context of teaching. Due to this, the study may have a significant impact on the field and knowledge base.

This study hopes to leave a long-lasting and positive impact on the educational field. First off, the study identified the impacts of math anxiety on functional impairment and HRQOL. This knowledge will benefit educators and clinicians as it will allow them to better understand the breadth of impact math anxiety has, and hopefully encourage better supports and interventions to be developed to support individuals experiencing math anxiety. This study also expanded the academic knowledge base on math anxiety. Because there is little in the academic literature on the impacts of math anxiety outside of formal academic settings, this study will contribute meaningfully to this under-researched area.

Rationale for Methodology

This study was characterized as an embedded quantitative correlational study with descriptive open-ended questions. Embedded research is conducted when both quantitative and descriptive data are needed to explain a particular phenomenon and where the use of both approaches in tandem will result in greater findings than using either quantitative or descriptive approaches independently (Creswell, 2016). In this study, the quantitative survey questions were the primary research tool and the descriptive open-ended responses were used to further support the research findings (Creswell, 2016).

Quantitative research was conducted to explain the phenomenon by collecting numerical data that are then analyzed using mathematically based methods, particularly statistics (Muijs, 2011). The quantitative portion of this investigation consisted of a quantitative survey which will highlight any correlation between the variables of interest (Muijs, 2011). In this case, the variables of interest consisted of math anxiety, HRQOL, and functional impairment.

Quantitative research is conducted by collecting numerical data and analyzing the trends, comparing groups, and identifying any relationships between variables (Creswell, 2016). By utilizing this type of research, it was possible to engage with a large sample of participants (Creswell, 2016). This allows for a broad-spectrum depiction of the research problem which in turn provided the ability to identify widespread relationships (Creswell, 2016).

When evaluating the goals and requirements for other quantitative research, it was established that none of them were appropriate for this study. Quasi-experimental and experimental research need everything but the independent variable to be controlled to identify cause and effect (Creswell, 2016). In contrast, this study sought to identify the relationship between already existing variables so that the relationship can be used to predict outcomes (Creswell, 2016). Neither survey designs, where the goal is to describe the sample population, nor descriptive designs, when the goal is to describe a current variable, were deemed useable as this research involved multiple variables (Creswell, 2016). Therefore, correlational design was used for the quantitative portion of this study as it is best used to measure and describe the relationship between variables (Creswell, 2016). Statistical analysis was then used to determine the8irectionn and degree of association between variables (Creswell, 2016).

In addition to the primary quantitative questions, descriptive research was also performed through responses to open-ended questions. Descriptive research is conducted by eliciting answers to questions that focus on the how, what, and why and then uses inductive reasoning to generate themes that can be used to explain the particular phenomenon (Brazier et al., 1992).

The descriptive portion of this study consisted of open-ended responses that were used to identify any themes that were present in order to support whether or not there was a correlation between the variables of interest. In this case, the variables of interest consisted of math anxiety, HRQOL, and functional impairment.

Researcher Position

When conducting research, it is important to be aware of the influences and personal history of the research to best understand the lens through which the research will be interpreted (Creswell, 2016). In this case the researcher has a Bachelor of Science in Mathematics and is currently teaching high school level mathematics. The researcher has also never personally experienced math anxiety but has interacted with individuals who may have been struggling with math anxiety but had not labelled it themselves.

Theoretical Framework

The theoretical framework that was used in this study is Beck's General Theory of Anxiety (BGTA). BGTA is based on the core premise that dysfunctional cognitions cause increases in emotional distress, physiological discomforts, and maladaptive behaviours (Beck, 2014). BGTA focuses on identifying which specific stimuli draws out certain dysfunctional thoughts or reactions (Beck, 2014). For example, with respect to math anxiety, one possible underlying distorted cognition is that the individual is incapable of performing mathematical skills due to biological and/or genetic factors. When confronted with a task that requires using mathematical skills, such as completing a math test, this distorted cognition results in an emotional response (fear of failure, shame, worry) and an associated behavioural response (e.g., avoidance). BGTA posits that this distorted cognition—and others related to it—is the direct cause of the math anxiety (comprising the emotional and behavioural responses to the distorted cognition).

When assessing HRQOL, it is possible to see if there are any perceived impairments within an individual's physical or mental health (Ware & Sherbourne, 1992). Physical health covers physical functioning, physical role, bodily pain, and general health; in contrast, mental health encompasses vitality, social functioning, emotional role, and mental well-being (Ware & Sherbourne, 1992). Therefore, any emotional or physiological concerns brought on by math anxiety would fall within the physical and mental health assessment of HRQOL.

To further support this, functional impairment assessments will identify limitations in a person's life (Ustün, 2009). Maladaptive behaviours are deemed as those that stop individuals from adapting to new or difficult circumstances and this is regularly assessed using a functional impairment approach (Wedig, 2009). By using an assessment of functional impairment (the Sheehan Disability Scale), the impact of these maladaptive behaviours can be quantified.

By combining these two approaches, it will be possible to identify any correlation between dysfunctional cognition (assumed based on the literature to occur in people who have math anxiety) and their emotional response or maladaptive behaviours (through HRQOL and functional impairment). The predicted correlation between math anxiety and HRQOL is negative due to the assumption that distorted cognitions will lead to emotional responses (e.g., fear) when individuals are presented with math situations, and positive for math anxiety functional impairment due to the assumption it leads to a maladaptive behaviour. This avoidance of mathematics could result in potential job repercussions or loss, which will be identified in the functional impairment assessment, and the emotional component of the negative job repercussions identified by a HRQOL assessment.

Definition of Important Terms

- *Distorted cognition* refers to inaccurate or rationalizing thoughts, attitudes, and/or beliefs concerning one's own or another's social behaviour (Liau et al., 1998).
- *Emotional response* is an emotional reaction, such as happiness, fear, or sadness, to a particular stimulus (American Psychological Association, 2020).
- *Functional impairment* refers to limitations in a person's ability to perform activities that are relevant to daily life (Stein & Jessop, 1990).
- *Health-related quality of life (HRQOL)* is an individual's perceived physical and mental health over time (Skevington et al., 2004).
- *Maladaptive behavioural response* means a behaviour that interferes with an individual's daily activities/living and/or ability to adjust and participate in different settings (Gray, 2013).

- *Math anxiety* is a feeling of tension, apprehension, or fear that interferes with math performance (Ashcraft, 2002).
- *Quality of life (QOL)* is an individual's perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards, and concerns (Skevington et al., 2004).

Assumptions, Limitations, and Delimitations

For this study, several assumptions needed to be taken into account. First, it was assumed that all survey participants answered the questions honestly as there is no academic or other benefit in answering the questions dishonestly. The study also assumed that the literature indicating that math anxiety has a negative correlation with academic achievement is accurate. This, in turn, led to the assumption that the degree of math anxiety experienced will result in similarly negative repercussions on HRQOL and functional impairment. The surveys used also have significant internal reliability and have been tested numerous times to ensure the questions are written in a way that are self-explanatory and easy to understand. The Sheehan Disability Scale (SDS) holds a Cronbach alpha score of 0.89 (Arbuckle et al., 2009), the Abbreviated-Math Anxiety Scale (AMAS) has a score of 0.9 (Hopko, 2003), and the Rand 36-item Short Form Health Survey (SF-36) has consistent scores of greater than 0.8 across its seven categories (Brazier et al., 1992).

This study utilized BGTA as the framework through which it viewed math anxiety and the survey data. BGTA, at its core, is comprised of dysfunctional core beliefs that result in an emotional response and lead to maladaptive behaviours. This study worked under the assumption that the previous findings in the literature already established that math anxiety results in dysfunctional core beliefs (Cobb et al., 1989; Dossey et al., 1988; Espinoza et al., 2013;

Fennema, 1989; Garofalo, 1989; Greenwood, 1984; Grouws & Cramer, 1989; McLeod, 1992; Post, 1992; Reyes, 1984), which are expanded upon in Chapter 2, and hence the survey only focused on identifying the emotional and behavioural impacts.

Outline of the Remainder of the Document

Chapter 1 provided an introduction and general overview of the problem that illustrates the background, research rationale, and theoretical framework for this study. Chapter 2 provides a detailed discussion of the literature surrounding this problem, including the literature on math anxiety, HRQOL, and functional impairment. The chapter also outlines the theoretical framework (BGTA) and the intersection of BGTA with studies on the impacts of math anxiety in the classroom. Chapter 3 describes the research methodology, participant selection, instruments used, data collection, data analysis, and ethical considerations. Chapter 4 presents results of the statistical analysis, consisting of Spearman correlational tests and regression analysis. Finally, Chapter 5 provides a summary of the findings, recommendations for future research, and implications for future practice.

CHAPTER TWO: REVIEW OF THE LITERATURE

Math anxiety refers to feelings of fear, tension, and apprehension that many people experience when engaging with math (Ashcraft, 2002). Specifically, math anxiety is a type of anxiety disorder in which the anxiety-provoking stimulus is math. This chapter will begin by explaining the intersection of mathematics and education, and then will outline literature on the etiology, prevalence, incidence, symptomology, and the impacts on functioning of math anxiety. Beck's General Theory of Anxiety (BGTA) will be outlined and used to explain the theoretical basis of connecting Health Related Quality of Life (HRQOL) and function impairment with math anxiety.

Math Education

Bloom's taxonomy, consisting of three learning domains, is a widely used framework for informing educational objectives (Sousa, 2017). Bloom's taxonomy encompasses three learning domains: cognitive, affective, and psychomotor (Sousa, 2017). The cognitive domain consists of mental skills and gaining of knowledge (Anderson et al., 2001). The affective domain comprises an individual's emotions, beliefs, and attitudes and the psychomotor domain focuses on the individual's physical movement, coordination, and motor skills (Sousa, 2017). In the past, math education has focused heavily on the cognitive domain, with less emphasis put on the affective and psychomotor domains as those factors were not believed to be an integral component of math education (McLeod, 1992). Also due to math's analytical nature, the cognitive domain has often been the focus of past mathematical research (McLeod, 1992). This has resulted in the six categories of the cognitive domain being a core focus of math education, with little emphasis placed on the affective or psychomotor domains due to their lack of believed applicability to math as a subject (Anderson et al., 2001).

However, recent research has identified that math education, or the actual act of learning math, is often viewed differently than other subjects as people will talk about inherent math ability (I am or am not a math person), rather than just math effort (time spent studying/doing homework; McLeod, 1992). This perception of math education being different even affects teachers, who are just as likely to discuss their classes' emotions or attitudes towards math (my class loves math) as their academic achievement (my students are above average this year; McLeod, 1992). This perception of math has led to the increased need, and shift, to address not only the cognitive factors but also affective factors in math education (McLeod, 1992).

The affective domain consists of five subdomains—receiving, responding, valuing, organization, and characterization—that are as equally integral to mathematics education as the cognitive factors listed previously (McLeod, 1992). In the past, the cognitive domain was the main focus of math education but recently it was found that affective issues (e.g., anxiety) can both impede math performance as well as impair education in the cognitive domain (Cargnelutti et al., 2017). Focusing only on cognitive development and not addressing the affective component has resulted in the separation of how success in math is viewed compared to other subjects. Rather than being about effort, it comes down to whether an individual has the inherent ability to do math or not (McLeod, 1992). It has also been found that affective issues (e.g., anxiety) can impede math performance specifically by impairing processing in the cognitive domain (Cargnelutti et al., 2017). Therefore, the affective domain plays an integral role in math education, just like the cognitive domain, and is impactful on overall math success. An understanding of math affect is necessary to best understand math anxiety due to it being an affective issue and because the proposed treatment strategies for math anxiety typically focus on addressing issues within the affective domain (McLeod, 1992).

Math Affect

Affective factors were first introduced in, and connected to, cognitive theories by Schacter and Singer (1963) and Simon (1967) but the topic has since grown with Mandler (1975, 1984) extensively connecting this concept to math education (McLeod, 1992). Mandler developed a general theory that was then applied to the teaching and learning of mathematical problem solving (McLeod, 1989). Mandler's perspective is that the greatest affective factors are caused by emotional responses when plans, or planned behaviours, are interrupted (McLeod, 1992). If individuals are not able to complete their anticipated plans as expected, physiological responses such as an increase in heartbeat or muscle tension result (McLeod, 1992). This physiological response, or arousal, results in individuals' attention being redirected to this interruption and in them attempting to find the meaning for this interruption (McLeod, 1992). Searching for the meaning of this interruption can cause cognitive evaluations, which can be classified as things like a happy surprise, a negative irritation, or even a major catastrophe (McLeod, 1992). This analysis of the arousal is used to provide meaning for the situation and is dictated by the individual's knowledge and beliefs (McLeod, 1992). Typically, this analysis of the arousal results in an emotional response that is short in duration (McLeod, 1992). The individual will then move on to find a different way to carry out the original plan (McLeod, 1992). However, if repeated interruptions occur under similar contexts, the emotional response is typically lessened but becomes more automatic (McLeod, 1992). As the response becomes more automatic, it results in engrained attitudes towards math such as a distaste due to not believing they are a math person (McLeod, 1992).

An example of Mandler's model would be a Grade 6 student who has been successful in other areas of math but is faced with a standard word problem for the first time (McLeod, 1992).

The student goes into the situation believing that this word problem should be easy to understand and have a reasonable solution that can be solved quickly (McLeod, 1992). If the student is unable to find a satisfactory answer in a reasonable time, this failure (or interruption) to solve the problem will likely lead to a physiological response or arousal (McLeod, 1992). The student will likely interpret this arousal as negative, typically as frustration (McLeod, 1992). If the student can then overcome this interruption, they will likely have a positive reaction to the experience due to a sense of accomplishment (McLeod, 1992). However, if the student is unable to overcome the barrier, and negative reactions to word problems are repeated, the negative reaction to word problems will become automatic (McLeod, 1992). This is where the engrained perception of being unable to do math can come from. In this case, the student will feel that they are unable to succeed on word problems and have established a negative attitude towards them.

This model, as described by Mandler (1984), results in three major dimensions of affect that impact the overall experience of mathematics and in particular math education. Initially students will hold beliefs about the subject of math and their perceptions of themselves that play an integral part in the development of their responses when confronted with these interruptions (McLeod, 1992). Once a student is confronted with an interruption, they then experience an emotional response, either positive or negative, that is typically more intense when a new task is presented (McLeod, 1992). Finally, when the beliefs and emotions that are experienced in the math situations occur consistently and are reinforced with the expected outcome, attitudes are developed towards mathematics as a whole, which is a factor in the perception that some people are or are not math people (McLeod, 1992).

Beliefs

As stated previously, beliefs are viewed as the initial step in this affect model. The beliefs that students develop are typically a product of their social environment and have, potentially, been emphasized and reinforced over long periods of time (McLeod, 1992). Students' beliefs about mathematics can be described within four categories: beliefs about mathematics, beliefs about self, beliefs about mathematics teaching, and beliefs about the social context (McLeod, 1992).

Beliefs about mathematics can vary drastically and focus on different aspects of the topic of mathematics as a whole. For example, males report a higher perceived usefulness of mathematics as opposed to their female peers (Fennema, 1989). Another belief is that math is a skill that some individuals possess and others do not. This skill-based belief in mathematics leads to anxiety (Greenwood, 1984) and can hinder higher-order thinking in mathematics (Garofalo, 1989). By having this belief, students are already putting themselves in a position where the beliefs could be further emphasized and be adjusted into an attitude regarding the subject. This belief about mathematics being a skill directly leads into the next section—beliefs about self.

Beliefs about self can be given many different titles, or looked at in different ways, such as confidence and/or self-concept. The distinct difference from beliefs about mathematics is that these beliefs stem from the perceptions individuals have about themselves rather than the subject itself. A common collection of beliefs in this category are gender based, such as males typically being more confident in their mathematics abilities than females, even though based on performance measures, females have a better reason to be (Espinoza et al., 2013; Post, 1992; Reyes, 1984). Male students are found to be more likely to attribute success in math to ability and failure to lack of effort, whereas females are more likely to attribute a failure in math to a lack of ability and success due to extra effort (McLeod, 1992). This confidence gap is not just prevalent between the genders but also can be seen across students of different ages. In a study conducted by Dossey et al. (1988), children in Grades 3, 7, and 11 were asked if they were good at doing mathematics. The percentage of students in Grade 3 who felt they were good at doing mathematics was 65%; however, by Grade 11 that percentage had dropped to 53%, providing a general idea of confidence diminishing as students progress through school (McLeod, 1992).

Also, beliefs about mathematics teaching can heavily influence an individual. This can be a result of preconceived notions for how math should be taught or the educational environment. This is particularly evident when you look at how a traditional mathematics classroom is set up as opposed to other subjects. In a traditional math class, students typically spend more time alone doing individual seat work whereas other subjects (such as social studies) provide more opportunity for group work, developing research skills, and working on improving higher-order thinking skills (McLeod, 1992). While there have been recent changes in math instructional engagement, a shift to more student/problem-centred learning (Liljedahl, 2016), students may still assume the stereotype that math is a very pen-and-paper-based course.

Finally, beliefs about social context are closely related to affective concerns (McLeod, 1992). Teaching social norms in elementary classrooms is directly related to the affective reactions the students display (Cobb et al., 1989), and a supportive high-school classroom environment that encourages enthusiastic learning heavily influences affective reactions (Grouws & Cramer, 1989). The social context is also not just dependent on the environment developed in the classroom but can also be influenced by parents' attitudes and beliefs, particularly for females who will reflect the social norms that their parents express (Parsons et al., 1982).

The collections of these beliefs, according to Mandler (1984), is what leads to the emotional reaction that occurs when the belief is interrupted. Therefore, it is important to acknowledge how emotions intersect with math education.

Emotions

When students are faced with a barrier to their plan/beliefs, a physiological arousal occurs that then results in an emotional response, typically negative, to assign meaning to the arousal that has occurred (Mandler, 1984). This emotional response is common, and not always problematic. When students are faced with new educational tasks, they may experience feelings of frustration but once they are able to push past the barrier, such as solving the question, students begin to feel relaxed and experience a wave of positive emotions (Bloom & Broder, 1950); however, this positive outcome is not always the case. If students are unable to find the correct solution, they may become increasingly frustrated and begin searching for any way to get past this barrier, even if it is irrational resulting in an unsatisfactory outcome (McLeod, 1992). Since these emotional experiences occur at both ends of the spectrum—joy if the barrier is overcome, frustration if it is not—the repeated occurrence of the emotions ascribed to whatever the original beliefs were results in the development of attitudes.

Attitudes

As stated previously, attitudes are the by-product of having a consistent outcome to a belief that is generating the same physiological and emotional response (McLeod, 1992). As these emotional responses are repeated, they become less intense but more automatic (Mandler, 1984). Therefore, attitudes can be considered an affective response that includes either positive or negative feelings of moderate intensity but are consistently stable (McLeod, 1992). Once these attitudes are established, it then also becomes possible that they are assigned to a different, but similar, situation (McLeod, 1992). If a student had already gone through the previous process of developing a negative attitude towards geometry proofs, this same attitude may then be assigned to algebra proofs (McLeod, 1992). Due to the time that attitudes take to develop, it also results in a decrease in enjoyment for math as students grow up, with 60% of Grade 3 students saying they enjoy math but only 50% of Grade 11 students saying they do (Dossey et al., 1988); these results are also consistent in other studies (Leder, 1987; McKnight et al., 1987).

This amalgamation of beliefs, emotions, and the resulting attitudes is a factor in the development of math anxiety but also a justification for its connection to BGTA, which will be expanded upon throughout this chapter.

What Is Math Anxiety?

Math anxiety impacts approximately 17% of the population, making it a common learning challenge for students (Luttenberger et al., 2018). Math anxiety is a negative reaction at the thought of doing math typically due to fear, tension, or apprehension (Maloney, 2012). Math-anxious individuals may experience intense panic when faced with a math problem on a test, opening a textbook, or even just at the prospect of entering a math classroom (Maloney, 2012). This fear can extend into other areas of life such as reviewing a grocery receipt or the fear of having to calculate a tip at dinner (Maloney, 2012). To understand math anxiety, it is important to have a full understanding of the research history, since this phenomenon is recent—only having been first discussed in the 1950s by Sister Mary Fides Gough.

Therefore, when using the Diagnostic and Statistical Manual of Mental Disorders – 5th edition (DSM-5) as a criterion for what anxiety is, it can be assumed that math anxiety occurs if the math class, math situation, or a math-related environment cause the negative symptoms to occur. Math anxiety is a prevalent issue estimated to impact 17% of the American population, and 30% of high school aged students reporting high levels of stress in a math classroom in Europe (Luttenberger et al., 2018). When discussing math anxiety, it is important to acknowledge that there may be many antecedents that interact and influence the development of math anxiety (Luttenberger et al., 2018). Math anxiety is heavily impacted and determined by many factors in a child’s life, such as their parents/teachers whom they look to as role models, culture, school/learning environment, gender stereotypes (boys are good at math, girls are good at English), genetic predisposition, and finally general anxiety proneness (Luttenberger et al., 2018). Math anxiety is an incredibly complex issue with many potential causes, problems, and life-long implications; therefore, it is important that all teachers are educated and prepared to support the growth of their students as best as possible (Luttenberger et al., 2018).

History of Math Anxiety

Math anxiety was first discussed before it was labelled as such. The earliest article discussing what would become math anxiety was by Sister Mary Fides Gough, who instead referred to it as "Mathemaphobia" in an article published in 1954. Gough (1954) acknowledged the impact that a fear of mathematics can have on students, resulting in poor math grades not from a lack of intelligence but instead due to an anxiety that surrounds the subject as a whole. At a similar time, Dreger and Aiken (1957) released an article also addressing this new phenomenon, which they referred to as "number anxiety." While much of the findings and discussions throughout this article are similar to what Gough discussed 3 years earlier, Dreger and Aiken added the use of statistics and noted that while students may struggle with both anxiety and number anxiety, the two do not have to go hand in hand; it is possible to struggle with one and not the other.

Richardson and Suinn (1972) introduced the term "math anxiety" and provided a specific definition for this experience: "a feeling of tension and anxiety that interferes with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (p. 551). Richardson and Suinn not only provided both the term and definition that is still used today but they also developed a math anxiety rating scale (The Math Anxiety Rating Scale; MARS) that allowed them to assess the impacts math anxiety was having on a student and also to determine if a student's struggles in a math classroom were due to math anxiety or some other cause. This tool allowed teachers and students to better identify if they are dealing with a math anxiety issue. The effectiveness of this tool has been further built upon and studied.

As math anxiety began to be viewed as a deeper problem and not just poor academic skills, it became more important that teachers support these students—not just academically but also emotionally. In general, there is no perfect solution to identify and support students who struggle with math anxiety, as each student is unique and the symptoms they demonstrate or the support they require will not be the same. Genshaft and Naglieri (1987) recommend a four-step process for teachers in order to assess the likelihood a student may have math anxiety. These steps include: stop and read records, look carefully, listen, and do some quick screenings (Genshaft et al., 1987). When stopping and reading records, teachers are looking for an ability and achievement gap potentially through students with good math skills but who are avoiding placement in higher academic math courses (Genshaft et al., 1987). When looking carefully, teachers should be looking for students who: rarely volunteer, sit in the back of the classroom, and who are successfully completing homework but struggling on tests (this could mean test anxiety and not math anxiety; Genshaft et al., 1987). When listening, teachers are paying attention to students' comments or conversations as they may highlight specific attitudes or anxious feelings towards math (Genshaft et al., 1987). Finally, teachers can do some quick screenings by using a math anxiety assessment tool/quiz that a student can fill out so that the teacher will have a better understanding of how the student is feeling (Genshaft et al., 1987). This paper acted as a turning point in the history of math anxiety as the focus within academics shifted from identifying and acknowledging math anxiety to finding solutions or supports that would benefit students.

In more current research, the MARS is still a widely used math anxiety measure along with the Abbreviated Math Anxiety Scale (AMAS; Schmitz et al., 2019). These two scales are the most widely used, reliable, and valid math anxiety measures and both have been adapted, abbreviated, and modified to apply to specific countries or age groups (Schmitz et al., 2019). When using the rating scales, it is important to differentiate between students who are struggling with math anxiety and those who simply have math anxiety associations (Schmitz et al., 2019). Math anxiety associations occur when an individual experiences some characterizations of math anxiety but are not severe or numerous enough to be deemed math anxious (Schmitz et al., 2019). Some examples of math anxiety associations are anxiousness, insecurity, nervousness, and worry or fear about math (Schmitz et al., 2019). Schmitz et al. (2019) found that there was no correlation between academic achievement in math and math anxiety associations; however, there was a strong correlation between explicit self-reported math anxiety and a poor performance in math academically. Therefore, a student's ability to self-identify that they are struggling with math anxiety provided a better predictor of negative academic performance in mathematics than teacher-reported observations of math anxiety associations in students (Schmitz et al., 2019). The researchers speculated this may be because math anxiety associations are not just manifested by students experiencing math anxiety but are also exhibited by students who are experiencing other issues as well (Schmitz et al., 2019). While this means it is challenging for teachers to properly identify students who may be struggling with math anxiety, it is still important to acknowledge any potential signs or symptoms of math anxiety, and follow up with a professional, as it may help start the conversation with that student (Schmitz et al., 2019).

Symptoms of Math Anxiety

Math anxiety has many different potential symptoms which are best split up into four different categories, the first being the way that math anxiety impacts an individual's beliefs. Math anxiety causes students to have negatively biased beliefs towards math, which can cause varying different impacts on their ability to succeed in the math classroom (Beilock et al., 2010). Very closely related are the impacts that math anxiety has on an individual's emotions. Math elicits a highly emotional response in math-anxious individuals that can be exhibited in numerous ways (Jansen et al., 2013). Third, math anxiety can cause physical symptoms, most commonly at the neurological level, such as impaired working memory (Maloney, 2012). Finally, math anxiety can impact the behaviours of an individual, which is most commonly exhibited as avoidance, causing them to lead an adjusted life due to the impact math anxiety has on their daily functioning (Ahmed, 2018). The following sections provide an in-depth analysis of the symptoms that individuals struggling with math anxiety may experience.

Beliefs

The beliefs a student struggling with math anxiety have play a deeply influential role in how they can address and navigate their own math anxiety. Students who are struggling with math anxiety are regularly trapped in a spiral of negative self-talk, whereby the individual is regularly putting themselves down (Casad et al., 2015). In this case negative self-talk would predominantly focus on situations involving math where the student is consistently jumping to the "worst case scenario" and always assuming that they will be unsuccessful (Beilock et al., 2010).

For those struggling with math anxiety, these thoughts can take on many different forms but are rooted in a consistent belief that they are unable to "succeed" in math (Beilock et al., 2010). One of the greatest influences on negative thoughts when dealing with math anxiety are role models (Beilock et al., 2010). For example, if a female teacher struggles with math anxiety, this is likely to directly (and negatively), impact their female students (Beilock et al., 2010). Beilock et al. (2010) found that at the start of the year both female and male students' grades in math were similar; however, by the end of the year female students were struggling more if they had a female teacher with math anxiety. Females were far more susceptible to imitate their female teachers' math anxiety then their male counterparts (Beilock et al., 2010).

Another equally, if not more, influential person in children's lives are their parents. While parents are not typically present in the classroom, the actions and attitudes that parents have towards education, particularly math, can influence the anxiety levels of their children (Casad et al., 2015). There was a strong correlation between parents who do not have math anxiety and are strong in math having children who also are strong in math and do not have math anxiety (Casad et al., 2015). In contrast, there was not a strong positive correlation between parents in general who are weak in math or struggle with math anxiety and their children struggling as well, except in mother–daughter relationships (Casad et al., 2015). In a mother–daughter relationships, it was found that if the mother was weak in math and had math anxiety there was an increased chance of the daughter struggling with math anxiety as well (Casad et al., 2015). This further supports the belief that negative inherent biases and beliefs in women's ability to do math will negatively impede young girls' success in the math classroom (Casad et al., 2015).

It is important to note that the situations where parents do pass on their math anxiety to their children only occurs when the parents try to play an active role in assisting their children

(Maloney et al., 2015). Children learn from their parents' math anxiety due to being exposed to their parents' language, attitudes, and skills when assisting them with math (Maloney et al., 2015). Therefore, it is believed that if parents were to receive support for their own math anxiety and were taught how to properly support their children's math work, then this cycle could be broken (Maloney et al., 2015). It is also important to note that while a parent may not fully pass on math anxiety, there is also a large likelihood that they will at least pass along negative attitudes towards math as a subject (Soni & Kumari, 2015).

Regardless of their source, all negative thoughts surrounding math increase the likelihood that a student will struggle with math anxiety and that they will have a poor math grade (Kaskens et al., 2020). When trying to understand what plays the greatest role in determining if a child is successful in a math class and/or if they struggle with math anxiety, a study looked at the following four influences: children's math problem-solving abilities, math self-concept, self-efficacy and anxiety, and behaviour (Kaskens et al., 2020). It was found that the greatest positive influence on a student's math skills was their teacher's own knowledge, which would correlate to an increased likelihood of using better teaching strategies (Kaskens et al., 2020). However, the greatest negative impact on a student's math grade and math anxiety was their self-efficacy (Kaskens et al., 2020). Students who struggled with a lack of self-confidence and had negative thoughts surrounding the subject of math were far less successful than their peers (Kaskens et al., 2020).

These negative self-thoughts can also hinder what is referred as the "self-math overlap" (Necka et al., 2015). The self-math overlap refers to whether a student believes that math is a core part of their own identity, which usually is presented as whether or not a student identifies as a "math person" (Necka et al., 2015). If a student believes that they are not a "math person" and do not view it as a core part of their identity, then there is an increased likelihood that they will struggle with math anxiety (Necka et al., 2015). In contrast, students who believe they are a math person are typically far more successful in the math class (Necka et al., 2015).

Negative thoughts are a prevalent concern when dealing with math anxiety but there is a gender difference. Typically, math scores in early high school are fairly equal between the genders, however there is a significant disparity in terms of math anxiety (Xie et al., 2019). Females have been found to have a significantly higher likelihood of struggling with math anxiety than their male peers (Xie et al., 2019). Self-esteem was found to play a bigger role in females and this influenced their levels of math anxiety (Xie et al., 2019).

Female students are also more susceptible to math anxiety due to an increased likelihood of “buying into” gender stereotypes (Beilock et al., 2010). It was found that their increase in math anxiety was due to their inherent belief of gender roles about boys being good at math and girls being good at English (Beilock et al., 2010). It has been found that if this negative stereotype is reinforced by the students being taught by a female teacher who is math anxious, then the female students struggled academically in math more by the end of the year (Beilock et al., 2010).

Emotions

With math anxiety, intense and seemingly inconsistent emotions can result from the math stimuli. These emotions may present themselves in many different ways but the most important factor is that they are deemed as an inappropriate response to the situation, such as crying at the thought of math homework or throwing a fit when given a math test (Jansen et al., 2013).

For students struggling with math anxiety, their emotions can be one of the greatest barriers to achieving what the student would consider to be a satisfactory grade (Jansen et al., 2013). When students are struggling with math anxiety, their emotional reaction about what their perceived math competence is causes them to struggle to be successful at their grade level

(Jansen et al., 2013). However, if a student is provided material that is appropriate for their perceived math competency, they experience less anxiety and are more likely to successfully complete the work (Jansen et al., 2013). The barrier though is that emotions still get in the way once they return to the appropriate grade level as their own perceptions cause them to be unsuccessful (Jansen et al., 2013).

Most of the information has predominantly focused on students who are under the age of 18; however, math anxiety is more likely to impact adults (Jameson & Fusco, 2014). Adults report significantly higher levels of math anxiety and, in particular, lower levels of math self-efficacy due to a higher likelihood of exhibiting a negative emotional response (Jameson & Fusco, 2014).

Physically

When looking at math anxiety there is also a significant physical response at play as well. In this case the physical response is typically at the neurological level (Lyons & Beilock, 2012). Due to this very real and physical reaction to math it is important to understand and validate the experience that students with math anxiety are going through (Klados et al., 2015). It is not a perceived but rather a real physical symptom of the math anxiety they are struggling with.

When looking at a physical reaction to math anxiety the first and most common is pain, which is also a regular symptom to any form of anxiety (Lyons & Beilock, 2012). Students who struggle with high levels of math anxiety find that their emotions are grounded in a threat response when presented with math as well as a very real sensation of pain (Lyons & Beilock, 2012). This threat response and pain is not actually triggered by the action of doing math but instead is caused by the anticipation of math to come, such as an upcoming test or shortly before attending math class (Lyons & Beilock, 2012).

Math anxiety does not just impact the body physically through pain; it also has a very real impact on working memory (Klados et al., 2015). Those who struggle with math anxiety experience a slower cognitive processing speed when presented with a math problem compared to their non-math-anxious peers (Klados et al., 2015). It is interesting to note that this decline in cognitive speed begins, and is greatest, during the early stages of a math task, much like how the anticipation of a math problem is what causes the greatest levels of pain (Klados et al., 2015).

Math anxiety also causes a physical reaction through the attention those so afflicted will place on math scenarios (Rubinsten et al., 2015). Rubinsten et al. (2015) studied whether math anxiety is due to an attentional bias. Cognitive theory surrounding general anxiety has found that an attentional bias toward negative stimulus or information can cause anxiety (Rubinsten et al., 2015). This study demonstrated that the same is true with math anxiety through the use of a dot probe task that found that high math-anxious participants would react faster to numerically associated stimuli (Rubinsten et al., 2015).

Artemenko et al. (2015) further analyzed the neural impacts of math anxiety and came to similar conclusions as Klados et al. (2015)—that math anxiety elicits a pain response in the brain that predominantly occurs before the student does the math problem. However, Artemenko et al. expanded on the fact that this negative emotional response impairs neural processing speed by showing it also causes math-anxious students to struggle with their math. Interestingly, the article took it one step further by addressing how best to support students with math anxiety when addressing it from a neurological perspective. Artemenko et al. recommended that math-anxious students receive emotional regulation support to mitigate the impacts on neural processing speed and performance caused by math anxiety.

Georges et al. (2016) found that a high level of math anxiety was positively correlated with poor number and/or spatial awareness skills. This further supports the fact that math anxiety is directly correlated with poor basic math skills (Georges et al., 2016).

Justicia et al. (2017) found that working memory and math self-concept were the two most impacted components of math skills that were negatively affected when a student was struggling with math anxiety. Working memory impairment was viewed as a student's inability to focus on math due to anxious feelings and math self-concept was viewed as a student's self-confidence towards the subject as whole (Justicia et al., 2017).

Behaviours

An equally important factor when looking at impacts of math anxiety is its impact on behaviours. Their reaction to the negative stimulus, math, can lead to problems such as avoidance which will negatively impact the student for potentially the remainder of their life.

When looking at the behaviours that those struggling with math anxiety exhibit, it is important to acknowledge both short and long term. Math anxiety can play an integral role on the careers that an individual considers, and eventually pursues (Ahmed, 2018). A long-term analysis was conducted on the impacts math anxiety had on people throughout their life by following a group of Grade 7 students who self-identified as struggling with math anxiety over 20 years (Ahmed, 2018). Math anxiety caused these students to make drastic changes over their academic and professional careers (Ahmed, 2018). Students who struggled with math anxiety were less likely to enroll in math courses throughout the remainder of their academics (Ahmed, 2018). Students who struggled with math anxiety were 7.4 times less likely to have entered a Science/Technology/Engineering/Math (STEM) career in the following 20 years than their peers (Ahmed, 2018). Math anxiety plays such an influential role in the behaviours of those afflicted that it can heavily influence the careers that students pursue (Ahmed, 2018).

Gender differences can influence math anxiety's impact on future careers. Females are significantly less likely to enter a STEM career if they struggle with math anxiety than their male counterparts (Huang et al., 2018). This is a compound of both the previously identified impact that math anxiety decreases a student's likelihood of entering a STEM career as well as the fact that women in general are less likely to enter STEM fields (Huang et al., 2018). In recent years the prevalence of women both working and 31irectshing in the STEM field has increased but there is still not equal representation between the genders (Wall, 2019).

So far when looking at math anxiety, most of the focus has been on studies that originated from either Canada or the United States. These articles are predominantly used as the information is most relevant to the students who participated in this study as it occurred in an Ontario university. However, it is important to note that math anxiety is a consistent problem across many countries with varying degrees of impact (Zhang, 2019). In general, all countries have a consistent consensus that there is a negative link between math anxiety and math performance (Zhang, 2019). Interestingly it has been found that the students struggling with math anxiety who experience the greatest negative impact on their grades are Asian and the students who experience the least impact on their grade are European (Zhang, 2019). Although this indicates possible socio-cultural factors, this is an under-researched area and the causes can only be speculated.

Prevalence/Incidence of Math Anxiety

Math anxiety is expected to impact roughly 17% of the population (Luttenberger et al., 2018). However, true prevalence of math anxiety is unknown. Richardson and Suinn (1972) estimate that 11% of college students show high math anxiety. In contrast, Betz (1978) found that about 68% of students in a college level math class experienced math anxiety. These data are inconsistent due to the lack of stringent use of a math anxiety rating system. There are two well-known math anxiety rating scales: the MARS and the AMAS (Schillinger et al., 2018). These two tools have undergone stringent reliability and validity testing (Hopko, 2003). While the MARS and AMAS are the only two consistent math anxiety assessment tools, it is not uncommon for researchers to allow individuals who struggle with math anxiety to self-identify for studies or to use information gathered from other studies that may not have been rooted in math anxiety, and then make assumptions about their data in order to apply it to math anxiety (such as the Ahmed's 2008 article). In reality, the true prevalence of math anxiety is unknown, however all of the studies show that in a class of 30 students you can expect to have at least one student who struggles with math anxiety (Betz, 1978; Luttenberger et al., 2018; Richardson & Suinn, 1972).

Impacts on Math Functioning

When looking at the impacts that math anxiety has on function, it is best analyzed through the cognitive and behavioural impacts that math anxiety has on individuals. Math anxiety impacts individuals in different ways, however the greatest impacts on math functioning itself are through the neurological changes to the brain and the avoidance behaviour that individuals present (Ahmed, 2018; Lyons & Beilock, 2012).

Addressing the issue of augmented behaviours leading to avoidance is the most visible impact on math functioning, and easiest for teachers or observers to notice. Those who struggle with math anxiety are far less likely to take math courses, put themselves in math situations, or spend any unnecessary time on math work (Huang et al., 2018). This decreased exposure to math causes these individuals to have less experience with the subject, which increases anxiety and causes a spiral effect as this increased anxiety makes them less likely to participate in future math activities which will cause more anxiety and so on (Maloney, 2012). However, avoidance is not the only reason that individuals who struggle with math anxiety struggle with their math functioning; the greatest barrier is the changes math anxiety has at the neurological level (Lyons & Beilock, 2012).

Math anxiety impacts the brain in three different ways: threat and pain response, working memory, and attentional bias. First, students who struggle with high levels of math anxiety find that their emotions are grounded in a threat response when presented with math as well as a very real sensation of pain (Lyons & Beilock, 2012). This threat response and pain is not actually triggered by the action of doing math but instead is caused by the anticipation of math to come, such as an upcoming test or shortly before attending math class (Lyons & Beilock, 2012). This threat response not only elicits a pain reaction but also impairs neural processing speed, which causes math anxious students to struggle with their math (Artemenko et al., 2015).

Second, math anxiety also has a very real impact on working memory (Klados et al., 2015). Those who struggle with math anxiety experience a slower cognitive processing speed when presented with a math problem compared to their non-math anxious peers (Klados et al., 2015). Much like the threat response discussed previously, this impact on working memory is greatest in anticipation and at the start of a math activity (Klados et al., 2015).

Finally, math anxiety also causes an attentional bias (Rubinsten et al., 2015). Cognitive theory surrounding general anxiety has found that an attentional bias toward negative stimulus or information can cause anxiety (Rubinsten et al., 2015). This is similar for math anxiety, which causes individuals to be more acutely aware of math in situations (Rubinsten et al., 2015). The combination of an attentional bias as well as the impacts that math anxiety has on working memory also led to poor number and/or spatial awareness skills (Georges et al., 2016).

The three impairments of math anxiety on math functioning in turn lead to a decrease in academic achievement by individuals struggling with math anxiety. On average, math anxiety causes students to achieve 27% lower than their peers who do not struggle with math anxiety (Çiftçi, 2015). This lower grade is not due to math-anxious students struggling with their math fluency (understanding of the concepts) but instead shows their inability to represent or display their knowledge on assignments/tests due to avoidance and impairments on working memory (Çiftçi, 2015).

Math Anxiety in Postsecondary Students

When looking at math anxiety in postsecondary students, there is limited research in this area due to a majority of the research focusing on primary and secondary students (Núñez-Peña et al., 2013). The limited research that has been done focuses on the academic impacts (Brown et al., 2020; Núñez-Peña et al., 2013; Schillinger et al., 2018). It was found that students who fail a math-based course are more likely to suffer from math anxiety (Núñez-Peña et al., 2013) and even more specifically students with math anxiety show lower levels of numerical and figural intelligence than their non-math-anxious peers (Schillinger et al., 2018). To address this gap, it is important for quality math content support to be available in postsecondary settings as this can be one of the best ways to support student success (Reid et al., 2018). While further support strategies for math anxiety have not been researched on postsecondary students, it can be assumed that some, if not all, strategies that are successful on primary/secondary students would be successful on postsecondary students as well.

The DSM-5 and Math Anxiety

Math anxiety is not specifically mentioned in the DSM-5. However, math anxiety would be considered a type of performance anxiety, which is a subtype of social anxiety, specific to mathematics. Anxiety is rooted in our survival instincts where it kept us safe by having us avoid dangerous situations (Kauffman & Landrum, 2018). However, anxiety disorders occur when the reaction to stress is abnormal in that it is excessive, debilitating, and prevents the individual from participating fully in that situation (Kauffman & Landrum, 2018). It is an important distinction that it is common for children to have anxiety around certain times of the year (start of school, before tests, exams, etc.) but it is when this anxiety is prolonged, an illogical response to the stimuli, and leads to impaired functioning that it is considered an anxiety disorder and should be viewed and treated as such (Kauffman & Landrum, 2018). For performance anxiety the required diagnostic criteria are the same as for social anxiety, except the fear is restricted to speaking or performing in public (American Psychiatric Association [APA], 2013). Therefore, the following diagnostic criteria is:

1) Marked fear or anxiety about one or more social situations in which the individual is exposed to possible scrutiny by others. Examples include social interactions (e.g., having a conversation, meeting unfamiliar people), being observed (e.g., eating or drinking), and performing in front of others (e.g., giving a speech).

   Note: In children, the anxiety must occur in peer settings and not just during interactions with adults.

2) The individual fears that he or she will act in a way or show anxiety symptoms that will be negatively evaluated (i.e., will be humiliating or embarrassing; will lead to rejection or offend others).

3) The social situations almost always provoke fear or anxiety.

   Note: In children, the fear or anxiety may be expressed by crying, tantrums, freezing, clinging, shrinking, or failing to speak in social situations.

4) The social situations are avoided or endured with intense fear or anxiety.

5) The fear or anxiety is out of proportion to the actual threat posed by the social situation and to the sociocultural context.

6) The fear, anxiety, or avoidance is persistent, typically lasting for 6 months or more.

7) The fear, anxiety, or avoidance causes clinically significant distress or impairment in social, occupational, or other important areas of functioning.
8) The fear, anxiety, or avoidance is not attributable to the physiological effects of a substance (e.g., a drug of abuse, a medication) or another medical condition.
9) The fear, anxiety, or avoidance is not better explained by the symptoms of another mental disorder, such as panic disorder, body dysmorphic disorder, or autism spectrum disorder.
10) If another medical condition (e.g., Parkinson's disease, obesity, disfigurement from burns or injury) is present, the fear, anxiety, or avoidance is clearly unrelated or is excessive.

Specify if:

Performance only: If the fear is restricted to speaking or performing in public.

(APA, 2013, Social Anxiety Disorder section)

It can be assumed that math anxiety would occur if math class, math situations or a math related environment cause the symptoms outlined above to occur. When math anxiety is reviewed in education literature, the components for predisposition are analyzed. When discussing math anxiety, it is important to acknowledge that there are antecedents that interact and influence the development of math anxiety; it is not just one cause leading to an effect (Luttenberger et al., 2018). Math anxiety is heavily impacted and determined by many factors in a child's life, such as their parents/teachers who are looked upon as a role model, culture, school/learning environment, gender stereotypes (boys are good at math, girls are good at English), genetic predisposition, and finally general anxiety proneness (Luttenberger et al., 2018). Math anxiety is an incredibly complex issue with countless potential causes, problems, and life-long implications; therefore, it is important that all teachers are educated and prepared to support the growth of their students as best as possible (Luttenberger et al., 2018).

Theoretical Framework: Beck's General Theory of Anxiety

BGTA is an evidence-based way to both conceptualize as well as treat psychological disorders by providing a collection of principles that can be applied across the spectrum of psychological disorders (Beck, 2014). This framework has been used to treat numerous mental illnesses by providing a structured path that can be used in all situations, including the variances in a disorder and across disorders (Beck, 2014).

BGTA is based on the core premise that dysfunctional belief causes an increase in emotional distress and maladaptive behaviour (Beck, 2014). The application focuses on identifying which specific stimuli draws out certain dysfunctional thoughts or reactions (Beck, 2014). For example, when thinking about anxiety someone may be so worried about failing a math test (stimuli) that they are unable to start because they believe they will fail anyway (dysfunctional belief). Further, when work is done to change these dysfunctional beliefs, it leads to a change in behaviours and emotions (Beck, 2014). This relationship between dysfunctional beliefs and emotion/behaviour provides the most basic framework for BGTA (Beck, 2014).

BGTA is rooted in the understanding that psychological disorders follow a cyclical framework (Beck, 2014). Individuals are provided with a specific situation or stimuli that results in dysfunctional beliefs, which impacts their emotions and produces maladaptive behaviour which can also lead to physical impacts (Beck, 2014). The stimuli vary depending on the psychological disorder and can be incredibly specific (anxiety at being handed a math test) to broad spectrum (anxiety in any situation involving numbers; Beck, 2014).

Each of these components of the cycle (beliefs, emotions, behaviour, and physical) interact with each other, with impairment in one leading to issues in the other categories as well (Beck, 2014). For example, the external stimuli for a student with math anxiety may be walking into a math classroom. This can activate a schema (the full reaction to the stimulus) based around the fact that “My academic success relies solely on how I do in math” that leads into the thought/belief “I am not a math person I will never get this.” This belief will shift an individual’s focus perhaps to the sensation of shaking hands upon entering the classroom, or the sensation of being on the edge of tears. The individual may also remember a situation when they were unsuccessful in the math classroom. All of this compounds together to provide a maladaptive behaviour such as refusing to do math work. This maladaptive behaviour may even be further supported by a short-term sensation of relief such as feeling relaxed at the thought of not having math today (Beck, 2014).

Therefore, in order for BGTA to be used as a framework to guide treatment, it is important to address not one but all of these cyclical components (Beck, 2014). Although addressing one component, such as beliefs, may benefit an individual to a certain degree, the best practice for achieving the highest level of symptom reduction is finding strategies and tools to support all four components of this cycle (Beck, 2014). In this case BGTA is rooted in providing alternatives or solutions that can counteract each of these components (Beck, 2014). For example, an adjustment to thoughts may provide a slightly different behaviour reaction so it is important that the behaviour—and not just the thought process— is adjusted (Beck, 2014).

This framework has been successfully used to support individuals with psychological disorders as well as provide a generic model that can be used to deepen the understanding of psychological concerns. By design, BGTA is structured to provide a basic framework that can be applied to new or varying psychological problems, which allows it to be adapted to math anxiety as well.

How BGTA Relates to Math Affect

Before focusing on the intersection of BGTA and math anxiety, it helps to first acknowledge that the BGTA framework (beliefs, emotions, and behaviours) very closely resembles the three components of math affect (beliefs, emotions, and attitudes). For BGTA the structure is that situations in which negative experiences have occurred result in negative belief associated with that situation (Beck, 2014). When put back in a similar situation individuals will immediately have a negative belief, that then results in a negative emotional, behavioural, and/or physiological reaction (Beck, 2014). This framework closely adheres to the structure that was first established by Mandler's (1984) general theory, which posits that when an interruption or barrier to an action occurs, the original (and potentially dysfunctional) beliefs the individual had results in an emotional reaction that if repeated can result in an engrained attitude. Once the attitude is engrained, it will become less extreme but more stable resulting in it quickly being applied to all situations that are in a similar context to the repeated interruptions that were experienced (Mandler, 1984). Mandler's general theory was originally applied to math affect earlier in this chapter, however the close connection to BGTA allows the aforementioned impacts on beliefs, emotions, and attitudes which results in the maladaptive behaviours to correlate with BGTA's own beliefs, emotions, and behaviours framework.

How BGTA Relates to Math Anxiety

When thinking about the many different ways math anxiety can impact an individual, it can be complicated. For many years it was believed that math anxiety was simply due to being bad at math and therefore to alleviate math anxiety you simply need to become better at math (Lyons & Beilock, 2012). This perspective was focusing on the visible outcomes of math anxiety (poor math grades) rather than looking at the root cause: an anxiety issue. When looking at causes for math anxiety, it is important to acknowledge the close relationship it shares with general anxiety (Hembree, 1990). Math anxiety is a type of anxiety provoked through varying math situations that allow the generic nature of the BGTA to be easily applied. As seen previously in this section, the impacts of math anxiety are already easily broken down into categories that align with BGTA: beliefs, emotions, and behaviours.

Health-Related Quality of Life

Quality of life (QOL) as an idea has been around for many years with Aristotle having discussed similar ideas but referring to it as "the good life" (Noval, 2016). However, it was in the 1960s that awareness of QOL grew among communities of social scientists, philosophers, and politicians (Katschnig, 1997). This led to numerous academics seeking to define exactly what QOL meant with varying degrees of specificity or lack thereof (Raphael et al., 1996). In general, QOL is an inclusive term used to describe and measure, often through surveys, many different subjective and objective aspects of a person's life (Felce, 1997). QOL measures seek to address this broad, and deeply individual, definition by taking into consideration the ability to access essential needs such as food and shelter as well as less tangible needs such as lifestyle satisfaction, community belonging, and self-fulfillment (Campbell et al., 1976). While this definition is certainly loose and broad, it is important to note that QOL is often not defined at all when it is referenced due to how individual QOL is (Gill, 1994). In a study of 75 randomly selected articles on QOL, very few tried to define QOL and even fewer justified their choice of QOL measures (Gill, 1994).

The increased prevalence of QOL research is a particular focus in the health-care field to assess the effects of interventions on individuals with new or chronic issues (Katschnig, 1997). QOL in the health-care field grew in popularity due to a shift in medical pedagogy from simply working to extend human life, to instead seeking to improve an individual's life in ways such as well-being, autonomy, and a sense of belonging (Katschnig, 1997). Following this shift, it became increasingly important to measure an individual's QOL to best gauge whether a treatment is benefitting an individual as well as assessing the impacts of health complications that can often be overlooked (i.e., what is the mental-health impact of being paralyzed, rather than just analyzing the physical impacts; Katschnig, 1997). This led to a more situational specific term of HRQOL.

HRQOL is defined by Cella (1995) as the extent to which one's usual or expected physical, emotional, and social well-being are affected by a medical issue or its treatment. In general terms HRQOL is used as a measure to better understand the effects of health issues on individuals by looking at the impacts on a person's daily functioning and lifestyle (Cella, 1995). When assessing HRQOL there are two main domain categories: physical health and mental health (Ware & Sherbourne, 1992). Physical health covers physical functioning, role-physical, bodily pain, and general health (Ware & Sherbourne, 1992). In contrast mental health encompasses vitality, social functioning, role-emotional, and mental well-being (Ware & Sherbourne, 1992). These categories are then emulated on HRQOL measures to provide a general overview of an individual's HRQOL in relation to their specific illness or treatment (Ware & Sherbourne, 1992).

When looking at assessments/surveys on HRQOL there are many to choose from, such as the Nottingham Health Profile (NHP); the Sickness Impact Profile (SIP); the Dartmouth Primary Care Cooperative Information Project (COOP) Charts; the Quality of Well-Being (QWB) Scale; the Health Utilities Index (HUI); and the EuroQol Instrument (EQ-5D; Coons et al., 2000). However, the most widely used HRQOL measure due to reliability and validity is the Rand 36-item Health Survey (SF-36; Coons et al., 2000).

Functional Impairment

Functional impairment is seen through the ways a trigger (in this case math anxiety) impacts an individual's behaviours as well as cognitive functioning. Research has already identified a decreased level of math exposure in math anxious individuals due to avoidance, which is best represented by the lack of math anxious individuals pursuing STEM careers (Ahmed, 2018). Between the avoidance of math-based career paths for math anxious individuals and the impacts math anxiety has on the brain imply functional impairment.

When assessing HRQOL, many studies also use a functional impairment measure (Barrera, 2009; Huppert et al., 2009; Rapaport et al., 2005; Romera, 2011). Functional impairment is not a topic of research on its own, such as QOL/HRQOL is, but instead is a component of assessment for diagnosing mental health disorders (Ustün, 2009). Functional impairment occurs when there are limitations in the social and occupational areas of a person's life, and in the DSM-5 this explanation is broadened to also include impairment in other forms of functioning (Ustün, 2009). Functional impairment also allows clinicians to be able to identify specific and quantifiable impairments to daily functioning (Ustün, 2009). This approach does not focus on whether or not an individual has holistic life satisfaction but instead identifies whether daily functions have been impeded (Booth, 1998).

Functional impairment was first acknowledged as a clinically significant criteria in the DSM in 1980 (Nielsen et al., 2020). Mental health disorders are assessed on 4 criteria, specific phenomenology, signs and symptoms, exclusion rules and if functional impairment is clinically significant (Ustün, 2009). Assessing an individual's functional properties, and whether or not there is an impairment, is an important component of this assessment due to the very nature of mental health disorders (Nielsen et al., 2020). Ideally, the criteria for assessing all disorders should be their symptoms, however, with mental disorders it can be necessary to use functional status as an indicator of normality due to symptoms not always being visible (i.e., when assessing phobias the diagnostic threshold is the extent of impact on normal functioning; Nielsen et al., 2020). The ability to assess the impact the symptoms are having on daily functioning allows clinicians to quantify the impact/severity of an individual's symptoms without solely relying on that individual's interpretation/personal experience (Ustün, 2009).

Once functional impairment is quantified, it also can be used to provide direction on treatment, track progress, and predict treatment outcome (Ustün, 2009). By understanding the specific impairments to an individual's functioning, clinical treatment then can focus on supporting, and mitigating, these impairments.

While HRQOL is very personal and subjective as it focuses on an individual's perception towards expectations of objective conditions and aspirations of subjective values in a life domain (Andrews, 1980), functional impairment is more quantifiable as it refers to limitations and an inability to carry out certain functions of one's daily life (Ustün, 2009). By using a combined approach of both HRQOL and functional impairment assessments, it is possible to identify if there is a similarity or difference between an individual's perception of overall life impacts versus specific limitations that impede daily functioning (Barrera, 2009). The inclusion of a functional impairment assessment also allows for the impacts to be quantifiable, therefore the degree of impact can be assessed (Ustün, 2009). It is important to understand the degree of impact so diagnosticians can determine if the severity warrants particular treatment (Ustün, 2009). Specifically, since functional impairment is used to diagnosis mental disorders, if it was found that math anxiety results in a high degree of functional impairment it implies that clinical treatment may be necessary, much like other mental-health disorders such as anxiety.

Many studies on anxiety disorders incorporate a measure on functional impairment (Baladón, 2016; Bobes, 2011; Hollander, 2010). In particular, these studies also utilize the most widely used measure of functional impairment, the SDS, as it is specifically reliable in measuring functional impairment in regard to anxiety (Coles, 2014). The SDS is then used to understand what functioning domains the anxiety is causing impairments in, which is essential in both diagnosing and providing treatment but also for identifying, in regard to math anxiety, if there are impairments occurring outside of the school domain.

Health-Related Quality of Life and Math Anxiety

As previously outlined in this chapter, math anxiety has been shown to impact an individual's beliefs, emotions, and behaviours in relation to the math classroom. These categories, and the symptoms that were identified in each of these categories, show correlation to the assessments outlined in HRQOL. HRQOL seeks to assess the physical health impacts—physical functioning, role-physical, bodily pain, and general health—and the mental health impacts: vitality, social functioning, role-emotional, and mental well-being (Ware & Sherbourne, 1992). Therefore, when assessing HRQOL there is an opportunity to see if the symptoms of math anxiety result in a perceived change of HRQOL.

When seeking to understand the relationship between math anxiety and HRQOL it is important to first reflect on past literature. Unfortunately, there is no research on the relationship between math anxiety and HRQOL or performance anxiety and HRQOL. However, studies have been conducted on the relationship between HRQOL and social anxiety. These studies highlight a potential similarity for math anxiety as math anxiety would be classified in the DSM-5 as social anxiety disorder—performance anxiety specific to mathematics (APA, 2013).

Past studies have identified a negative correlation between social anxiety and HRQOL (Dryman, 2015; Saarni, 2007; Simon et al., 2002). It was found that social anxiety disorder negatively correlates with lower HRQOL scores in individuals who are 20 years and older (Saarni, 2007). This was further supported as it was found that the fear of negative and positive evaluation directly impacts HRQOL (Dryman, 2015). This study is particularly impactful as the fear of negative evaluation, which is identified as a contributing factor for math anxiety (Beilock et al., 2010), has shown to be strongly related to deficits in social functioning (Dryman, 2015). Therefore, a relationship between math anxiety and, particularly, the social functioning component of HRQOL assessments should exhibit a negative correlation (Dryman, 2015).

Finally, this relationship was also investigated using the SF-36 HRQOL measure with 33 participants who identified as having social anxiety disorder (Simon et al., 2002). It was further identified that social anxiety has a negative relationship not only with social functioning but also with the mental health and social functioning subscales (Simon et al., 2002). Therefore, it is established that social anxiety has a negative correlational relationship with HRQOL (Dryman, 2015; Saarni, 2007; Simon et al., 2002).

Functional Impairment and Math Anxiety

Functional impairment is seen through the way math anxiety impacts an individual’s behaviours as well as cognitive functioning. Research has identified a decreased level of math exposure in math-anxious individuals due to avoidance, which is best represented by the lack of math-anxious individuals pursuing STEM careers (Ahmed, 2018). The impacts math anxiety has on the brain through a threat and pain response, working memory, and attentional bias provide a possibility that there is functional impairment.

With functional impairment often being a component of (or assessed along with) HRQOL, it is important to acknowledge the difference and benefits in its assessment (Barrera, 2009; Huppert et al., 2009; Rapaport et al., 2005; Romera, 2011). Functional impairment focuses on identifying specific and quantifiable impairments to daily functioning (Ustün, 2009). This approach does not focus on whether or not an individual has holistic life satisfaction but instead identifies whether daily functions have been impeded (Booth, 1998). It is possible, although research highlights that it is uncommon, to experience positive HRQOL and still have a high degree of functional impairment (Barrera, 2009; Huppert et al., 2009; Rapaport et al., 2005; Romera, 2011). This is due to the difference between perception and limitations. The former focuses on an individual's "attitude" while the latter identifies any challenges the individual faces. Therefore, by using a combined approach of both HRQOL and functional impairment, it is possible to have a better overview of an individual's experience living with a condition (Barrera, 2009).

The connection between functional impairment and math anxiety is a concept that has not been studied. However, research has been done on the relationship between a math disability and functional impairment (Auerbach et al., 2008; Shalev et al., 1995; Shalev et al., 2000; White et al., 1992; Willcutt et al., 2013). A math disability has been found to cause significant academic and social impairment, two components of functional impairment (Willcutt et al., 2013).

This evidence of functional impairment on individuals who have a math disability highlights a potential similarity for math anxiety. Math anxiety may not be considered a math disability; although Ashcraft et al. (2007) suggest future research is needed, some of the symptoms are similar. An individual who has a math disability experiences symptoms such as issues in memorization, number sense, fluent calculation, and math reasoning (APA, 2013). This can align with the aforementioned math anxiety symptoms such as impacts on an individual's working memory (Klados et al., 2015) and number sense skills (Georges et al., 2016).

There is also evidence that anxiety symptoms have a negative correlation with functional impairment (McKnight, 2016). Current studies find that over half of individuals with anxiety disorders report mid-to-high functional impairment (Kessler et al., 2005). This relationship is related even further through studies that looked at the relationship between functional impairment and social anxiety (Aderka, 2012; Balázs et al., 2013; Schneier et al., 1994). It was found that social anxiety leads to substantial levels of functional impairment, particularly in the work/school and social life categories (Aderka, 2012). Therefore, due to the already established connection between social anxiety and math anxiety this relationship can be assumed to be replicated with math anxiety.

Beck's General Theory of Anxiety, Health-Related Quality of Life, and Functional Impairment

BGTA posits that distorted cognition is the cause of the math anxiety. Therefore, the emotional, physiological, and behavioural responses should be quantifiable. For this purpose, HRQOL and functional impairment measures will be used to identify this connection.

With HRQOL it is possible to see if there are any perceived impairments within an individual's physical or mental health (Ware & Sherbourne, 1992). Physical health covers physical functioning, physical role, bodily pain, and general health; in contrast, mental health encompasses vitality, social functioning, emotional role, and mental well-being (Ware & Sherbourne, 1992). Therefore, any emotional or physiological concerns brought on by math anxiety would fall within the physical and mental health assessment of HRQOL.

To further support this, functional impairment assessments will identify limitations in a person’s life (Ustün, 2009). Maladaptive behaviours are deemed those that stop you from adapting to new or difficult circumstances; this is regularly assessed using a functional approach (Wedig, 2009). By using an assessment of functional impairment, the impact of these maladaptive behaviours can be quantified. By combining these two approaches it will be possible to identify any correlation between dysfunctional cognition (people who have math anxiety) and their emotional distress, physiological Impacts, or maladaptive behaviours (through HRQOL and functional impairment).

An example of this relationship begins with the belief that math is not doable for everyone, which can lead to an emotional response of fear when presented with math situations, such as taking shop inventory at your work, which in turn leads to a maladaptive behaviour, in this case avoidance and not taking inventory. This avoidance of inventory would result in potential job repercussions or loss which will be identified in the functional impairment assessment, and the emotional component of this job loss would be identified by an HRQOL assessment.

Summary

When looking at HRQOL and functional impairment, math anxiety can play a huge role in how a student approaches, succeeds, and develops while attending school. Math anxiety is “a feeling of tension and anxiety that interferes with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations” (Richardson & Suinn, 1972, p. 551). This anxiety was first identified in 1954 by Sister Mary Gough and has been increasing in research and prevalence ever since with current studies finding roughly 17% of students struggle with math anxiety (Luttenberger et al., 2018).

With this increase in prevalence, it is important to understand math anxiety's impacts on students and how to mitigate these impacts. Math anxiety can be viewed and treated through BGTA as a framework that focuses on the thoughts, emotions, behaviours, and physical symptoms an individual experiences when they are approaching a math anxiety inducing situation (Beck, 2014). BGTA can not only identify the symptoms and help highlight the overall impacts but also provides a treatment strategy to deal with maladaptive beliefs, focus, and behaviours which can be adjusted to allow for an individual to experience decreased levels of math anxiety (Beck, 2014).

By assessing the correlation between math anxiety, HRQOL and/or functional impairment through a BGTA framework we can have a better understanding of the overall impacts of math anxiety, rather than previous research that has focussed on exclusively the academic impacts.

CHAPTER THREE: METHODOLOGY AND PROCEDURES

The methodological format that this study followed was an embedded quantitative correlational study with descriptive open-ended questions that involved an online survey to explore the relationship, and identify if there was a correlation, between math anxiety, Health Related Quality of Life (HRQOL), and functional impairment. The online survey consisted of the Abbreviated Math Anxiety Scale (AMAS), Rand 36-item Short Form Health Survey (SF-36), and the Sheehan Disability Scale (SDS) along with three open-ended questions that allowed for mass data collection through convenience sampling.

The survey was accessible via an online link allowing for participants to complete the study using convenience sampling. This research sought to identify the impacts of math anxiety on students' lives outside of the math classroom, which led to a correlational relationship positively or negatively with HRQOL and functional impairment. In the long term, research identifying the relationship math anxiety has with HRQOL and functional impairment is necessary to further explore the degree of the interaction. If findings continue to identify that math anxiety has a high degree of impact on an individual's daily life (HRQOL and/or functional impairment), this will encourage educational institutions to enact changes in practices and policies.

Statement of the Problem

This study sought to identify if there is a statistically significant correlation between math anxiety, HRQOL, and functional impairment. The embedded quantitative correlational study with descriptive open-ended questions was available for 2 months, allowing for participant recruitment after which statistical analysis was conducted.

This study was relevant as there is currently a gap in the literature on the impacts of math anxiety outside of the classroom. Current studies cover the numerous ways that math anxiety impacts a student in the classroom or what cognitive difficulties math-anxious students have; however, no research has been done on the impacts to HRQOL or functional impairment.

Research Questions and Hypotheses

- RQ1: Is there a relationship between math anxiety and HRQOL in postsecondary students?
  - H1: Math anxiety is negatively correlated with HRQOL in postsecondary students.
- RQ2: Is there a relationship between math anxiety and functional impairments in postsecondary students?
  - H2: Math anxiety is positively correlated with functional impairment in postsecondary students.

Population and Sample Section

After receiving ethics clearance from Brock University (REB 21-077), the survey and all necessary information along with it was distributed to participants who volunteered to participate in the study. To gain participants for the study, a Facebook page was created that included the letter of information and consent form and will act as a location for the completed thesis to be shared. Professors and colleagues in Brock Residence Life then sent out recruitment emails that included the Facebook link to their students. Participants were provided with either a QR code or weblink that gave all necessary information such as the survey, consent form, letter explaining the study, and all other relevant information. None of these participants were pressured into participating in the study and were reminded at multiple points that they could decline research consent at any point.

Participants were gathered using convenience sampling; a strategy in which participants are chosen due to their location near the study, therefore making them “convenient” participants (Creswell, 2016). In this case the location was Brock University. The benefit of using the convenience sampling approach is the survey was easily distributable to a wider collection of the population (Creswell, 2016).

The sample population consisted of university students who provided their year of study (listed as “Student’s Year in Program), typically undergraduate degree’s take 4 years to complete however some program’s are longer, or students may have taken more than one program. In Ontario we also refer to the “Program of Study” as the faculty/department that a student is enrolled/studying in. For example a student in the third year of their Bachelor of Science major in Mathematics would be referred to as a student in year 3 of their program, and their program of study is mathematics and science.

The survey started with the AMAS and then asked generic demographic questions prior to continuing with the two other instruments used (the SF-36 and SDS). Following completion of the SDS survey, three open-ended questions were asked. The purpose of this study was to gather transferable data about the relationship math anxiety has with HRQOL and functional impairment. While the survey was conducted exclusively at Brock University, there were no other controls on demographic or geographic criteria. Therefore, following the AMAS survey some demographic questions were asked. The responses to these questions allowed for an accurate presentation of information on who was included in the sample population while still maintaining the anonymity of all participants. See Table 1 for a breakdown of these demographics.

Research Design and Methodology

This research was conducted using an embedded correlational study with descriptive open-ended questions. An embedded design was beneficial as it allowed for aspects of both quantitative and descriptive research to be used, including the detail and contextualized results from quantitative data and the generalizable insights of descriptive data (Creswell, 2016). For the

Table 1

Participant Demographics

Demographic	Frequency	Percent
Gender	113	100%
Male	44	39%
Female	59	52%
Gender Fluid	5	4%
Other	3	3%
Prefer Not to Share	2	2%
Student's Year in Program	113	100%
1	16	14%
2	13	12%
3	17	15%
4	15	13%
5+	20	18%
N/A	32	28%
Student's Program of Study	113	100%
Business	11	10%
Education	32	28%
Humanities	11	10%
Social Science	11	10%
Applied Health Science	8	7%
Mathematics and Science	10	9%
Fine and Performing Arts	5	4%
Graduate Studies	2	2%
N/A	23	20%

purpose of this research, quantitative data was used as the primary research tool to identify any relationship between levels of math anxiety, HRQOL, and functional impairment, with descriptive data being used to substantiate these claims.

The study was a correlational design conducted through the use of an online survey. Correlational statistics were used to identify and measure the degree of association between the two established variables (Creswell, 2016). While correlational statistics did identify an association between variables it does not confirm probable causality, instead only identifying a relationship between the variables (Creswell, 2016). Statistical analysis is expected to identify the direction and degree of association between the variables.

Establishing Credibility

Quantitative Instrumentation

The questionnaire used three previously validated instruments: the AMAS, SF-36, and SDS.

Abbreviated Math Anxiety Scale (AMAS)

The AMAS utilizes self-reporting to assess the level of math anxiety an individual has using nine questions answered on a 5-point Likert scale with two subscales of Learning Math Anxiety and Math Evaluation Anxiety (Hopko, 2003). This scale was chosen due to its high level of internal consistency of α=0.90 with the subscales of Learning Math Anxiety achieving α=0.85 and Math Evaluation Anxiety reaching α=0.88 (Hopko, 2003). While there are other math anxiety rating scales, only the Math Anxiety Rating Scale (MARS) has been sufficiently studied for reliability and validity (Hopko, 2003). The MARS is also a reliable tool; however, it consists of 96 items and therefore was deemed far longer than necessary for this study. In contrast, the nine items of the AMAS that demonstrate an equally high level of reliability to that of the MARS make it an equally effective and more concise choice for studies, leading to it being the most widely used math anxiety rating scale (Schillinger, 2018).

36-Item Short Form Health Survey (SF-36)

The SF-36 is a 36-question survey designed to assess the HRQOL of an individual through eight subscales consisting of physical functioning, role limitations due to physical problems, social functioning, bodily pain, general mental health, role limitations due to emotional problems, vitality, and general health perceptions (Ware & Sherbourne, 1992). These subscales are all answered using a Likert scale of varying length, from two to five options (Ware & Sherbourne, 1992). This scale was selected due to its internal reliability of α=0.78 to α=0.93 depending on the subscale (Ware & Sherbourne, 1992). The SF-36 is not only a reliable instrument but is also the most widely used HRQOL survey due to its accuracy as well as concise construction (Ware & Sherbourne, 1992). For the purpose of this study, it is expected that the subscales of social functioning, general mental health, and role limitations due to emotional problems will show the highest correlation with the AMAS.

Sheehan Disability Scale (SDS)

The SDS is a five-item self-completion Likert scale-based survey that measures the impact of mental health symptomology within three settings: work, social, and family functioning (Hodgins, 2013). Due to its simplicity, brevity, and high validity (internal reliability of α=0.89 (Leon, 1997), the SDS has become the most widely used functional impairment scale within academic research (Hodgins, 2013). Due to each subscale consisting of only one question, a reliability test retest from Coles (2014) was used to establish the reliability of the SDS subscales. The work/school life subscale has an internal reliability of α=0.59, the social/leisure life subscale has an internal reliability of α=0.69, and the family/home life subscale has an internal reliability of α=0.69 (Coles, 2014). The scale is particularly beneficial for this study as it allows the researcher to specify the symptomology they want participants to be considering while filling in this scale, such as math anxiety, rather than merely being a holistic look at their current state (Hodgins, 2013). It is important to note that this survey is not assessing HRQOL or symptom severity and distress but rather functional impairment (Hodgins, 2013). While functional impairment is similar to HRQOL and symptom severity and distress, HRQOL is far more individual specific and an individual's personal outlook can dramatically change results (Hodgins, 2013). Functional impairment, and in turn the SDS, is assessing whether the specified symptom is causing impairment in the participant's ability to complete daily tasks and function optimally (Hodgins, 2013).

Descriptive Instrumentation

Open-Ended Responses

Descriptive data were collected simultaneously with the questionnaire data and consisted of three open-ended questions. The open-ended questions focused on participants' experience with math anxiety outside of the classroom.

The questions were developed prior to the study and were designed to supplement the findings of the quantitative questionnaire. The questions were open-ended, to encourage responses that expanded on the survey findings. The use of open-ended questions allowed participants to explain their personal experiences without any restrictions on them by past research or the current researcher (Creswell, 2016). The open-ended questions in the survey allowed participants to explain their experience with math anxiety, and how it had impacted them outside of the classroom (at work, socially, or personally).

All open-ended responses were saved as part of the overall survey. Unfortunately, due to the anonymous nature of the survey it was not possible for member checking to occur. Therefore, it was assumed that participants would have taken the opportunity to review their responses to the open-ended questions prior to submission to minimize misinterpretation. When not in use, all data collected from participants were kept in password-protected files on the researcher's personal computer and stored in a locked office. It is important to ensure accuracy and credibility in research findings, therefore the open-ended question data were validated using triangulation and procedural transparency.

Triangulation

Triangulation is used in research by involving multiple data sources to improve a study's accuracy (Creswell, 2016). This technique was employed to ensure data validity and accuracy by comparing results from multiple participants and multiple data collection sources. By surveying a large sample of participants with varying backgrounds and views, themes that are identified in different open-ended responses are deemed to be more accurate and credible. By collecting data in both the questionnaire as well as the open-ended responses, this further validated these findings, as similar results were found.

Procedural Transparency

Transparency allows the readers of this study to analyze the evidence, analysis, and process (Moravcsik, 2014; Tuval-Mashiach, 2017). Moravcsik (2014) outlines the three components of transparency to be data, analytic, and production transparency. Data transparency enables readers to read the evidence that will be used to support the research project (Moravcsik, 2014). In this study data transparency was used when including the direct quotes from participants' responses, which were used to support the quantitative findings. Analytic transparency is employed to provide readers with the specific information and structure of how the data analysis procedure occurred (Moravcsik, 2014). It can be challenging to document the process of analysis on open-ended responses for transparency when doing descriptive research and explaining all aspects of the process ensures a more valid and trustworthy understanding of the data (Tuval-Mashiach, 2017). This study explained how the responses were separated into different categories and then used to supplement the quantitative findings and how the questions were designed to align with the themes of each scale. Production transparency showed readers how evidence was chosen from all of the different responses (Moravcsik, 2014). By using production transparency, the researcher also included the rationale for choosing each component of the research methodology. Transparency is important to help strengthen this study's validity and credibility (Tuval-Mashiach, 2017).

Data Collection and Management

Data were collected through an embedded correlational study with descriptive open-ended questions. The questions in the survey provided data by gathering demographic information (gender, school level, program), identifying the level of math anxiety in the participant, identifying the HRQOL of the participant, and identifying the functional impairment due to math anxiety of a participant. All data from the surveys were stored in password-protected files on my password-protected computer.

In order to participate in the study, participants accessed the survey through an online link. From there they were provided with the letter of intent as well as consent form. If they did not provide consent, they were not allowed to continue with the survey and their information was removed. Due to all survey responses being anonymous, participants did not have the opportunity to revoke consent after completion of the survey; this was clearly stated on the consent form. The survey was created to quantify the experiences of participants using a combination of multiple choice and Likert scales taken from previously validated instruments.

By utilizing Likert scales and multiple-choice questions, participant selections were quantifiable and then statistically analyzed. The average completion time was approximately 5 minutes and the survey was conducted entirely online. By conducting the survey online (through the use of SurveyMonkey software), data collection and recording will be automatic. Following data collection, the results were then inputted into SPSS (Statistical Package for the Social Sciences) where it was analyzed.

Data Analysis Procedures

The embedded correlational survey was then used to generate three different general scores per participant, along with several subscale scores per survey, which correlated with each of the three instruments used. The AMAS provided a score on the level of math anxiety the participant has, the SF-36 provided a score on the HRQOL of the participant, and finally the SDS provided a score on how functionally impaired due to math anxiety the participant is. Using this data and SPSS, null hypothesis significance testing was conducted to identify if there was a relationship of statistical significance between the variables. This analysis provided the effect size and confidence intervals of the relationship allowing conclusions to be drawn. From there statistical analysis was performed on the information to allow for further exploration of the relationships through the use of regression analysis. All data were collected and used to answer the research question: What relationship does math anxiety have with HRQOL and functional impairment?

Before any analysis, the items were recoded on the SF-36 scale. Original response categories 1, 2, 3, 4, and 5 were recoded to the value of 100, 75, 50, 25, and 0, respectively, for items 1, 2, 20, 22, 34, and 36. Original response categories 1, 2, and 3, were recoded to the value of 0, 50, and 100, respectively, for items 3 to 12. Original response categories 1 and 3 were recoded to the value of 0 and 100, respectively, for items 13 to 19. Original response categories 1, 2, 3, 4, 5, and 6 were recoded to the value of 100, 80, 60, 40, 20, and 0, respectively, for items 21, 23, 26, 27, and 30. Original response categories 1, 2, 3, 4, 5, and 6 were recoded to the value of 0, 20, 40, 60, 80, and 100, respectively, for items 24, 25, 28, 29, and 31. Original response categories 1, 2, 3, 4, and 5 were recoded to the value of 0, 25, 50, 75, and 100, respectively, for items 32, 33, and 35. Recoding was conducted to allow for mathematical analysis of the scales. After recoding, the items were averaged to form the SF-36 score. The SDS scale was formed by summing the four items (questions) into a single dimensional measure of global functional impairment that ranges from 0 to 30 or assessing individually to obtain a score per subscale (i.e. functional impairment in; school, work, social and family life).

After recoding items, data clean-up was conducted. First, any survey instruments that were not fully completed were removed because not fully completing the questionnaire may indicate less consideration of responses and a lack of engagement in the study; 176 people started the survey and after removing surveys with less than a 100% completion rate for the instruments used 114 survey responses remain. Participants who did not complete demographic questions or open-ended questions were still included. Next the average survey completion time was 5 minutes and 46 seconds. Any surveys that were completed in under 1.5 minutes were removed as this implies responses were rushed and not carefully thought out. One person completed the survey in under 1.5 minutes so the new survey total is 113. The survey responses were then checked to see if there were any straight-line or patterned responses that may need to be removed, however none were found. Removing the partial responses as noted above is not believed to have negatively impacted the results because of the 63 responses removed, 57 had no information beyond the initial consent and any data from the remaining six responses are not a large enough population to make a substantive change to the results found from the 113 complete responses. Therefore, no further analysis was conducted on the excluded responses.

After data clean-up and variable recoding was conducted, the data was then formed into scales and subscales scores and reliability analysis was run to determine internal consistency and validity of scales and their subscales. Descriptive statistics were used to show mean and standard deviation of all scales and subscales. Spearman correlation coefficients were used to determine the relationship between the AMAS Total Score and SF-36 Total Score (and its subscale scores), and between the AMAS Total Score and SDS Total Score (and its subscale scores). Regression analysis was used to determine whether the AMAS Total Score significantly predicts the SF-36 Total Score (and its subscale scores) and whether the AMAS Total Score significantly predicts the SDS Total Score (and its subscale scores).

The methodology used for the descriptive analysis of this study consisted of organizing and analyzing all open-ended responses and then separating them into themes based on: HRQOL; functional impairment; functional impairment at work; functional impairment at home; functional impairment in social/family life; functional impairment at school; and functional impairment mental math. These themes correlated with the themes from the quantitative survey's and were used to provide context and further support the findings.

Ethical Considerations

Because this study involved human participants, there were ethical implications that must be considered. This also led to the necessity of approval by the Social Science Research Ethics Board of Brock University. To ensure that anonymity was maintained for all participants, no identifiable information was collected beyond basic demographic questions such as age, gender, year of study, and faculty.

Prior to beginning the survey participants were required to review the attached research letter outlining the purpose of the study as well as sign the consent form attached to the start of the survey. Participants were also reminded of the opportunity to withdraw consent at any time either by withdrawing from the study or declining to answer certain questions. Due to all survey responses being anonymous, participants did not have the opportunity to revoke consent after completion of the survey; this was clearly stated on the consent form. Participants were made aware that the researcher (me) may seek to publish some or all of the study in a research journal and that the thesis study as a whole will be published in the Brock repository.

Also, all computer files that pertain to the study were password protected, as well as the computer itself, to decrease the risk of anonymity being breached and any negative implications impacting the participants due to someone discovering their real names.

In research, ethics risk is seen as experiences beyond what participants would encounter in their day-to-day life. The survey did not discuss anything beyond the typical lived experiences of these individuals, however there is a potential that recounting their experiences may stir a triggering or unpleasant memory. To mitigate this risk, all participants, regardless of emotional reaction, were provided with a list of free mental-health resources that they could use if needed. The list consisted of the phone number and website for Brock's free counselling service, Distress Centre Niagara's support hotline, and a link to resources available through Pathstones in St. Catharines. The list was available at the end of the survey as well as on the Facebook page.

Methodological Assumptions

It is important to note that this study is not a representation of the experiences of all individuals who experience math anxiety. The purpose of this study was to provide general information about the relationship math anxiety has with HRQOL and functional impairment through the sample populations survey responses.

Also, this study utilized Beck's General Theory of Anxiety (BGTA) as the framework through which it viewed math anxiety and the survey data. BGTA, at its core, is comprised of dysfunctional core beliefs that result in an emotional response and lead to maladaptive behaviours. This study worked under the assumption that the previous findings in the literature already established that math anxiety results in dysfunctional core beliefs (Cobb et al., 1989; Dossey et al., 1988; Espinoza et al., 2013; Fennema, 1989; Garofalo, 1989; Greenwood, 1984; Grouws & Cramer, 1989; McLeod, 1992; Post, 1992; Reyes, 1984), which are expanded upon in Chapter 2, and hence the survey only focused on identifying the emotional impacts and maladaptive behaviours caused by this assumed inherent dysfunctional belief math-anxious individuals have.

Study Limitations

Though there are benefits to embedded correlational research, as stated previously, it does come with limitations that need to be acknowledged. In this study convenience sampling was used to find a large participant population. However, convenience sampling can result in participants from similar geographic areas, socio-economic backgrounds, ethnic backgrounds, and other lived experiences (Emerson, 2015). In this case the starting point for convenience sampling was Brock University, which could result in a large number of participants with similar experiences and also similar levels of academic success. Therefore, as a result of these factors the data may not be a good representation of all math-anxious individuals in the population and instead the study should be replicated on the general population where the results may differ.

Finally, the most unique and potentially impactful limitation, this study was conducted during the COVID-19 pandemic. This resulted in the necessity to keep all aspects of the study virtual to avoid in-person gatherings. This may have resulted in the sample excluding any participants who are not comfortable with the virtual setting, resulting in a potential bias. There is also the potential that due to the toll the COVID-19 pandemic and provincial state of emergency has taken on individuals' mental health, the quality of life and functional impairment results may be biased as well. Therefore, more research must take place to establish if findings are generalizable to both a wider population, and still hold true when pandemic lockdown's are not actively occurring.

Chapter Summary

This study is an embedded correlational design that is correlational and based around an online survey to explore, and to identify, the relationship between math anxiety, HRQOL, and functional impairment. By looking specifically at math anxiety, this study seeks to identify potential factors that can impair HRQOL or result in increased functional impairment.

For this study, convenience sampling was used with participants volunteering for the study through recruitment emails sent out by Brock University's professors and Residence Life Department, as well as posters put up on campus. The study was available for 2 months allowing for participants from any demographic to participate. Care was taken to ensure the anonymity of all research participants. The study involved the completion of a survey that starts with the AMAS, then has generic demographic questions, and concludes with the SF-36, SDS, and open-ended questions. All three surveys used were previously validated instruments. This study was a correlational design that utilized SurveyMonkey to distribute the survey and necessary consent forms.

As stated, this survey utilized three previously validated instruments: the AMAS, the SF-36, and the SDS. The AMAS is a 9-item, Likert scale-based survey that identifies the severity of math anxiety through self-identification (Hopko, 2003). The SF-36 is the most widely used QOL survey using a Likert-based system that assesses an individual's HRQOL in eight subscales consisting of physical functioning, role limitations due to physical problems, social functioning, bodily pain, general mental health, role limitations due to emotional problems, vitality, and general health perceptions (Ware & Sherbourne, 1992). Finally, the SDS is a 5-item self-completion Likert scale-based survey that measures the impact of mental health symptomology within three settings: work, social, and family functioning (Hodgins, 2013). After data collection was completed, the results were imported into SPSS and then analyzed.

This allowed for identification of whether a relationship exists between math anxiety, HRQOL, and functional impairment. Due to convenience sampling and the population size, results will not be a good representation of the wider population but can be used to inform future research (Creswell, 2016).

CHAPTER FOUR: DATA ANALYSIS AND RESULTS

The purpose of this study was to identify if there was a relationship between math anxiety, Health Related Quality of Life (HRQOL) and functional impairment. This study utilized an embedded correlational design based around an online survey with open-ended responses. To better understand this relationship the following research questions (and their corresponding hypotheses) were addressed:

- RQ1: Is there a relationship between math anxiety and HRQOL in postsecondary students?
    - H1: Math anxiety is negatively correlated with HRQOL in postsecondary students.
- RQ2: Is there a relationship between math anxiety and functional impairments in postsecondary students?
    - H2: Math anxiety is positively correlated with functional impairment in postsecondary students.

To analyze and identify this relationship, an online survey was used that consists of a questionnaire made up of multiple-choice, Likert-scale, and open-ended questions. The responses from the open-ended questions were used to support the statistical findings. The study was conducted at a medium-sized university in southern Ontario, Canada.

Reliability

Reliability analysis was conducted to determine internal consistency reliability of the following scales: Abbreviated Math Anxiety Scale (AMAS), Rand 36-item Short Form Health Survey (SF36), Sheehan Disability Scale (SDS), and their subscales. Since all scales and subscales have a Cronbach's alpha coefficient that is greater than 0.70, they are considered to have good internal consistency reliability. See Table 2.

Table 2

Reliability Analysis Results

Scale	Cronbach's alpha	M	SD
Abbreviated Math Anxiety Scale (AMAS)	.942	2.97	1.07
SF-36 Scale	.939	56.21	17.71
Physical functioning	.943	88.82	21.72
Role limitations due to physical health	.902	78.60	36.00
Role limitations due to emotional problems	.863	48.74	44.00
Energy/fatigue	.930	44.41	26.04
Emotional well-being	.923	55.39	25.03
Social functioning	.726	57.97	25.18
Pain	.813	83.01	20.14
General health	.896	60.13	24.40
Sheehan disability scale (SDS)	.906	9.69	10.09

Is There a Relationship Between Math Anxiety and HRQOL in Postsecondary Students?

A Spearman correlation coefficient was used to determine the relationship between the AMAS Total Score and SF-36 Total Score. A Spearman correlation was chosen due to its ability to assess monotonic relationships. The data appeared to have some degree of skewness and kurtosis therefore a Spearman rank correlation was deemed ideal compared to using Pearson. The results indicate a significant negative relationship: $r(113) = -.470$; $p < .001$. As the AMAS score increases the SF-36 score decreases. This relationship implies that an increase in math anxiety correlates to a decrease in HRQOL. This can be further supported by the open-ended responses that were provided asking respondents for examples of situations outside of the math classroom where math anxiety impacted their lives.

Of the 113 open-ended responses that outlined the negative impacts of math anxiety on life outside of the classroom, 19 of the responses focused on some aspect of HRQOL. All of these responses focused on some element of the participants' emotions, mood, or mental health. Some participants stated that math anxiety lead to impacts on their mood, such as: "dwelling on the past"; "whenever I am put on the spot by a colleague asking a math question, I feel embarrassed when I need a calculator"; "my partner is an accountant and explains money and math to me or how to save etc which makes me tense"; and "managing my own finances is stressful." These responses highlight the emotional impact math anxiety can have on an individual, however it can result in even more severe outcomes such as impairments to mental health. Of the 19 responses on HRQOL, five of them mentioned an impact on their mental health, either anxiety or depression, such as: "I do not work but I am at school, testing makes me very stressed and I am registered with SAS due to the intensity of my anxiety"; "anxiety from math classroom causing further anxiety in general life which leads to issues with all other things"; and "yes, panic attacks after tests." Other responses elaborated further, such as those provided by the following two participants:

> Math anxiety/stress has led me to feel overly anxious and depressed outside of the time in which I am doing math homework, or am in the math classroom. At it's worst, it has led to sleep disturbances and high emotional distress.
>
> I once got a negative performance review from a manager once because of my anxiety around calculating change for customers without a calculator, also had anxiety attacks caused by customers who would make comments if I used a calculator to give them the discounted price of an item instead of doing it in my head.

The impacts that math anxiety has across the spectrum of HRQOL is best represented by this participants statement:

> I would say the nerves that I have with math caused me to become obsessive with working hard. I would spend way too much time studying and doing homework just to feel confident in myself and try not to stress. If anything my math anxiety caused me to over work to the point of exhaustion and not being able to balance other personal life and work related things.

Therefore, these open-ended responses not only imply a negative correlation between math anxiety and HRQOL but also further support that math anxiety specifically impairs an individual's emotional well-being/mental health. To further examine this specific relationship the subscales of the SF-36 were compared to the AMAS.

To examine which specific aspects of HRQOL are impacted by math anxiety, Spearman correlations were conducted between the AMAS Total score and the eight subscale scores of the SF-36: physical functioning, role limitations due to physical health, role limitations due to emotional problems, energy/fatigue, emotional well-being, social functioning, pain, and general health. The results are presented in Table 3. As shown in Table 3, as the AMAS Total score increases six of the SF-36 subscale scores (physical functioning, role limitations due to physical health, role limitations due to emotional problems, energy/fatigue, emotional well-being, social functioning, and general health) significantly decrease. These relationships imply that an increase in math anxiety correlates to a decrease in 7 of the HRQOL domains.

As shown in Table 3 the greatest correlations occur between the AMAS Total score and the SF-36 subscales of emotional well-being, role limited due to emotional problems, and general health. This implies that math anxiety has the greatest impact on an individual's emotions and general health. This is further supported by one participant's open-ended response that "Math anxiety/stress has led me to feel overly anxious and depressed outside of the time in which I am doing math homework, or am in the math classroom. At its worst, it has led to sleep disturbances and high emotional distress." Another participant also shared how math anxiety leads to emotional impacts, such as anxiety, outside of the classroom "Anxiety from math classroom causing further anxiety in general life which leads to issues with all other things." As implied by the survey correlations this response further supports the idea that math anxiety leads to impairments to an individual's emotional well-being.

Regression Analysis Results

To determine the relationship between math anxiety and HRQOL more precisely, a series of hierarchical linear regressions were conducted to identify if scores for one variable can be predicted by scores from another variable while controlling for other variables (Yockey, 2018). In this case, hierarchical linear regression was used to determine if scores on a math anxiety measure could predict scores on a HRQOL measure while statistically controlling for the participants' year of study, faculty the participant was enrolled in, and gender. To accomplish this a series of three-stage hierarchical linear regression were conducted with SF-36 Total and subscale scores as the dependent variables. Year of study and study faculty was entered at Stage 1 of the regressions to control for academic factors influencing results. Gender was entered at Stage 2 to control for any gender influences on the data.

Table 3

Spearman – Is Math Anxiety and HRQOL Negatively Correlated?

		AMAS	Physical Function	Role Limitation due to physical function	Role Limitation due to emotional problems	Energy and fatigue	Emotional Well-being	Social Function	Pain	General Health
AMAS	r	1	-.199*	-.326**	-.482**	-.214*	-.518**	-.189**	.171	-.423**
	p		.035	.001	.001	.023	.001	.045	.071	.001
	N	113	113	113	113	113	113	113	113	113
Physical Functioning	r	-.199*	1	.541**	.301**	.108	.251**	.224*	-.526**	.410**
	p	.035		.001	.001	.254	.007	.017	.001	.001
	N	113	113	113	113	113	113	113	113	113
Role Limitations Due to Physical Functioning	r	-.326**	.541**	1	.509**	.102	.265**	.105	-.644**	.304**
	p	.001	.001		.001	.280	.005	.269	.001	.001
	N	113	113	118	113	113	113	113	113	113
Role Limitations Due to Emotional Problems	r	-.482**	.301**	.509**	1	.363**	.507**	.249**	-.339**	.487**
	p	.001	.001	.001		.001	.001	.008	.001	.001
	N	113	113	113	113	113	113	113	113	113
Energy/Fatigue	r	-.214*	.108	.102	.363**	1	.354**	.106	-.237*	.577**
	p	.023	.254	.280	.001		.001	.262	.012	.001
	N	113	113	113	113	113	113	113	113	113
Emotional Well-being	r	-.518**	.251**	.265**	.507**	.354**	1	.239*	-.058	.589**
	p	.001	.007	.005	.001	.001		.011	.541	.001
	N	113	113	113	113	113	113	113	113	113
Social Functioning	r	-.189**	.224*	.105	.249**	.106	.239*	1	-.085	.381**
	p	.045	.017	.269	.008	.262	.011		.370	.001
	N	113	113	113	113	113	113	113	113	113
Pain	r	.171	-.526**	-.644**	-.339**	-.237*	-.058	-.085	1	-.170
	p	.071	.001	.001	.001	.012	.541	.370		.073
	N	113	113	113	113	113	113	113	118	113
General Health	r	-.423**	.410**	.304**	.487**	.577**	.589**	.381**	-.170	1
	p	.001	.001	.001	.001	.001	.001	.001	.073	
	N	113	113	113	113	113	113	113	113	113

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

Prior to conducting the hierarchical linear regressions, the relevant assumptions of this statistical analysis were tested. Firstly, a sample size of 113 was deemed adequate given four independent variables to be included in the analysis (Tabachnick & Fidell, 2001). The assumption of singularity was also met as the independent variable, AMAS Total score, was not a combination of other independent variables. No extreme univariate outliers were identified in initial data screening, so modifications were unneeded. An examination of the Mahalanobis distance scores indicated no multivariate outliers. Residual and scatter plots indicated the assumptions of normality, linearity and homoscedasticity were all satisfied (Hair, 1998; Pallant, 2001).

Does Math Anxiety Predict Overall HRQOL?

A three-stage hierarchical linear regression was conducted with SF-36 Total Score as the dependent variable. The regression statistics are presented in Table 4.

The hierarchical linear regression revealed that at Stage 1, Year of Study and Faculty contributed insignificantly to the regression model, F (2,110) = 1.210, $p< .302$) and accounted for 2.2% of the variation in the SF-36. Introducing the gender variable explained an additional 3.5% of variation in the SF-36 and this change in $R2$ was not significant, F (3,109) = 2.193, $p < .093$. Finally, adding the AMAS Total Score to the regression model explained an additional 20.6% of the variation in the SF-36 Total Score and this change in $R2$ square was significant, F (4,108) = 9.631, $p < .001$. All together the four variables account for 26.3% of the variance in SF36 Total Scores with the AMAS Total Score being the most significant predictor. Therefore, math anxiety can be deemed a significant predictor for overall HRQOL, accounting for 20.6% of the variation in scores.

Table 4

Regression – Does Math Anxiety Predict HRQOL?

Variables	*Beta*	*t*	R	R^2	Change R^2
Step 1			.147	.022	.022
Year of Study	.024	.235			
Faculty	.136	1.323			
Step 2			.239	.057	.035
Year of Study	-.008	-.076			
Faculty	.124	1.225			
Gender	-.192	-2.022*			
Step 3			.513	.263	.206
Year of Study	-.027	-.296			
Faculty	.043	.471			
Gender	-.118	-1.378			
AMAS	-.471	-5.494***			

Note. N = 113; *p<.05, **p<.01, ***p<.001

Does Math Anxiety Predict Specific Domains of HRQOL?

To better understand what domains of HRQOL are predicted by math anxiety, a series of three-stage hierarchical linear regressions were conducted on each of the eight subscales of the SF-36 using the AMAS Total score as the predictor. First the Physical Functioning subscale was set as the dependent variable. The regression statistics are presented in Table 5.

The hierarchical linear regression revealed that at Stage 1, Year of Study and Faculty contributed insignificantly to the regression model, F (2,110) = .014, $p < .986$) and accounted for 0% of the variation in the Physical Functioning subscale. Introducing the gender variable explained no additional variation in the Physical Functioning subscale and this change in $R2$ was not significant, F (3,109) = .014, $p < .998$. Finally, adding the AMAS Total score to the regression model explained an additional 10.9% of the variation in the Physical Functioning subscale and this change in $R2$ square was significant, F (4,108) = 3.328, $p < .013$. All together the four variables account for 11.0% of the variance in the SF-36 Physical Functioning subscale with the AMAS Total score being the most significant predictor. Therefore, math anxiety can be deemed a predictor for physical functioning, accounting for 10.9% of the variation in the scores.

Table 5

Regression – Does Math Anxiety Predict Physical Functioning?

Variables	*Beta*	*t*	R	R^2	Change R^2
Step 1			.016	.000	.000
Year of Study	.017	.160			
Faculty	-.002	-.019			
Step 2			.020	.000	.000
Year of Study	.019	.176			
Faculty	-.001	-.012			
Gender	.012	.121			
Step 3			.331	.110	.109
Year of Study	.005	.046			
Faculty	-.060	-.602			
Gender	.066	.702			
AMAS	-.343	-3.642***			

Note. N = 113; *p<.05, **p<.01, ***p<.001

Another three-stage hierarchical linear regression was conducted with the SF-36 subscale of Role Limited Due to Physical Functioning. The regression statistics are presented in Table 6.

The hierarchical linear regression revealed that at Stage 1, Year of Study and Faculty contributed non-significantly to the regression model, F (2,110) = .568, p< .568) and accounted for 1.0% of the variation in the SF-36 Role Limited Due to Physical Functioning subscale. Introducing the gender variable explained 1.1% of the variation in the Role Limited Due to Physical Functioning subscale and this change in $R2$ was not significant, F (3,109) = .803, p < .495. Finally, adding the AMAS Total score to the regression model explained an additional 12.0% of the variation in the Role Limited Due to Physical Functioning subscale and this change in $R2$ square was significant, F (4,108) = 4.449, p < .002. All together the four variables account for 14.1% of the variance in the SF-36 Role Limited Due to Physical Functioning subscale with the AMAS Total score being the most significant predictor. Therefore, math anxiety can be deemed a predictor for role limitation due to physical functioning, accounting for 12.0% of the variation in scores.

Table 6

Regression – Does Math Anxiety Predict Role Limitations Due to Physical Functioning?

Variables	*Beta*	*t*	R	R^2	Change R^2
Step 1			.101	.010	.010
Year of Study	.092	.895			
Faculty	.019	.180			
Step 2			.147	.022	.011
Year of Study	.074	.712			
Faculty	.012	.117			
Gender	-.109	-1.128			
Step 3			.376	.141	.120
Year of Study	.060	.607			
Faculty	-.050	-.507			
Gender	-.052	-.568			
AMAS	-.359	-3.882***			

Note. N = 113; *p<.05, **p<.01, ***p<.001

Another three-stage hierarchical linear regression was conducted with the SF-36 subscale of Role Limited Due to Emotional Problems. The regression statistics are presented in Table 7.

The hierarchical linear regression revealed that at Stage 1, Year of Study and Faculty contributed non-significantly to the regression model, F (2,110) = 1.279, $p< .283$) and accounted for 2.3% of the variation in the SF-36 Role Limited Due to Emotional Problems subscale. Introducing the gender variable explained 10.3% of the variation in the SF-36 Role Limited Due to Emotional Problems subscale and this change in $R2$ was significant, F (3,109) = 5.244, $p <$ .002. Finally, adding the AMAS Total score to the regression model explained an additional 19.8% of the variation in the SF-36 Role Limited Due to Emotional Problems subscale and this change in $R2$ square was significant, F (4,108) = 12.956, $p < .001$. All together the four variables account for 32.4% of the variance in the SF-36 Role Limited Due to Emotional Problems subscale with the AMAS Total score being the most significant predictor. Therefore, math anxiety can be deemed a predictor for role limitation due to emotional problems, accounting for 19.8% of the variation in the scores.

Table 7

Regression – Does Math Anxiety Predict Role Limitations Due to Emotional Problems?

Variables	*Beta*	*t*	R	R^2	Change R^2
Step 1			.151	.023	.023
Year of Study	-.007	-.066			
Faculty	.153	.153			
Step 2			.355	.126	.103
Year of Study	-.061	-.622			
Faculty	.134	1.370			
Gender	-.328	-3.591***			
Step 3			.569	.324	.198
Year of Study	-.080	-.919			
Faculty	.054	.618			
Gender	-.255	-3.123***			
AMAS	-.462	-5.627***			

Note. N = 113; *p<.05, **p<.01, ***p<.001

Another three-stage hierarchical linear regression was conducted with the SF-36 subscale of Energy/Fatigue. The regression statistics are presented in Table 8.

The hierarchical linear regression revealed that at Stage 1, Year of Study and Faculty contributed non-significantly to the regression model, F (2,110) = 1.400, $p < .251$) and accounted for 2.5% of the variation in the SF-36 Energy/Fatigue subscale. Introducing the gender variable explained 8.9% of the variation in the SF-36 Energy/Fatigue subscale and this change in $R2$ was significant, F (3,109) = 4.654, $p < .004$. Finally, adding the AMAS Total score to the regression model explained an additional 2.4% of the variation in the Energy/Fatigue subscale and this change in $R2$ square was significant, F (4,108) = 4.296, $p < .003$. All together the four variables account for 13.7% of the variance in the SF-36 Energy/Fatigue subscale with the gender variable being the most significant predictor. Therefore, although math anxiety can be deemed a predictor of energy and fatigue, accounting for 2.4% of the variation in the scores, gender is a more significant predictor.

Table 8

Regression – Does Math Anxiety Predict Energy/Fatigue?

Variables	*Beta*	*t*	R	R^2	Change R^2
Step 1			.158	.025	.025
Year of Study	-.168	-1.639			
Faculty	.097	.952			
Step 2			.337	.114	.089
Year of Study	-.218	-2.200*			
Faculty	.079	.806			
Gender	-.304	-3.303***			
Step 3			.371	.137	.024
Year of Study	-.225	-2.284**			
Faculty	.052	.523			
Gender	-.279	-3.018***			
AMAS	-.160	-1.723**			

Note. N = 113; *p<.05, **p<.01, ***p<.001

Another three-stage hierarchical linear regression was conducted with the SF-36 subscale of Emotional Well-being. The regression statistics are presented in Table 9.

The hierarchical linear regression revealed that at Stage 1, Year of Study and Faculty contributed significantly to the regression model, F (2,110) = 6.393, p< .002) and accounted for 10.4% of the variation in the SF-36 Emotional Well-being subscale. Introducing the gender variable explained 2.0% of the variation in the SF-36 Emotional Well-being subscale and this change in $R2$ was significant, F (3,109) = 5.128, p < .002. Finally, adding the AMAS Total score to the regression model explained an additional 18.7% of the variation in the SF-36 Emotional Well-being subscale and this change in $R2$ square was significant, F (4,108) = 12.170, p < .001. All together the four variables account for 31.1% of the variance in the SF-36 Emotional Well-being subscale with the AMAS score being the most significant predictor. Therefore, math anxiety can be deemed a predictor for emotional well-being, accounting for 18.7% of the variation in the scores.

Table 9

Regression – Does Math Anxiety Predict Emotional Well-Being?

Variables	*Beta*	*t*	R	R^2	Change R^2
Step 1			.323	.104	.104
Year of Study	.133	1.359			
Faculty	.246	2.509**			
Step 2			.352	.124	.020
Year of Study	.110	1.111			
Faculty	.238	2.433**			
Gender	-.143	-1.560			
Step 3			.557	.311	.187
Year of Study	.091	1.039			
Faculty	.160	1.818			
Gender	-.072	-.871			
AMAS	-.449	-5.413**			

Note. N = 113; *p<.05, **p<.01, ***p<.001

Another three-stage hierarchical linear regression was conducted with the SF-36 subscale of Social Functioning. The regression statistics are presented in Table 10.

The hierarchical linear regression revealed that at Stage 1, Year of Study and Faculty contributed insignificantly to the regression model, *F* (2,110) = .227, *p*< .797) and accounted for 0.4% of the variation in SF-36 Social Functioning subscale. Introducing the gender variable explained no change in the Social Functioning subscale and this change in *R2* was not significant, *F* (3,109) = .151, *p* < .929. Finally, adding the AMAS Total score to the regression model explained an additional 1.8% of the variation in the Social Functioning subscale and this change in *R2* square was not significant, *F* (4,108) = .618, *p* < .651. All together the four variables account for 2.2% of the variance in the SF-36 Social Functioning subscale with the none of the variables being significant predictors. Therefore, math anxiety cannot be deemed a predictor for social functioning.

Table 10

Regression – Does Math Anxiety Predict Social Functioning?

Variables	*Beta*	*t*	R	R^2	Change R^2
Step 1			.064	.004	.004
Year of Study	.044	.428			
Faculty	.032	.311			
Step 2			.064	.004	.000
Year of Study	.043	.413			
Faculty	.032	.306			
Gender	-.005	-.049			
Step 3			.150	.022	.018
Year of Study	.038	.361			
Faculty	.008	.074			
Gender	.017	.176			
AMAS	-.140	-1.419			

Note. N = 113; *p<.05, **p<.01, ***p<.001

Another three-stage hierarchical linear regression was conducted with the SF-36 subscale of Pain. The regression statistics are presented in Table 11.

The hierarchical linear regression revealed that at Stage 1, Year of Study and Faculty contributed insignificantly to the regression model, F (2,110) = 1.481, $p < .232$) and accounted for 2.6% of the variation in the SF-36 Pain subscale. Introducing the gender variable explained 1.8% of the variation in the Pain subscale and this change in *R2* was significant, F (3,109) = 1.676, $p < .176$. Finally, adding the AMAS Total score to the regression model explained an additional 7.4% of the variation in the SF-36 Pain subscale and this change in *R2* square was significant, F (4,108) = 3.602, $p < .009$. All together the four variables account for 11.8% of the variance in the SF-36 Pain subscale with the AMAS score being the most significant predictor. Therefore, math anxiety can be deemed a predictor for pain, accounting for 7.4% of the variation in the scores.

Table 11

Regression – Does Math Anxiety Predict Pain?

Variables	*Beta*	*t*	R	R^2	Change R^2
Step 1			.162	.026	.026
Year of Study	.157	1.538			
Faculty	.011	.107			
Step 2			.210	.044	.018
Year of Study	.180	1.746			
Faculty	.019	.188			
Gender	.136	1.428			
Step 3			.343	.118	.074
Year of Study	.191	1.923*			
Faculty	.068	.678			
Gender	.092	.985			
AMAS	.281	3.002***			

Note. N = 113; *p<.05, **p<.01, ***p<.001

Finally, a three-stage hierarchical linear regression was conducted with the SF-36 subscale of General Health. The regression statistics are presented in Table 12.

The hierarchical linear regression revealed that at Stage 1, Year of Study and Faculty contributed insignificantly to the regression model, F (2,110) = .812, p< .446) and accounted for 1.5% of the variation in the SF-36 General Health subscale. Introducing the gender variable explained 4.1% of the variation in the SF-36 General Health subscale and this change in $R2$ was not significant, F (3,109) = 2.125, p < .101. Finally, adding the AMAS Total score to the regression model explained an additional 18.9% of the variation in the SF-36 General Health subscale and this change in $R2$ square was significant, F (4,108) = 8.714, p < .001. All together the four variables account for 24.4% of the variance in the SF-36 General Health subscale with the AMAS Total score being the most significant predictor. Therefore, math anxiety can be deemed a predictor for general health, accounting for 18.9% of the variation in the scores.

Table 12

Regression – Does Math Anxiety Predict General Health?

Variables	*Beta*	*t*	R	R^2	Change R^2
Step 1			.121	.015	.015
Year of Study	.010	.095			
Faculty	.116	1.132			
Step 2			.235	.055	.041
Year of Study	-.024	-.239			
Faculty	.104	1.027			
Gender	-.206	-2.167*			
Step 3			.494	.244	.189
Year of Study	-.043	-.464			
Faculty	.026	.287			
Gender	-.135	-1.1559			
AMAS	-.451	-5.192***			

Note. N = 113; *p<.05, **p<.01, ***p<.001

The previous eight regression analyses focused on comparing the AMAS Total scores to the subscales of the SF-36. The results show that the AMAS Total score is a significant predictor for seven of the SF-36 subscales, but it is not a significant predictor for the social functioning subscale. This demonstrates that math anxiety significantly affects most of the factors of HRQOL.

Is There a Relationship Between Math Anxiety and Functional Impairment in Postsecondary Students?

A Spearman correlation coefficient was used to determine the relationship between the AMAS Total score and the SDS Total score. The data appeared to have some degree of skewness and kurtosis therefore a Spearman rank correlation was deemed more applicable than using a Pearson correlation. The results indicate a significant positive relationship, $r(113) = .691$; $p < .001$ between the two scores. As the AMAS Total score increases, the SDS Total Score also increases.

Consistent with this correlation, of the 113 open-ended responses that outlined the negative impacts of math anxiety on life outside of the classroom, 94 of the responses focused on some aspect of functional impairment, either in reference to school, work, social/leisure life, or home/family life. The open-ended responses suggest that some functional impairment is the result of having to perform mental math, as 22 of the responses, across all of the functional impairment categories, referenced this as a component of their anxiety. This concept of mental math was seen in several responses, such as: “Having to perform equations without the assistance of a calculator or register”; “doing simple math on the spot”; “having to split a bill or add a tip in my head”; “situations involving mental math such as calculating tip, splitting a bill, or even adding up scores in sports”; or another who was even more direct by simply stating that “mental math” is where they experience anxiety outside of the classroom.

Table 13

Spearman – Are Math Anxiety and Functional Impairment Correlated?

		Abbreviated Math Anxiety Scale Score (AMAS)	Sheehan Disability Scale Score (SDS)
Abbreviated Math Anxiety Scale Score (AMAS)	r	1	.691**
	p		.001
	N	113	113
Sheehan Disability Scale Score (SDS)	r	.691**	1
	p	.001	
	N	113	113

**. Correlation is significant at the 0.01 level (2-tailed).

The responses also regularly grouped the anxiety of mental math with performance anxiety as many responses mentioned that performing mental math when others were present was a source of anxiety, such as: “if I have to split the bill myself in front of customers”; “doing mental calculations in front of others/superiors”; and “if someone asks me to do a mental calculation” or “mental math in front of others.”

To further examine the relationship between the AMAS and SDS the AMAS Total score was compared individually to the four subscales of the SDS. A Spearman correlation coefficient was used to determine the relationship between the Total AMAS score and the subscales of the SDS: the symptoms have disrupted your work; the symptoms have disrupted your school performance; the symptoms have disrupted your social life/leisure activities; and the symptoms have disrupted your family life/home responsibilities. The results are presented in Table 14. As the AMAS Total score increases all the scores on the subscales of the SDS (the symptoms have disrupted your: work, school, social life, home life) decrease. This relationship implies that an increase in math anxiety correlates to an increase in functional impairment in all domains, with the greatest impact occurring on an individual’s functioning at work.

When looking at the open-ended responses and categorizing them based on the subscales, 19 of these responses discussed work, two discussed school, 16 discussed social settings, and 14 discussed home/family life. It was evident via the open-ended responses that work was one of the areas where math anxiety resulted in the most functional impairment such as one participant who stated “submitting payroll, having to enter and calculate statistics using Microsoft excel and having to do general tasks at work that may involve some sort of math”; “budget-focused work responsibilities”; “having to keep track of inventory”; and “doing new things at work or having to do calculations I’m unfamiliar with.”

Table 14

Do Math Anxiety and the Subscales of Functional Impairment Correlate

		Abbreviated Math Anxiety Scale AMAS	The symptoms have disrupted your work life	The symptoms have disrupted your school life	The symptoms have disrupted your social life/leisure activities	The symptoms have disrupted your family life/home responsibilities
Abbreviated Math Anxiety Scale Score AMAS	r	1	.620**	.568 **	.593**	.552**
	p		.001	.001	.001	.001
	N	113	113	113	113	113
The symptoms have disrupted your work life	r	.620**	1	.717**	.700**	.677**
	p	.001		.001	.001	.001
	N	113	113	113	113	113
The symptoms have disrupted your school life	r	.568 **	.717 **	1	.739**	.683**
	p	.001	.001		.001	.001
	N	113	113	113	113	113
The symptoms have disrupted your social life/leisure activities	r	.593**	.700**	.739**	1	.872**
	p	.001	.000	.001		.001
	N	113	113	113	113	113
The symptoms have disrupted your family life/home responsibilities	r	.552**	.677**	.683**	.872**	1
	p	.001	.001	.001	.001	
	N	113	113	113	113	113

**. Correlation is significant at the 0.01 level (2-tailed).

Following work, social settings were the next most prominent category for math anxiety to result in functional impairment based on the responses, such as: “playing games and it involves math”; “whenever we are adding scores/playing games where you have to keep track of numbers”; “when asked math questions in front of friends or splitting bills”; or “playing darts with friends and have to do the simple subtraction quick as everyone else.” Following social settings family/home life was the next most prominent category with responses that focused specifically on financial situations, such as: “whenever I’m out shopping, trying to budget”; “managing my own finances is stressful”; “completing federal tax forms”; or the combination of both—“I do not do my own finances/taxes.” Finally, the least mentioned category in the open-ended responses was the school setting, with two responses: “it influenced my career/university choice” and “writing papers, speeches/presentations and submitting large assignments.” The fact that the category with the greatest number of open-ended responses is work further supports the findings already established between the AMAS and SDS.

Does Math Anxiety Predict Functional Impairments?

To examine this question, a series of three-step hierarchical linear regressions were calculated. This series of hierarchical regressions used the same steps as regressions run previously examining HRQOL. Prior to conducting the hierarchical linear regressions, the relevant assumptions of this statistical analysis were tested. Firstly, a sample size of 113 was deemed adequate given four independent variables to be included in the analysis (Tabachnick & Fidell, 2001). The assumption of singularity was also met as the independent variable, AMAS Total score was not a combination of other independent variables. No extreme univariate outliers were identified in initial data screening, so modifications were unneeded. An examination of the Mahalanobis distance scores indicated no multivariate outliers. Residual and scatter plots indicated the assumptions of normality, linearity, and homoscedasticity were all satisfied (Hair et al., 1998; Pallant, 2001).

To begin, a three-stage hierarchical linear regression was conducted with the SDS Total score as the dependent variable. The regression statistics are presented in Table 15.

The hierarchical linear regression revealed that at Stage 1, Year of Study and Faculty contributed significantly to the regression model, F (2,110) = 22.607, $p < .001$) and accounted for 29.1% of the variation in the SDS Total score. Introducing the gender variable explained no additional change in variation for the SDS Total score and the change in *R2* was not significant. Finally, adding the AMAS Total score to the regression model explained an additional 33.6% of the variation in the SDS Total score and this change in *R2* square was significant, F (4,108) = 45.493, $p < .001$. All together the four variables account for 62.8% of the variance in the SDS Total Score with the AMAS Total Score being the most significant predictor. Therefore, math anxiety can be deemed a predictor for overall functional impairment, accounting for 33.6% of the variation in the scores.

Table 15

Regression – Does Math Anxiety Predict Functional Impairment?

Variables	*Beta*	*t*	R	R^2	Change R^2
Step 1			.540	.291	.291
Year of Study	-.378	-4.334***			
Faculty	-.264	-3.028***			
Step 2			.540	.291	.000
Year of Study	-.380	-4.280***			
Faculty	-.265	-3.016***			
Gender	-.009	-.111			
Step 3			.792	.628	.336
Year of Study	-.355	-5.494***			
Faculty	-.161	-2.486**			
Gender	-.104	-1.714			
AMAS	.602	9.873***			

Note. N = 113; *p<.05, **p<.01, ***p<.001

Does Math Anxiety Predict Specific Factors of Functional Impairment?

To better understand what factors of functional impairment are predicted by math anxiety a series of three-stage hierarchical linear regressions was conducted on each of the four subscales of the SDS (Work Life, School Life, Social Life, Family Life) using the AMAS Total score as the predictor. The first three-stage hierarchical linear regression was conducted with the SDS subscale of Work Life. The regression statistics are presented in Table 16.

The hierarchical linear regression revealed that at Stage 1, Year of Study and Faculty contributed significantly to the regression model, F (2,110) = 14.429, $p < .001$) and accounted for 20.8% of the variation in the Work Life subscale. Introducing the gender variable explained no additional change in variation for the Work Life subscale and the change in $R2$ was not significant. Finally, adding the AMAS Total score to the regression model explained an additional 32.7% of the variation in the Work Life subscale and this change in $R2$ square was significant, F (4,108) = 31.596, $p < .001$. All together the four variables account for 53.9% of the variance in the Work Life subscale with the AMAS Total score being the most significant predictor. Therefore, math anxiety can be deemed a predictor for functional impairment in work life, accounting for 32.7% of the variation in the scores.

Table 16

Regression – Does Math Anxiety Predict Functional Impairment at Work?

Variables	*Beta*	*t*	R	R^2	Change R^2
Step 1			.456	.208	.208
Year of Study	-.316	-3.430***			
Faculty	-.227	-2.457**			
Step 2			.461	.212	.004
Year of Study	-.328	-3.502***			
Faculty	-.231	-2.492**			
Gender	-.067	-.774			
Step 3			.734	.539	.327
Year of Study	-.303	-4.219***			
Faculty	-.128	-1.782			
Gender	-.161	-2.381**			
AMAS	.593	8.756***			

Note. N = 113; *p<.05, **p<.01, ***p<.001

Another three-stage hierarchical linear regression was conducted with the SDS subscale of School Life. The regression statistics are presented in Table 17.

The hierarchical linear regression revealed that at Stage 1, Year of Study and Faculty contributed significantly to the regression model, F (2,110) = 26.775, $p< .001$) and accounted for 32.7% of the variation in the School Life subscale. Introducing the gender variable explained a 0.1% change in variation for the School Life subscale and the change in *R2* was not significant. Finally, adding the AMAS Total score to the regression model explained an additional 23.7% of the variation in the School Life subscale and this change in *R2* square was significant, F (4,108) = 35.027, $p < .001$. All together the four variables account for 56.5% of the variance in the School Life subscale with the academic factor variables being the most significant predictor. Despite not being the strongest predictor of school life functional impairment, math anxiety can be deemed a predictor for functional impairment in school life, accounting for 23.7% of the variation in the scores.

Table 17

Regression – Does Math Anxiety Predict Functional Impairment at School?

Variables	*Beta*	*t*	R	R^2	Change R^2
Step 1			.572	.327	.327
Year of Study	-.445	-5.233**			
Faculty	-.225	-2.652**			
Step 2			.573	.328	.001
Year of Study	-.441	-5.101***			
Faculty	-.224	-2.619**			
Gender	.025	.309			
Step 3			.751	.565	.237
Year of Study	-.420	-6.011***			
Faculty	-.137	-1.955*			
Gender	-.055	-.836			
AMAS	.505	7.663***			

Note. N = 113; *p<.05, **p<.01, ***p<.001

Another three-stage hierarchical linear regression was conducted with the SDS subscale of Social Life. The regression statistics are presented in Table 18.

The hierarchical linear regression revealed that at Stage 1, Year of Study and Faculty contributed significantly to the regression model, F (2,110) = 15.336, $p < .001$) and accounted for 21.8% of the variation in the Social Life subscale. Introducing the gender variable explained a 0.1% change in variation for the Social Life subscale and the change in *R2* was not significant. Finally, adding the AMAS Total score to the regression model explained an additional 27.3% of the variation in the Social Life subscale and this change in *R2* square was significant, F (4,108) = 26.180, $p < .001$. All together the four variables account for 49.2% of the variance in the Social Life subscale with the AMAS Total score being the most significant predictor. Therefore, math anxiety can be deemed a predictor for functional impairment in social life, accounting for 27.3% of the variation.

Table 18

Regression – Does Math Anxiety Predict Functional Impairment in Social Life?

Variables	*Beta*	*t*	R	R^2	Change R^2
Step 1			.467	.218	.218
Year of Study	-.303	-3.309***			
Faculty	-.255	-2.786**			
Step 2			.467	.219	.001
Year of Study	-.300	-3.217***			
Faculty	-.254	-2.756**			
Gender	.022	.253			
Step 3			.702	.492	.273
Year of Study	-.278	-3.677***			
Faculty	-.161	-2.122*			
Gender	-.064	-.900			
AMAS	.543	7.632***			

Note. N = 113; *p<.05, **p<.01, ***p<.001

Another three-stage hierarchical linear regression was conducted with the SDS subscale of Family Life. The regression statistics are presented in Table 19.

The hierarchical linear regression revealed that at Stage 1, Year of Study and Faculty contributed significantly to the regression model, F (2,110) = 12.818, p< .001) and accounted for 18.9% of the variation in the Family Life subscale. Introducing the gender variable resulted in no change in variation for the Home and Family Life subscale and the change in *R2* was not significant. Finally, adding the AMAS Total score to the regression model explained an additional 26.5% of the variation in the Family Life subscale and this change in *R2* square was significant F (4,108) = 22.462, p < .001. All together the four variables account for 45.4% of the variance in the Family Life subscale with the AMAS Total score being the most significant predictor. Therefore, math anxiety can be deemed a predictor for functional impairment in family life, accounting for 26.5% of the variation in the scores.

The previous four regression analyses demonstrate that all four components of functional impairments measured by the SDS (work life, school life, social life, and family life) can be significantly predicted by math anxiety measured by the AMAS. This implies that math anxiety results in functional impairment in multiple life domains.

Table 19

Regression – Does Math Anxiety Predict Functional Impairment at School in Family Life?

Variables	*Beta*	*t*	R	R^2	Change R^2
Step 1			.435	.189	.189
Year of Study	-.272	-2.916***			
Faculty	-.249	-2.663**			
Step 2			.435	.189	.000
Year of Study	-.275	-2.900**			
Faculty	-.250	-2.659**			
Gender	-.018	-.209			
Step 3			.674	.454	.265
Year of Study	-.254	-3.238***			
Faculty	-.158	-2.010*			
Gender	-.103	-1.396			
AMAS	.534	7.238***			

Note. N = 113; *p<.05, **p<.01, ***p<.001

Chapter Summary

RQ1: Is There a Relationship Between Math Anxiety and Health-Related Quality of Life?

There appears to be a moderate statistically significant relationship between math anxiety, measured by the total score on the AMAS, and HRQOL, as measured by the total score on the SF-36. As math anxiety increases, HRQOL decreases. After controlling for gender, year of study, and study major, total scores on the AMAS predicted total scores on the SF-36, accounting for approximately 20.6% of unique shared variance between the two scores.

Looking at the subscales of the SF-36, it appears that math anxiety as measured by the total score on the AMAS has the greatest impact on emotional well-being, role limited to emotional problems, and general health subscales. This is further supported by the open-ended responses where individuals provided insight into how math anxiety impacted them outside of the classroom where responses consistently focused on the emotional impacts of their math anxiety.

RQ2: Is There a Relationship Between Math Anxiety and Functional Impairment?

There appears to be a moderate statistically significant relationship between math anxiety, as measured by the total score on the AMAS, and functional impairment, as measured by the total score on the SDS. As math anxiety increases so does functional impairment. After controlling for gender, year of study, and study major, total scores on the AMAS predicted total scores on the SDS, accounting for approximately 33.6% of unique shared variance between the two scores.

Looking at the subscales of the SDS, it appears that math anxiety, as measured by the total score on the AMAS, leads to impairments at work, school, social life and home/family life. This is further supported by the open-ended responses where individuals provided insight into how math anxiety impacted them outside of the classroom where responses consistently focused on social, work, and personal situations that trigger their math anxiety.

CHAPTER FIVE: CONCLUSION, INTERPRETATION, AND DISCUSSION

Math anxiety is a topic that is gaining attention in today's classrooms. Multiple studies have been conducted to assess its impacts on a child's education or how to support a child with math anxiety in the classroom. However, very few studies look at the impacts it has outside of the classroom (Ahmed, 2018), and those few only look through the lens of future career choices. This study sought to identify whether math anxiety impacts the individual outside of the classroom, through Health Related Quality of Life (HRQOL) and functional impairment. Identifying if math anxiety is an issue that solely impacts education, or if it impacts all aspects of an individual's life, can influence what supports need to be provided. If math anxiety does impact HRQOL and/or functional impairment, then this is an issue that requires both more support and awareness.

Discussion of Findings

This study contributes to the literature by demonstrating there is a relationship between math anxiety, HRQOL, and functional impairment in postsecondary students. The quantitative data provided evidence that math anxiety is connected to multiple facets of HRQOL and to elements of functional impairment. The descriptive data provided examples of how math anxiety impacted participants' lived experience. While these findings are somewhat novel as no other study (to my knowledge) has examined these connections, they still align with current literature in the field.

Math Anxiety Academic Impacts

Prior to this study, ample research has been conducted on the impacts of math anxiety on academic achievement (Çiftçi, 2015; Georges et al., 2016; Huang et al., 2018; Justicia et al., 2017; Klados et al., 2015; Schillinger et al., 2014; Schmitz et al., 2019). This study found that math anxiety has a positive correlation, and is a predictor, for functional impairment in an individual's school life. This implies that individuals' functioning is impaired when they are in an academic setting due to their math anxiety. In terms of the established definition of functional impairment, this means that math anxiety results in limitations to an individual's ability to perform activities that are relevant to daily life (Stein & Jessop, 1990), in this case specifically in an academic setting.

The impairment that math-anxious individuals experience in an academic setting is specifically identified in other studies showing that math anxiety results in impaired working memory (Justicia et al., 2017; Klados et al., 2015), attentional bias (Rubinsten et al., 2015), threat/pain response (Lyons & Beilock, 2012), number and spatial skills (Georges et al., 2016; Schillinger et al., 2018), and overall results in math-anxious individuals achieving 27% lower than their non-math anxious peers (Çiftçi, 2015). Therefore, the findings of this study, that math anxiety results in functional impairment in an academic setting, support the already established literature that math anxiety results in impairments to academic achievement.

Math Anxiety Emotional Impacts

Within this study the greatest HRQOL correlations occurred between the Rand 36-item Short Form Health Survey (SF-36) subscales that were based on an individual's emotions and the Abbreviated Math Anxiety Scale (AMAS; i.e., emotional well-being and role limitations due to emotional problems). This implies that math anxiety leads to impairments in an individual's emotional regulation/functioning, which is also supported by the current literature (Beilock et al., 2010; Casad et al., 2015; Jansen et al., 2013; Kaskens et al., 2020; Necka et al., 2015).

Previous research identified that math anxiety results in impairments to an individual's emotional responses via; negative self-talk (Casad et al., 2015), a worst-case scenario mindset

(Beilock et al., 2010), lack of self-confidence (Kaskens et al., 2020; Necka et al., 2015), and can result in an emotional response (e.g., tears; Jansen et al., 2013). Therefore, the findings of this study, as well as previous research, imply that math anxiety results in impairments to an individual's emotional functioning.

Math Anxiety Gender Impacts

In previous studies, it has been identified that math anxiety is more prevalent in females (Beilock et al., 2010; Casad et al., 2015; Huang et al., 2018; Xie et al., 2019). This study was not looking at the prevalence of math anxiety but instead was assessing the impacts that math anxiety has on an individual's HRQOL and/or functional impairment. When looking at the differences between gender on the impacts math anxiety has on their HRQOL/functional impairment, there was only a minor variation. In HRQOL gender was only a more significant predictor for impairments than math anxiety on one subscale, energy/fatigue, but did result in a significant variance of at least 2% for the subscales of general health, role limitations due to emotional problems, and emotional well-being as well as the AMAS total score. These findings do support what has been established in literature as the increased prevalence of math anxiety in females is attributed to lower levels of self-esteem and emotional regulation (Xie et al., 2019). The findings in Xie et al. (2019) correlate with the findings of this study that increased variance due to gender occurred on the AMAS subscales of role limitations due to emotional problems and emotional well-being as these are the only SF-36 subscales that address emotional regulation. This supports the already established findings that there is a gender difference in both prevalence as well as impacts of math anxiety.

For functional impairment, gender was not found to be a predictor for the Sheehan Disability Scale (SDS) or any of its subscales; the greatest variance occurred with the subscale of work life and was only 0.4%. Therefore, the findings of this study did not identify any difference in functional impairment caused by math anxiety between the genders.

Math Anxiety is Positively Correlated with Functional Impairment

When initially comparing the overall score of the AMAS to the overall score of the SDS it was clear that there was a significant negative relationship. Upon further analysis the subscale that showed the highest correlation with the AMAS was: the symptoms have disrupted your work life subscale. While no other studies have examined the connection between math anxiety and functional impairment specifically, there is evidence that math anxiety results in maladaptive behaviours (Ahmed, 2018; Huang et al., 2018; Maloney, 2012) and there is evidence that maladaptive behaviours lead to functional impairment (Balázs et al., 2013; Buckner et al., 2018; De Waal et al., 2004; Löwe et al., 2008).

When looking at the literature it appears that math anxiety results in augmented academic and career pathways. At a base level individuals with math anxiety tend to avoid math-based activities (Maloney, 2012) however this is then further seen by avoidance of math courses throughout their education (Huang et al., 2018). This augmented pathway carries on throughout life with math anxious individuals being seven times less likely to enter the Science/Technology/Engineering/Math (STEM) field than their peers (Ahmed, 2018). Ahmed's (2018) study implies that there is some impairment in math anxious individuals job choices as they have augmented their behaviour to exclude jobs that are likely to involve math (STEM). This implied impairment is further supported by the findings in this study which highlight an individual's work life as the greatest area of functional impairment, as identified by the positive correlation between AMAS and SDS.

The connection between functional impairment and math anxiety is a concept that has not been studied. However, research has been done on the relationship between a math disability and functional impairment (Auerbach et al., 2008; Shalev et al., 2000; Shalev et al., 1995; White et al., 1992; Willcutt et al., 2013). A math disability has been found to cause significant academic and social impairment, two components of functional impairment (Willcott et al., 2011). This evidence of functional impairment on individuals who have a math disability highlights a potential similarity for math anxiety, which is further supported by this study's findings. Math anxiety may not be considered a math disability, although Ashcraft et al. (2007) suggest future research is needed, as some of the symptoms are similar. An individual who has a math disability experiences symptoms such as issues in memorization, number sense, fluent calculation, and math reasoning (APA, 2013). This can align with the aforementioned math anxiety symptoms such as impacts on an individual's working memory (Klados et al., 2015), and number sense skills (Georges et al., 2016).

There is also evidence that anxiety symptoms have a positive correlation with functional impairment (McKnight, 2016). Current studies find that over half of individuals with anxiety disorders report mid-to-high functional impairment (Kessler et al., 2005). This relationship is related even further through studies that looked at the relationship between functional impairment and social anxiety (Aderka, 2012; Balázs et al., 2013; Schneier et al., 1994). It was found that social anxiety leads to substantial levels of functional impairment, particularly in the work/school and social life categories (Aderka, 2012), which is replicated in this study with those categories showing the highest correlation with math anxiety as well. Therefore, due to the already established connection between social anxiety and math anxiety this relationship can be assumed to be replicated with math anxiety.

The impairments on an individual's school and work life, and career (Ahmed, 2018), imply a maladaptive behavioural response. This behavioural response also supports the connection to Beck's General Theory of Anxiety (BGTA). BGTA states that a dysfunctional belief (which is assumed based on previous literature for math anxiety) leads to an emotional response and maladaptive behaviours (Beck, 2014). Therefore, there should be evidence of an emotional, which will be discussed later, and behavioural impact when an individual struggles with math anxiety as exhibited by the correlation with the SF-36 and SDS respectively.

Math Anxiety Is Negatively Correlated With HRQOL

This study found a significant negative relationship between the overall AMAS score and the overall SF-36 score. Upon further analysis the subscales that showed the highest correlation with the AMAS were: role limitations due to emotional problems, general health, and emotional well-being. While no other specific studies have examined the connection between math anxiety and HRQOL there is some evidence that math anxiety involves a more general negative emotional response to stressful stimuli as previously established in this chapter (Beilock et al., 2010; Casad et al., 2015; Jansen et al., 2013; Kaskens et al., 2020; Necka et al., 2015). In particular, math anxiety has been identified as resulting in emotional dysregulation (Artemenko et al., 2015; Daches et al., 2021). The correlations between this study's findings of impairments in an individual's emotional well-being and role limitations due to emotional problems as well as the aforementioned emotional dysregulation implies that math anxiety negatively impacts HRQOL, particularly in regards to an individual's emotions.

As stated, no specific studies have been done on the correlation between math anxiety and HRQOL, however past studies have identified a negative correlation between social anxiety and HRQOL (Dryman, 2015; Saarni, 2007; Simon et al., 2002). It was found that social anxiety disorder negatively correlates with lower HRQOL scores in individuals who are 20 years and older (Saarni, 2007). This was further supported as it was found that the fear of negative and positive evaluation, components of performance anxiety, directly impacts HRQOL (Dryman, 2015). This study is particularly impactful as the fear of negative evaluation, which is identified as a contributing factor for math anxiety (Beilock et al., 2010), has shown to be strongly related to deficits in social and emotional functioning (Dryman, 2015). Specifically, this relationship was also investigated using the SF-36 HRQOL measure with participants who were identified as having social anxiety disorder (Simon et al., 2002). It was further identified that social anxiety not only has a negative relationship with social functioning but also the mental health and emotional functioning subscales (Simon et al., 2002). Therefore, the negative correlation found between math anxiety and the emotional functioning component of HRQOL is supported by the current literature (Dryman, 2015).

This impairment in an individual's emotional response is also supported by the framework chosen for this study, BGTA. BGTA states that a dysfunctional belief (which is assumed based on previous literature for math anxiety) leads to an emotional response and maladaptive behaviours (Beck, 2014). Therefore, there should be evidence of an emotional and behavioural impact when an individual struggles with math anxiety. The behavioural impact was discussed previously, however the emotional impact is made clear by the greatest significant negative correlations between the AMAS and the SF36 occurring with the subscales of role limitations due to emotional problems and emotional well-being.

Recommendations for Research

This study has led to several different recommendations for future research. Moving forward, future researchers should: first replicate this study post-lockdown's due to the pandemic, confirm that HRQOL and functional impairment are the best measures for assessing impacts on daily life, develop/apply a framework for future research (this study suggests BGTA), and develop/apply a research backed intervention strategy (this study suggests Cognitive Behaviour Therapy (CBT)).

One of the greatest limitations of this study was that it occurred during the lockdowns and pandemic at a time when anxiety levels in general were heightened (Government of Canada, 2021). This influenced not only data collection, as it all had to be done electronically, but also potentially influenced the responses participants were giving. This study focused heavily on individuals reflecting on their current experiences, physically and emotionally, and then correlated this with their degree of math anxiety. However, it is possible that individuals currently are experiencing atypical mental health, particularly anxiety, due to the impacts of pandemic life. This could have resulted in skewed data. Therefore, replicating the study when pandemic lockdowns are not actively occurring would ensure that the results are valid. Also when replicating the study, it would be beneficial to broaden the sample size as well as the population that is being sampled. This study was conducted on university students and therefore may not be representative of the larger population. Using a more varied sample of the population would ensure that the results are in fact generalizable and would make the findings more robust.

Further research should also be conducted specifically on what the best measures are for assessing impacts on daily life, both in general and in regards to math anxiety. This study chose the categories of HRQOL and functional impairment as categorical representatives for assessing daily life and then used the SF-36 and SDS as measures for these categories, respectively. Further research should be conducted to ensure that first, HRQOL and daily functioning are in fact the best categories for assessment but also that the SF-36 and SDS are the best measures for this situation. Utilizing different functional impairment and HRQOL measures that still resulted in similar findings would also add to the reliability of this study's findings.

Next, research should be conducted to identify if the BGTA framework is ideal for conceptualizing math anxiety, or if it should have its own specific theory as a framework. The BGTA framework consists of beliefs, emotions, and behaviours (Beck, 2014). Due to the previous findings in past literature, as well as some open-ended responses, math anxiety is already assumed to have dysfunctional beliefs, however future research should confirm and measure this assumption. The findings of this study highlight the impacts on both emotions (the SF-36) and on behaviours (the SDS). The emotional regulation impacts are made clear by the SF-36 survey's top subscale correlations of emotional well-being and energy/fatigue. The third greatest correlation between the AMAS and SF-36 role limitations due to emotional problems implies the connection to the next step in the BGTA framework, behaviours. This impact on behaviour is then further supported by the SDS due to the high level of correlation which implies impacts on daily functioning (i.e., maladaptive behaviours). With the greatest impact occurring on social life/leisure activities implying that augmented behaviour occurs in these settings. This implies that math anxiety does connect with BGTA by following a similar dysfunctional belief leading to an emotional reaction and resulting in a maladaptive behaviour. Since math anxiety follows the framework for BGTA, this would imply that by using BGTA as a framework researchers can rely on, and recheck, that similar findings consistent with other anxiety disorders are also consistent with math anxiety.

This in turn would both provide direction for future research but also streamline possible support and intervention strategies such as CBT. CBT intervention consists of a twofold strategy comprised of cognitive and behavioural techniques (Fenn & Byrne, 2013). Since the impacts of math anxiety are rooted in dysfunctional thoughts that result in maladaptive behaviours, it is important to target both the dysfunctional thoughts and the maladaptive behavioural response (Fenn & Byrne, 2013).

Intervention targeting the dysfunctional thoughts can consist of many different approaches. A key intervention strategy is “guided discovery” which consists of Socratic questioning (Fenn & Byrne, 2013). However, just addressing the dysfunctional thought is not always enough as it is rooted in an even deeper dysfunctional belief (Fenn & Byrne, 2013). While “guided discovery” and Socratic questioning can still be effective interventions for addressing the dysfunctional belief, additional strategies may be needed (Fenn & Byrne, 2013). These strategies can consist of keeping a positive data log or thought records. Typically core beliefs are addressed later in treatment as they are the least accessible level of cognition and therefore positive strategies for dysfunctional assumptions and negative automatic thoughts are established first (Fenn & Byrne, 2013).

In step with the cognitive intervention, it is also important to address maladaptive behaviours. As an individual is undergoing the cognitive interventions it is important to still address the maladaptive behaviours to ensure that new maladaptive behaviours are not developed for the augmented thought process that is now occurring (Fenn & Byrne, 2013). It also ensures that even if the dysfunctional thoughts occur the maladaptive behaviours may still be mitigated (Fenn & Byrne, 2013). Behavioural techniques are used to decrease, and eventually eliminate the maladaptive behaviours. Activity scheduling and graded task assignments are used to increase daily functioning and systemically enhance pleasurable or productive experiences. Behavioural experiments are also often used in interventions for anxiety based mental health disorders (Fenn & Byrne, 2013). To mitigate the physical and emotional reactions that occur due to the dysfunctional thoughts and encourage the use of the new maladaptive behaviours relaxation training and breathing exercises may be used (Fenn & Byrne, 2013).

When looking at post-secondary students, CBT is already a widely accepted intervention strategy for anxiety disorders (Heinig et al., 2017; Salza et al., 2020; Stefan et al., 2019) and specifically viewed as one of the best for treating social anxiety (Zagorski, 2014). This implies that math anxiety, which has been established as meeting the criteria for performance anxiety which is a subset of social anxiety, may also be successfully treated using CBT. Unfortuntaely, there is no research on math anxiety and CBT using post-secondary students however, this connection has already been tested in one study, using elementary (grade 1-8) students, did find that CBT was effective in decreasing math anxiety and increasing math self-concept and it is assumed that findings would be similar for post-secondary students (Asanjarani & Zarebahramabadi, 2021). In contrast the literature review highlighted that current intervention strategies often focus on supporting the academic math skills of the effected k-12 students, which has shown some success and can be assumed to also apply to post-secondary students (Artemenko et al., 2015; Genshaft & Naglieri, 1987; Maloney et al., 2015). Therefore, future research should be directed towards identifying if CBT is an effective strategy for math anxiety and if the current academic based supports are effective in conjunction with CBT, separate, or should be removed entirely as CBT is superior.

Recommendations for Practice

This study identified that there was a significant negative correlation between the AMAS and the SF-36, and further regression analysis identified the AMAS as a significant negative predictor of the SF-36. It also found a significant positive correlation between the AMAS and the SDS with further regression analysis identifying the AMAS as a significant positive predictor of the SDS. This along with the further correlations between the subscales implies that math anxiety does lead to functional impairment and poor HRQOL.

These findings have led to several different recommendations for practice. Moving forward: math anxiety intervention strategies should be taught in school (this study recommends CBT) and math anxiety should be viewed as a mental health issue which will lead to de-stigmatization in both the classroom and workplace.

The greatest recommendation for practice is to view math anxiety as a mental health issue, specifically as performance anxiety, and to apply appropriate mental health intervention strategies (Luttenberger et al., 2018). As established in Chapter 2, math anxiety meets the Diagnostic and Statistical Manual of Mental Disorders – 5th edition (DSM-5) definition for performance anxiety, however it is not widely viewed as such. The findings of this research heavily focused on highlighting how math anxiety meets the framework outlined by BGTA and therefore worked under the assumption that math anxiety would have similar characteristics to other anxiety-based disorders, specifically performance anxiety. The consistency between math anxiety and BGTA supports the recommendation that math anxiety should be viewed as a mental health issue.

Also, current math anxiety research consists of short and disjointed studies (Luttenberger et al., 2018). If math anxiety is viewed as a subset of performance anxiety this could encourage a clinometric framework to be established/repurposed (this study suggests BGTA). This framework could then be applied to math anxiety research which would allow for a better description of the phenomenon, new rating scales, and severity indexes that can also help measure clinically backed intervention strategies (this study suggests CBT) which can be agreed upon by researchers and practitioners (Luttenberger et al., 2018).

Viewing math anxiety as a mental health issue could also change how its addressed in the workplace. The SDS and the open-ended responses in this study highlighted work as the area of greatest functional impairment, with the open-ended responses more specifically highlighting that the anxiety is performance based, and typically occurs when the individual has to do mental math. If math anxiety is viewed as a mental health issue, and therefore a disability, then workplaces would be legally required to accommodate these individuals (Lepofsky, 2020). While the accommodations may not provide a cure for math anxiety, they may mitigate the impacts of the symptoms while at work. However, sometimes accommodations do not suffice, and it is important to have an appropriate intervention strategy.

Using CBT to treat math anxiety has been discussed previously, however it is important that these strategies and tools are taught to the public so that they can be used. While this study was focused on the impacts of math anxiety outside of school, school-based supports are still a fantastic place to initially start intervention for mental health issues (Kidger et al., 2016; Ojio et al., 2015; Srikala & Kishore, 2010), in this case math anxiety. An academic setting is still one of the easiest places to first identify math anxiety due to the high level of interaction students have with their teachers as well as academic achievement being one of the most identifiable symptoms of math anxiety (Genshaft & Naglieri, 1987). Therefore, math anxiety-based supports, or training, should be available to students so that they can learn possible strategies and be aware of the supports to help minimize the impact of math anxiety on their daily life, even after leaving the school setting. Due to the simplistic nature of CBT one of its main benefits is the ability for it to be applied without the use of a professional (Fenn & Byrne, 2013). Therefore, teachers, or an external professional, could teach CBT intervention strategies to the class and students would be able to use them on their own. This would be a great way for students to be provided the tools to not only mitigate the impacts of math anxiety but also any other mental health disorders they may be struggling with.

By more openly discussing mental health and educating the class on intervention strategies via CBT, it will also lead to destigmatization (Srikala & Kishore, 2010). The stigma surrounding mental health issues is one of the many reasons why individuals do not seek support

(Corrigan, 2004; Corrigan et al., 2014; Gary, 2005; Ojio et al., 2015). But offering specific training and encouraging more open dialogue on mental health has been shown to reduce this stigma (Ojio et al., 2015). If the stigma in schools was decreased and students were better educated on mental health, and particularly math anxiety, this could lead to more students openly discussing their struggles, which will help them receive the necessary support they need to be successful and thrive (Ojio et al., 2015).

Unfortunately, there is a negative side or unintended consequence to consider. Current research has highlighted that including a mental health issue in the DSM can lead to public-stigma, self-stigma and active label avoidance (Ben-Zeev et al., 2010). Therefore, to minimize this potential increase in stigma, clinicians could avoid specifically highlighting math anxiety as a separate issue in the DSM and instead treat it as they would treat performance anxiety, where the performing is math-based tasks. While this may still result in some increased stigma, it would allow for the benefits of viewing math anxiety as a mental health issue while hopefully mitigating some of the negatives.

Therefore, in future practice math anxiety should be viewed similar to other mental health issues and rely on the BGTA framework with intervention strategies based around CBT. This shift in perception can start in the classroom by normalizing math anxiety, educating students on the supports available to them, and teaching them intervention strategies. This shift will also change the workplace, if math anxiety is a mental health issue then it would be deemed a disability and workplaces would be required to accommodate (Branch, 2022). This support, and awareness of the issue, can lead to less functional impairment in the workplace along with decreased stigma. By decreasing the stigma surrounding math anxiety individuals will also be more likely to seek help and by viewing math anxiety as a mental health issue individuals can use a similar, and familiar, support system as other mental health issues to get help.

Conclusion

The purpose of this chapter was to discuss the findings from this embedded mixed-methods correlational study conducted at Brock University to analyze the relationship between math anxiety and HRQOL and/or functional impairment. It considered whether or not the AMAS was a significant negative predictor for the SF-36 and if the AMAS was a significant positive predictor for the SDS. It was found that the AMAS is a significant negative predictor for the general SF-36 score ($r(113) = -.470$; $p < .001$) and ($B = 9.631$, $p < .001$) and a significant positive predictor for the SDS ($r(113) = .691$; $p < .001$) and ($B = 45.493$, $p < .001$). Therefore, math anxiety can be deemed a significant negative predictor for HRQOL and a significant positive predictor for functional impairment. These findings were further supported by the open-ended responses.

In this chapter, it was recommended for practice, based on the findings of the present study, that math anxiety be treated as a mental health issue. By viewing math anxiety as a mental health issue, specifically as performance anxiety, CBT could then be used as an intervention strategy which can be provided in schools, the workplace, or to the general public via therapists. Moving forward researchers should next look to see if the findings can be replicated: in a non-pandemic lockdown setting and with a larger, and more diverse, sample population. Research should also be focused on what the best categories to measure impacts on daily life are and what measurement tools are best. This study chose HRQOL and functional impairment for the first and SF-36 and SDS for the second.

It is essential that moving forwards math anxiety is treated as performance anxiety and the appropriate resources are in place to support this mental health disorder. By showing that math anxiety does indeed impair individuals in everyday life, and not just academics, and linking it to the quality of their life, this study has started the process to broaden the scope of the conversation and research so that more complete and impactful improvements can be made in individuals' lives. As the acceptance of math anxiety as a mental disorder increase the priorities can change from researching causation and effect to more heavily targeting intervention and support strategies. It is imperative that individuals struggling with math anxiety are supported so that they can achieve their full potential and be provided with resources and strategies to help manage (or mitigate) their math anxiety.

References

Aderka, H. (2012). Functional impairment in social anxiety disorder. *Journal of Anxiety Disorders*, *26*(3), 393–400. https://doi.org/10.1016/j.janxdis.2012.01.003

Ahmed, W. (2018). Developmental trajectories of math anxiety during adolescence: Associations with STEM career choice. *Journal of Adolescence*, *67*(1), 158–166. https://doi.org/10.1016/j.adolescence.2018.06.010

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). https://doi.org/10.1176/appi.books.9780890425596

American Psychological Association. (2020). Emotional response. In *APA dictionary of psychology*. https://dictionary.apa.org/emotional-response

Anderson, L. W., Krathwohl, D. R., Airasian, P. W., Cruikshank, K. A., Mayer, R. E., Pintrich, P. R., Raths, J., & Wittrock, M. C. (Eds.). (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives*. Longman.

Andrews, M. (1980). Measures of self-reported well-being: Their affective, cognitive, and other components. *Social Indicators Research*, *8*(2), 127–155. https://doi.org/10.1007/BF00286474

Arbuckle, R., Frye, M. A., Brecher, M., Paulsson, B., Rajagopalan, K., Palmer, S., & Innocenti, A. D. (2009). The psychometric validation of the Sheehan Disability Scale (SDS) in patients with bipolar disorder. *Psychiatry Research*, *165*(1–2), 163–174. https://doi.org/10.1016/j.psychres.2007.11.018

Artemenko, C., Daroczy, G., & Nuerk, H. (2015). Neural correlates of math anxiety – an overview and implications. *Frontiers in Psychology*, *6*, Article 1333. https://doi.org/10.3389/fpsyg.2015.01333

Asanjarani, F., & Zarebahramabadi, M. (2021). Evaluating the effectiveness of cognitive behavioral therapy on math self-concept and math anxiety of elementary school students. *Preventing School Failure*, *65*(3), 223–229. https://doi.org/10.1080/1045988X.2021.1888685

Ashcraft, M. H. (2002). Math anxiety: Personal, educational, and cognitive consequences. *Current Directions in Psychological Science*, *11*(5), 181–185. https://doi.org/10.1111/1467-8721.00196

Ashcraft, M. H., Krause, J. A., & Hopko, D. R. (2007). Is math anxiety a mathematical learning disability? In D. B. Berch & M. M. M. Mazzocco (Eds.), *Why is math so hard for some children? The nature and origins of mathematical learning difficulties and disabilities* (p. 329–348). Paul H. Brookes.

Auerbach, J. G., Gross-Tsur, V., Manor, O., & Shalev, R. S. (2008). Emotional and Behavioral Characteristics Over a Six-Year Period in Youths With Persistent and Nonpersistent Dyscalculia. Journal of Learning Disabilities, 41(3), 263–273. https://doi.org/10.1177/0022219408315637

Baladón, R. (2016). Gender differences in the impact of mental disorders and chronic physical conditions on health-related quality of life among non-demented primary care elderly patients. *Quality of Life Research*, *25*(6), 1461–1474. https://doi.org/10.1007/s11136-0151182-5

Balázs, J., Miklósi, M., Keresztény, A., Hoven, C. W., Carli, V., Wasserman, C., Apter, A., Bobes, J., Brunner, R., Cosman, D., Cotter, P., Haring, C., Iosue, M., Kaess, M., Kahn, J-P., Keeley, H., Marusic, D., Postuvan, V., Resch, F., … Wasserman, D. (2013). Adolescent subthreshold-depression and anxiety: psychopathology, functional impairment and increased suicide risk. *Journal of Child Psychology and Psychiatry*, *54*(6), 670–677. https://doi.org/10.1111/jcpp.12016

Barrera, N. (2009). Quality of life impairment in generalized anxiety disorder, social phobia, and panic disorder. *Journal of Anxiety Disorders*, *23*(8), 1086–1090. https://doi.org/10.1016/j.janxdis.2009.07.011

Beck, H. (2014). Advances in cognitive theory and therapy: The generic cognitive model. *Annual Review of Clinical Psychology*, *10*(1), 1–24. https://doi.org/10.1146/annurev-clinpsy-032813-153734

Beilock, S., Gunderson, E., Ramirez, G., & Levine, S. (2010). Female teachers' math anxiety affects girls' math achievement. *Proceedings of the National Academy of Sciences*, *107*(5), 1860–1863. https://doi.org/10.1073/pnas.0910967107

Ben-Zeev, D., Young, M. A., & Corrigan, P. W. (2010). DSM-V and the stigma of mental illness. *Journal of Mental Health*, *19*(4), 318–327. https://doi.org/10.3109/09638237.2010.492484

Betz, N. E. (1978). Prevalence, distribution, and correlates of math anxiety in college students. *Journal of Counseling Psychology*, *25*(5), 441–448. https://doi.org/10.1037/0022-0167.25.5.441

Bloom, B. S., & Broder, L. J. (1950). Problem-solving processes of college students. *Journal of Consulting Psychology*, *14*(6), 503–503. https://doi.org/10.1037/h0051062

Bobes, C. (2011). Disability and health-related quality of life in outpatients with generalised anxiety disorder treated in psychiatric clinics: Is there still room for improvement? *Annals of General Psychiatry*, *10*(1), Article 7. https://doi.org/10.1186/1744-859X-10-7

Booth, B. (1998). Functional impairment and co-occurring psychiatric disorders in medically hospitalized men. *Archives of Internal Medicine*, *158*(14), 1551–1559. https://doi.org/10.1001/archinte.158.14.1551

Brazier, J. E., Harper, R., Jones, N. M., O'Cathain, A., Thomas, K. J., Usherwood, T., & Westlake, L. (1992). Validating the SF-36 health survey questionnaire: New outcome measure for primary care. *BMJ, 305*(6846), 160–164. https://doi.org/10.1136/bmj.305.6846.160

Brown, J. L., Ortiz-Padilla, M., & Soto-Varela, R. (2020). Does mathematical anxiety differ cross-culturally? *Journal of New Approaches in Educational Research, 9*(1), 126–136. https://doi.org/10.7821/naer.2020.1.464

Buckner, T. W., Batt, K., Quon, D., Witkop, M., Recht, M., Kessler, C., Baumann, K., Hernandez, G., Wang, M., Cooper, D. L., & Kempton, C. L. (2018). Assessments of pain, functional impairment, anxiety, and depression in US adults with hemophilia across patient-reported outcome instruments in the Pain, Functional Impairment, and Quality of Life (P-FiQ) study. *European Journal of Haematology*, *100*(S1), 5–13. https://doi.org/10.1111/ejh.13027

Campbell, A. (1976). Subjective measures of well-being. *American Psychologist, 31(2), 117-124.* https://doi.org/10.1037/0003-066X.31.2.117

Cargnelutti, E., Tomasetto, C., & Passolunghi, M. C. (2017). The interplay between affective and cognitive factors in shaping early proficiency in mathematics. *Trends in Neuroscience and Education, 8–9,* 28–36. https://doi.org/10.1016/j.tine.2017.10.002

Casad, B., Hale, P., & Wachs, F. (2015). Parent-child math anxiety and math-gender stereotypes predict adolescents' math education outcomes. *Frontiers in Psychology*, *6*, Article 1597. https://doi.org/10.3389/fpsyg.2015.01597

Cella, D. (1995). Methods and problems in measuring quality of life. *Supportive Care in Cancer*, *3*(1), 11–22. https://doi.org/10.1007/BF00343916

Çiftçi, S. K. (2015). Effects of secondary school students' perceptions of mathematics education quality on mathematics anxiety and achievement. *Educational Sciences: Theory and Practice*, *15*(6), 1487–1501. https://doi.org/10.12738/estp.2015.6.2829

Cobb, P., Yackel, E., & Wood, T. (1989). Young children's emotional acts while engaged in mathematical problem solving. In D. B. McLeod & V. M. Adams (Eds.), *Affect and mathematical problem solving* (pp. 117–148). Springer. https://doi.org/10.1007/978-1-4612-3614-6_9

Coles, C. (2014). Psychometric evaluation of the Sheehan Disability Scale in adult patients with attention-deficit/hyperactivity disorder. *Neuropsychiatric Disease and Treatment*, *10*, 887–895. https://doi.org/10.2147/NDT.S55220

Coons, S. J., Rao, S., Keininger, D. L., & Hays, R. D. (2000). A comparative review of generic quality-of-life instruments. *PharmacoEconomics*, *17*(1), 13–35. https://doi.org/10.2165/00019053-200017010-00002

Corrigan, P. (2004). How stigma interferes with mental health care. *American Psychologist*, *59*(7), 614–625. https://doi.org/10.1037/0003-066x.59.7.614

Corrigan, P. W., Druss, B. G., & Perlick, D. A. (2014). The impact of mental illness stigma on seeking and participating in mental health care. *Psychological Science in the Public Interest*, *15*(2), 37–70. https://doi.org/10.1177/1529100614531398

Creswell, J. W. (2016). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research* (5th ed.). Pearson.

Daches Cohen, L., Korem, N., & Rubinsten, O. (2021). Math anxiety is related to math difficulties and composed of emotion regulation and anxiety predisposition: A network analysis study. *Brain Sciences*, *11*(12), Article 1609. https://doi.org/10.3390/brainsci11121609

De Waal, M. W. M., Arnold, I. A., Eekhof, J. A. H., & Van Hemert, A. M. (2004). Somatoform disorders in general practice: Prevalence, functional impairment and comorbidity with anxiety and depressive disorders. *British Journal of Psychiatry*, *184*(6), 470–476. https://doi.org/10.1192/bjp.184.6.470

Dossey, J. A., Mullis, I. V. S., Lingquist, M. M., & Chambers, D. L. (1988). *The mathematics report card: Are we measuring up? Trends and achievements based on the 1986 national assessment*. Educational Testing Service. https://eric.ed.gov/?id=ED300206

Dreger, R., & Aiken, L. (1957). The identification of number anxiety in a college population. *Journal of Educational Psychology*, *48*(6), 344–351. https://doi.org/10.1037/h0045894

Dryman, G. (2015). Social anxiety disorder and quality of life: How fears of negative and positive evaluation relate to specific domains of life satisfaction. *Journal of Anxiety Disorders*, *38*, 1–8. https://doi.org/10.1016/j.janxdis.2015.12.003

Emerson, R. (2015). Convenience sampling, random sampling, and snowball sampling: How does sampling affect the validity of research? *Journal of Visual Impairment & Blindness*, *109*(2), 164–168. https://doi.org/10.1177/0145482X1510900215

Espinoza, P., Arêas da Luz Fontes, A. B., & Arms-Chavez, C. J. (2013). Attributional gender bias: Teachers' ability and effort explanations for students' math performance. *Social Psychology of Education*, *17*(1), 105–126. https://doi.org/10.1007/s11218-013-9226-6

Felce, D. (1997). Defining and applying the concept of quality of life. *Journal of Intellectual Disability Research*, *41*(2), 126–135. https://doi.org/10.1111/j.1365-2788.1997.tb00689.x

Fenn, K., & Byrne, M. (2013). The key principles of cognitive behavioural therapy. *InnovAiT: Education and Inspiration for General Practice*, *6*(9), 579–585. https://doi.org/10.1177/1755738012471029

Fennema, E. (1989). The study of affect and mathematics: A proposed generic model for research. In D. B. McLeod & V. M. Adams (Eds.), *Affect and mathematical problem solving* (pp. 205–219). Springer. https://doi.org/10.1007/978-1-4612-3614-6_14

Garofalo, J. (1989). Beliefs, responses, and mathematics education: Observations from the back of the classroom. *School Science and Mathematics*, *89*(6), 451–455. https://doi.org/10.1111/j.1949-8594.1989.tb11947.x

Gary, F. A. (2005). Stigma: Barrier to mental health care among ethnic minorities. *Issues in Mental Health Nursing*, *26*(10), 979–999. https://doi.org/10.1080/01612840500280638

Genshaft, J., & Naglieri, J. (1987). *A mindset for math: Techniques for identifying and working with math-anxious girls*. Ohio State University. https://files.eric.ed.gov/fulltext/ED293691.pdf

Georges, C., Hoffmann, D., & Schiltz, C. (2016). How math anxiety relates to number-space associations. *Frontiers in Psychology*, *7*, Article 1401. https://doi.org/10.3389%2Ffpsyg.2016.01401

Gill, T. (1994). A critical appraisal of the quality of quality-of-life measurements. *JAMA*, *272*(8), 619–626. https://doi.org/10.1001/jama.272.8.619

Gough, M. F. (1954). Why failures in mathematics? Mathemaphobia: Causes and treatments. *The Clearing House*, *28*(5), 290–294. https://doi.org/10.1080/00098655.1954.11476830

Government of Canada. (2021, June 2). *Symptoms of anxiety and depression during the COVID-19 pandemic*. https://www.canada.ca/en/public-health/services/publications/diseases-conditions/symptoms-anxiety-depression-covid-19-pandemic.html

Gray, S.A.O. (2013). Maladaptive behavior. In F. R. Volkmar (Ed.), Encyclopedia of autism spectrum disorders. Springer. https://doi.org/10.1007/978-1-4419-1698-3_239

Greenwood, J. (1984). SoundOFF: My anxieties about math anxiety. *The Mathematics Teacher*, *77*(9), 662–663. https://doi.org/10.5951/mt.77.9.0662

Grouws, D. A., & Cramer, K. (1989). Teaching practices and student affect in problem-solving lessons of select junior-high mathematics teachers. In D. B. McLeod & V. M. Adams (Eds.), *Affect and mathematical problem solving* (pp. 149–161). Springer. https://doi.org/10.1007/978-1-4612-3614-6_10

Hair, J. F. (1998). Multivariate data analysis. Upper Saddle River, N.J: Prentice Hall.

Heinig, I., Pittig, A., Richter, J., Hummel, K., Alt, I., Dickhöver, K., Gamer, J., Hollandt, M., Koelkebeck, K., Maenz, A., Tennie, S., Totzeck, C., Yang, Y., Arolt, V., Deckert, J., Domschke, K., Fydrich, T., Hamm, A., Hoyer, J., … Wittchen, H.-U. (2017). Optimizing exposure-based CBT for anxiety disorders via enhanced extinction: Design and methods of a multicentre randomized clinical trial. *International Journal of Methods in Psychiatric Research*, *26*(2), Article e1560. https://doi.org/10.1002/mpr.1560

Hembree, R. (1990). The nature, effects, and relief of mathematics anxiety. *Journal for Research in Mathematics Education*, *21*(1), 33–46. https://doi.org/10.2307/749455

Hodgins, D. (2013). Reliability and validity of the Sheehan Disability Scale modified for pathological gambling. *BMC Psychiatry*, *13*(1), 177–177. https://doi.org/10.1186/1471-244X-13-177

Hollander, S. (2010). Quality of life outcomes in patients with obsessive-compulsive disorder: Relationship to treatment response and symptom relapse. *The Journal of Clinical Psychiatry*, *71*(6), 784–792. https://doi.org/10.4088/JCP.09m05911blu

Hopko, M. (2003). The Abbreviated Math Anxiety Scale (AMAS): Construction, validity, and reliability. *Assessment*, *10*(2), 178–182. https://doi.org/10.1177/1073191103010002008

Huang, X., Zhang, J., & Hudson, L. (2018). Impact of math self-efficacy, math anxiety, and growth mindset on math and science career interest for middle school students: The gender moderating effect. *European Journal of Psychology of Education*, *34*(3), 621–640. https://doi.org/10.1007/s10212-018-0403-z

Huppert, J. D., Simpson, H. B., Nissenson, K. J., Liebowitz, M. R., & Foa, E. B. (2009). Quality of life and functional impairment in obsessive-compulsive disorder: A comparison of patients with and without comorbidity, patients in remission, and healthy controls. *Depression and Anxiety*, *26*(1), 39–45. https://doi.org/10.1002/da.20506

Jameson, M., & Fusco, B. (2014). Math anxiety, math self-concept, and math self-efficacy in adult learners compared to traditional undergraduate students. *Adult Education Quarterly*, *64*(4), 306–322. https://doi.org/10.1177/0741713614541461

Janakiram, M. (Producer). (2017, September 14). *How anxiety around math hurts student performance* [Audio podcast episode]. CBC Radio. https://www.cbc.ca/radio/thecurrent/the-current-for-september-142017-1.4287712/how-anxiety-around-math-hurts-student-performance-1.4287941

Jansen, B., Louwerse, J., Straatemeier, M., Van der Ven, S., Klinkenberg, S., & Van der Maas, H. (2013). The influence of experiencing success in math on math anxiety, perceived math competence, and math performance. *Learning and Individual Differences*, *24*, 190–197. https://doi.org/10.1016/j.lindif.2012.12.014

Justicia, G. M. J., Martín, P. M. E., Linares, R., & Pelegrina, S. (2017). Math anxiety and math performance in children: The mediating roles of working memory and math self-concept.

British Journal of Educational Psychology, *87*(4), 573–589. https://doi.org/10.1111/bjep.12165

Kaskens, J., Segers, E., Goei, S., van Luit, J., & Verhoeven, L. (2020). Impact of children's math self-concept, math self-efficacy, math anxiety, and teacher competencies on math development. *Teaching and Teacher Education*, *94*, Article 103096. https://doi.org/10.1016/j.tate.2020.103096

Katschnig, H. (1997). How useful is the concept of quality of life in psychiatry? *Current Opinion in Psychiatry*, *10*(5), 337–345. https://doi.org/10.1097/00001504-199709000-00001

Kauffman, J. M., & Landrum, T. J. (2018). *Characteristics of emotional and behavioral disorders of children and youth*. Pearson.

Kessler, C., Chiu, W. T., Demler, O., & Walters, E. E. (2005). Prevalence, severity, and comorbidity of twelve-month DSM-IV disorders in the National Comorbidity Survey Replication (NCS-R). *Archives of General Psychiatry*, *62*(6), 617–627. https://doi.org/10.1001/archpsyc.62.6.617

Kidger, J., Stone, T., Tilling, K., Brockman, R., Campbell, R., Ford, T., Hollingworth, W., King, M., Araya, R., & Gunnell, D. (2016). A pilot cluster randomised controlled trial of a support and training intervention to improve the mental health of secondary school teachers and students—The WISE (Wellbeing in Secondary Education) study. *BMC Public Health*, *16*(1), Article 1060. https://doi.org/10.1186/s12889-016-3737-y

Klados, M., Simos, P., Micheloyannis, S., Margulies, D., & Bamidis, P. (2015). ERP measures of math anxiety: How math anxiety affects working memory and mental calculation tasks? *Frontiers in Behavioral Neuroscience*, *9*, Article 282. https://doi.org/10.3389/fnbeh.2015.00282

Leder, G.C. (1987). Attitudes towards mathematics. In T. A. Romberg & D. M. Stewart (Eds.), *The monitoring of school mathematics* (Vol 2., pp. 261–277). Wisconsin Center for Education Research. https://files.eric.ed.gov/fulltext/ED289709.pdf#page=264

Leon, O. (1997). Assessing psychiatric impairment in primary care with the Sheehan Disability Scale. *International Journal of Psychiatry in Medicine*, *27*(2), 93–105. https://doi.org/10.2190/T8EM-C8YH-373N-1UWD

Lepofsky, D. (2020). Ontario’s Human Rights Tribunal Bungles the School Boards’ Human Rights Duty to Accommodate Students with Disabilities - J.F. v. Waterloo Catholic District School Board - An Erroneous Rejection of a Student’s Request to Bring His Autism Service Dog to School. National Journal of Constitutional Law, 40(1), 37–66.

Liau, A., Barriga, A., & Gibbs, J. (1998). Relations between self-serving cognitive distortions and overt vs. covert antisocial behavior in adolescents. *Aggressive Behavior*, *24*(5), 335–346. https://doi.org/10.1002/(SICI)1098-2337(1998)24:5<335::AID-AB1>3.0.CO;2G

Liljedahl, P. (2016). Building thinking classrooms: Conditions for problem-solving. In P. Felmer, E. Pehkonen, & J. Kilpatrick (Eds.), *Posing and solving mathematical problems* (pp. 361–386). Springer. https://doi.org/10.1007/978-3-319-28023-3_21

Löwe, B., Spitzer, R. L., Williams, J. B. W., Mussell, M., Schellberg, D., & Kroenke, K. (2008). Depression, anxiety and somatization in primary care: Syndrome overlap and functional impairment. *General Hospital Psychiatry*, *30*(3), 191–199. https://doi.org/10.1016/j.genhosppsych.2008.01.001

Luttenberger, S., Wimmer, S., & Paechter, M. (2018). Spotlight on math anxiety. *Psychology Research and Behavior Management*, *11*, 311–322. https://doi.org/10.2147/prbm.s141421

Lyons, I., & Beilock, S. (2012). When math hurts: Math anxiety predicts pain network activation in anticipation of doing math. *PLOS ONE*, *7*(10), Article e48076. https://doi.org/10.1371/journal.pone.0048076

Maloney, B. (2012). Erratum: Math anxiety: Who has it, why it develops, and how to guard against it. *Trends in Cognitive Sciences*, *16*(10), 526–526. https://doi.org/10.1016/j.tics.2012.08.011

Maloney, E., Ramirez, G., Gunderson, E., Levine, S., & Beilock, S. (2015). Intergenerational effects of parents' math anxiety on children's math achievement and anxiety. *Psychological Science*, *26*(9), 1480–1488. https://doi.org/10.1177/0956797615592630

Mandler, G. (1975). *Mind and emotion*. Krieger.

Mandler, G. (1984). *Mind and body: Psychology of emotion and stress*. Norton.

Marshall, E., Mann. V., & Wilson, D. (2016). Maths anxiety: A collaboration. *ADSHE 2016 Conference Proceedings*. https://tinyurl.com/2p892ybv

McKnight, M. (2016). Anxiety symptoms and functional impairment: A systematic review of the correlation between the two measures. *Clinical Psychology Review*, *45*, 115–130. https://doi.org/10.1016/j.cpr.2015.10.005

McKnight, C., Crosswhite, F. J., Dossey, J. A., Kifer, E., Swafford, J. O., Travers, K. J., & Cooney, T. J. (1987). *The underachieving curriculum: Assessing U.S. school mathematics from an international perspective*. Stipes. https://files.eric.ed.gov/fulltext/ED297930.pdf

McLeod, D. B. (1992). Research on affect in mathematics education: A reconceptualization. In D. A. Grows (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 575–596). Macmillan.

Moravcsik, A. (2014). Transparency: The revolution in qualitative research. *PS: Political Science & Politics*, *47*(1), 48–53. https://doi.org/10.1017/S1049096513001789

Muijs, D. (2011). *Doing quantitative research in education with SPSS* (2nd ed.). SAGE.

Necka, E., Sokolowski, H., & Lyons, I. (2015). The role of self-math overlap in understanding math anxiety and the relation between math anxiety and performance. *Frontiers in Psychology*, *6*, Article 1543. https://doi.org/10.3389/fpsyg.2015.01543

Nielsen, M. K., Christensen, K. S. Neergaard, M. A., Bidstrup, P. E., & Guldin, M. -B. (2020). Exploring Functional Impairment in Light of Prolonged Grief Disorder: A Prospective, Population-Based Cohort Study. *Frontiers in Psychiatry, 11, 537674-537674.* https://doi.org/10.3389/fpsyt.2020.537674

Noval, B. L. (2016). Chapter 8: The history of the idea of quality of life. *Elgar Online: The online content platform for Edward Elgar Publishing.* https://www.elgaronline.com/view/edcoll/9781783471164/9781783471164.00013.xml

Núñez-Peña, M., Suárez-Pellicioni, M., & Bono, R. (2013). Effects of math anxiety on student success in higher education. *International Journal of Educational Research*, *58,* 36–43. https://doi.org/10.1016/j.ijer.2012.12.004

Ojio, Y., Yonehara, H., Taneichi, S., Yamasaki, S., Ando, S., Togo, F., Nishida, A., & Sasaki, T. (2015). Effects of school-based mental health literacy education for secondary school students to be delivered by school teachers: A preliminary study. *Psychiatry and Clinical Neurosciences*, *69*(9), 572–579. https://doi.org/10.1111/pcn.12320

Pallant, J. (2001). SPSS survival manual : a step by step guide to data analysis using SPSS for Windows (Version 10). Buckingham: Open University Press.

Parsons, J. E., Adler, T. F., & Kaczala, C. M. (1982). Socialization of achievement attitudes and beliefs: Parental influences. *Child Development*, *53*(2), 310–321. https://doi.org/10.2307/1128973

Post, T. R. (1992). *Teaching mathematics in grades K-8: research-based methods*. Allyn & Bacon.

Raphael, B. (1996). Assessing the quality of life of persons with developmental disabilities: Description of a new model, measuring instruments, and initial findings. *International Journal of Disability, Development, and Education*, *43*(1), 25–42. https://doi.org/10.1080/0156655960430103

Rapaport, M. H., Clary, C., Fayyad, R., & Endicott, J. (2005). Quality-of-life impairment in depressive and anxiety disorders. The American Journal of Psychiatry, *162*(6), 1171–1178. https://doi.org/10.1176/appi.ajp.162.6.1171

Reid, M., Reid, S., & Hewitt, J. (2018). Nervous about numbers, math content knowledge and math anxiety of teacher candidates. *The MT Review*. https://mtrj.library.utoronto.ca/index.php/mtrj/article/view/29216

Reyes, L. H. (1984). Affective variables and mathematics education. *The Elementary School Journal*, *84*(5), 558–581. https://doi.org/10.1086/461384

Richardson, F. C., & Suinn, R. M. (1972). The Mathematics Anxiety Rating Scale: Psychometric data. *Journal of Counseling Psychology*, *19*(6), 551–554. https://doi.org/10.1037/h0033456

Romera, M. (2011). Functional impairment related to painful physical symptoms in patients with generalized anxiety disorder with or without comorbid major depressive disorder: Post hoc analysis of a cross-sectional study. *BMC Psychiatry*, *11*(1), 69–69. https://doi.org/10.1186/1471-244X-11-69

Rubinsten, O., Eidlin, H., Wohl, H., & Akibli, O. (2015). Attentional bias in math anxiety. *Frontiers in Psychology*, *6*, Article 1539. https://doi.org/10.3389/fpsyg.2015.01539

Saarni, S. (2007). Impact of psychiatric disorders on health-related quality of life: General population survey. *British Journal of Psychiatry*, *190*(4), 326–332. https://doi.org/10.1192/bjp.bp.106.025106

Salza, A., Giusti, L., Ussorio, D., Casacchia, M., & Roncone, R. (2020). Cognitive behavioral therapy (CBT) anxiety management and reasoning bias modification in young adults with anxiety disorders: A real-world study of a therapist-assisted computerized (TACCBT) program vs. “person-to-person” group CBT. *Internet Interventions*, *19*, Article 100305. https://doi.org/10.1016/j.invent.2020.100305

Schachter, S., & Singer, J. (1963). “Cognitive, social, and physiological determinants of emotional state”: Erratum. *Psychological Review*, *70*(1), 121–122. https://doi.org/10.1037/h0038845

Schillinger, F., Vogel, S., Diedrich, J., & Grabner, R. (2018). Math anxiety, intelligence, and performance in mathematics: Insights from the German adaptation of the Abbreviated Math Anxiety Scale (AMAS-G). *Learning and Individual Differences*, *61*, 109–119. https://doi.org/10.1016/j.lindif.2017.11.014

Schmitz, E. A., Jansen, B. R. J., Wiers, R. W., & Salemink, E. (2019). Do implicitly measured math–anxiety associations play a role in math behavior? *Journal of Experimental Child Psychology*, *186*, 171–188. https://doi.org/10.1016/j.jecp.2019.05.013

Schneier, F. R., Heckelman, L. R., Garfinkel, R., Campeas, R., Fallon, B. A., Gitow, A., Street, L., Del Bene, D., & Liebowitz, M. R. (1994). Functional impairment in socialphobia. *The Journal of Clinical Psychiatry*, *55*(8), 322–331.

Shalev, R. S., Auerbach, J., & Gross-Tsur, V. (1995). Developmental Dyscalculia Behavioral and Attentional Aspects: A Research Note. Journal of Child Psychology and Psychiatry, 36(7), 1261–1268. https://doi.org/10.1111/j.1469-7610.1995.tb01369.x

Shalev, R., Auerbach, J., Manor, O., & Gross-Tsur. (2000). Developmental dyscalculia: prevalence and prognosis. European Child & Adolescent Psychiatry, 9(1), 58–64. https://doi.org/10.1007/s007870070009

Simon, H. A. (1967). Motivational and emotional controls of cognition. *Psychological Review*, *74*(1), 29–39. https://doi.org/10.1037/h0024127

Simon, N. M., Otto, M. W., Korbly, N. B., Peters, P. M., Nicolaou, D. C., & Pollack, M. H. (2002). Quality of life in social anxiety disorder compared with panic disorder and the general population. *Psychiatric Services*, *53*(6), 714–718. https://doi.org/10.1176/appi.ps.53.6.714

Skevington, S. M., Lotfy, M., & O'Connell, K. A. (2004). The World Health Organization's WHOQOL-BREF quality of life assessment: Psychometric properties and results of the international field trial. A Report from the WHOQOL Group. *Quality of Life Research*, *13*(2), 299–310. https://doi.org/10.1023/b:qure.0000018486.91360.00

Soni, A., & Kumari, S. (2015). The role of parental math anxiety and math attitude in their children's math achievement. *International Journal of Science and Mathematics Education*, *15*(2), 331–347. https://doi.org/10.1007/s10763-015-9687-5

Sousa, D. A. (2017). *How the brain learns* (5th ed.). Corwin.

Srikala, B., & Kishore, K. K. V. (2010). Empowering adolescents with life skills education in schools—School mental health program: Does it work? *Indian Journal of Psychiatry*, *52*(4), 344–349. https://doi.org/10.4103/0019-5545.74310

Stefan, S., Cristea, I. A., Szentagotai Tatar, A., & David, D. (2019). Cognitive-behavioral therapy (CBT) for generalized anxiety disorder: Contrasting various CBT approaches in a randomized clinical trial. *Journal of Clinical Psychology*, *75*(7), 1188–1202. https://doi.org/10.1002/jclp.22779

Stein, R. E., & Jessop, D. J. (1990). Functional Status II(R). *Medical Care*, *28*(11), 1041–1055. https://doi.org/10.1097/00005650-199011000-00006

Tabachnick, B. G., & Fidell, L. S. (2001). *Using multivariate statistics* (4th ed.). Pearson.

Tuval-Mashiach, R. (2017). Raising the curtain: The importance of transparency in qualitative research. *Qualitative Psychology*, *4*(2), 126–138. https://doi.org/10.1037/qup0000062

Ustün, K. (2009). What is “functional impairment”? Disentangling disability from clinical significance. *World Psychiatry*, *8*(2), 82–85. https://doi.org/10.1002%2Fj.2051-5545.2009.tb00219.x

Wall, K. (2019, May 2). *Persistence and representation of women in STEM programs*. Statistics Canada. https://www150.statcan.gc.ca/n1/pub/75-006-x/2019001/article/00006-eng.html

Ware, S., & Sherbourne, C. (1992). The MOS 36-item short-form health survey (SF-36): I. Conceptual framework and item selection. *Medical Care*, *30*(6), 473–483. https://www.jstor.org/stable/3765916

Wedig, N. (2009). The functional assessment of maladaptive behaviors: A preliminary evaluation of binge eating and purging among women. *Psychiatry Research*, *178*(3), 518–524. https://doi.org/10.1016/j.psychres.2009.05.010

White, J. L., Moffitt, T. E., & Silva, P. A. (1992). Neuropsychological and socio-emotional correlates of specific-arithmetic disability. *Archives of clinical neuropsychology: the official journal of the National Academy of Neuropsychologists*, *7*(1), 1–16.

Xie, F., Xin, Z., Chen, X., & Zhang, L. (2019). Gender difference of Chinese high school students' math anxiety: The effects of self-esteem, test anxiety and general anxiety. *Sex Roles, 81*(3), 235–244. https://doi.org/10.1007/s11199-018-0982-9

Yockey, R. D. (2018). SPSS demystified : a simple guide and reference (Third edition.). New York, NY: Routledge.

Zagorski, N. (2014). CBT may be best treatment for social anxiety disorder, study finds. *Psychiatric News, 49*(21). https://doi.org/10.1176/appi.pn.2014.11a24

Zhang, Z. (2019). The relationship between math anxiety and math performance: A meta analytic investigation. *Frontiers in Psychology*, *10*, Article 1613. https://doi.org/10.3389/fpsyg.2019.01613

Appendix A

Letter of Invitation

Hi I am reaching out to any Brock University students who believe they experience math anxiety. My name is Owen Harris and I am currently a Master's of Education student at Brock University working on my Thesis which looks at the impacts math anxiety has on health related quality of life and functional impairment.

To participate you must be:

- A current Brock University student
- Able to access the internet to complete an online survey

Survey

If you meet this criteria then you are invited to participate in the study. In order to participate please complete the anonymous online survey which can be found at the link provided below. Please ensure you read the full consent form prior to starting the survey as you will be unable to relinquish consent once the survey results have been submitted, due to the anonymous nature. The survey is expected to take approximately 20 minutes to complete. The study will look at your math anxiety and how it relates to your perception of Health Related Quality of Life and any functional impairment you experience due to your symptoms.

Please feel free to contact me if you have any questions or would like more information about my research study.

Owen Harris
Primary Student Investigator
(905) 325 – 0063
oh13rm@brocku.ca

Appendix B

Consent Form

Informed Consent

Date: **January 21, 2021**
Project Title: **The Impacts of Math Anxiety on Health Related Quality of Life**

Principal Investigator (PI): **Owen Harris, student**
Faculty of **Education**
Brock University
(905) 325 – 0063 oh13rm@brocku.ca

Faculty Supervisor: **Michael Savage, professor**
Department of **Education**
Brock University
(905) 688-5550 Ext. **6138 msavage@brocku.ca**

INVITATION
You are invited to participate in a study that involves research. The purpose of this study is to identify whether math anxiety impacts an individual's quality of life.

WHAT'S INVOLVED
As a participant, you will be asked to complete an online survey which will consist of some demographic questions and then follow with a math anxiety scale (the AMAS), a health related quality of life scale (the SF-36), a functional impairment scale (the SDS) and some short open ended questions. Participation will take approximately 20 minutes of your time.

POTENTIAL BENEFITS AND RISKS
Possible benefits of participation include the identification of the impacts of math anxiety on daily life. This could increase the awareness of math anxiety and both inform and prioritize future decisions by school boards on how to best support students with math anxiety. There also may be risks associated with participation as reliving anxiety inducing situations may trigger negative emotions.

CONFIDENTIALITY

All information you provide is considered confidential; your name will not be included or, in any other way, associated with the data collected in the study. Furthermore, because our interest is in the average responses of the entire group of participants, you will not be identified individually in any way in written reports of this research.

Data collected during this study will be stored on my personal, password protected computer. All files that contain any participant information will also be individually password protected. Data will be kept for the duration of the study, which is expected to conclude by June 1, 2023 after which time all participant information will be destroyed to ensure confidentiality.

Access to this data will be restricted to myself, Owen Harris, the principal investigator and to my supervisor, Michael Savage.

VOLUNTARY PARTICIPATION

Participation in this study is voluntary. If you wish, you may decline to answer any questions or participate in any component of the study. Further, you may decide to withdraw from this study at any time and may do so without any penalty or loss of benefits to which you are entitled.

PUBLICATION OF RESULTS

Results of this study may be published in professional journals and presented at conferences. Feedback about this study will be available by contacting the principal investigator, Owen Harris, through email (oh13rm@brocku.ca)or by phone (905) 325 – 0063 upon completion of the study. Participants will be contacted upon completion of the study so that they are aware they can provide feedback.

CONTACT INFORMATION AND ETHICS CLEARANCE

If you have any questions about this study or require further information, please contact the principal investigator, Owen Harris, or the supervisor, Michael Savage, using the contact information provided above. This study has been reviewed and received ethics clearance through the Research Ethics Board at Brock University REB: 21-077 SAVAGE. If you have any comments or concerns about your rights as a research participant, please contact the Research Ethics Office at (905) 688-5550 Ext. 3035, reb@brocku.ca.

Thank you for your assistance in this project. Please keep a copy of this form for your records.

CONSENT FORM

I agree to participate in this study described above. I have made this decision based on the information I have read in the Information-Consent Letter. I have had the opportunity to receive any additional details I wanted about the study and understand that I may ask questions in the future. I understand that I may withdraw this consent at any time.

Name: ____

Signature: ____ Date: _________________

Appendix C

Online Survey

Abbreviated Math Anxiety Scale (AMAS) (Copyright © Hopko et al., 2003)

1. Having to use the tables in the back of a math book
    a. Low Anxiety
    b. Low/medium anxiety
    c. Medium anxiety
    d. Medium/high anxiety
    e. High anxiety
2. Thinking about an upcoming math test 1 day before
    a. Low Anxiety
    b. Low/medium anxiety
    c. Medium anxiety
    d. Medium/high anxiety
    e. High anxiety
3. Watching a teacher work an algebraic equation on the blackboard
    a. Low Anxiety
    b. Low/medium anxiety
    c. Medium anxiety
    d. Medium/high anxiety
    e. High anxiety
4. Taking an examination in a math course
    a. Low Anxiety
    b. Low/medium anxiety
    c. Medium anxiety
    d. Medium/high anxiety
    e. High anxiety
5. Being given a homework assignment of many difficult problems that is due the next class meeting
    a. Low Anxiety
    b. Low/medium anxiety
    c. Medium anxiety
    d. Medium/high anxiety
    e. High anxiety
6. Listening to a lecture in math class
    a. Low Anxiety
    b. Low/medium anxiety
    c. Medium anxiety
    d. Medium/high anxiety
    e. High anxiety
7. Listening to another student explain a math formula
    a. Low Anxiety

   b. Low/medium anxiety
   c. Medium anxiety
   d. Medium/high anxiety
   e. High anxiety
8. Being given a “pop” quiz in math class
   a. Low Anxiety
   b. Low/medium anxiety
   c. Medium anxiety
   d. Medium/high anxiety
   e. High anxiety
9. Starting a new chapter in a math book
   a. Low Anxiety
   b. Low/medium anxiety
   c. Medium anxiety
   d. Medium/high anxiety
   e. High anxiety

Open Ended question

10. **Was there any other math based situations in the classroom that caused anxiety? Has online-learning due to the Covid-19 pandemic caused any new anxiety inducing situations?**

Demographic questions

11. Do you believe you struggle with Math Anxiety?
    a. Yes
    b. No
12. What is your gender?
    a. Male
    b. Female
    c. Gender Fluid
    d. Other
    e. Prefer not to share
13. What year of university studies are you in?
    a. 1
    b. 2
    c. 3
    d. 4
    e. 5+
14. What Academic Department are you in?
    a. Science
    b. Social Science
    c. Humanities
    d. Art’s
    e. Business
15. Are you an education student who will be taking the math proficiency test in the future?

   a. Yes
   b. No
16. If you answered yes to the previous question, are you anxious about the math proficiency test?
   a. Very
   b. Medium
   c. Low
   d. Not at all
   e. N/A

36-Item Short Form Health Survey (SF-36) (Copyright © Ware & Sherbourne, 1992)

17. In general, would you say your health is:
   a. Excellent
   b. Very good
   c. Good
   d. Fair
   e. Poor
18. Compared to one year ago, how would you rate your health in general now?
   a. Much better now than one year ago
   b. Somewhat better now than one year ago
   c. About the same
   d. Somewhat worse now than one year ago
   e. Much worse now than one year ago

Questions 15 – 24 are about activities you might do during a typical day. Does your health now limit in these activities? If so how much?

19. Vigorous activities, such as running, lifting heavy objects, participating in strenuous sports
   a. Yes, limited a lot
   b. Yes, limited a little
   c. No, not limited at all
20. Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf
   a. Yes, limited a lot
   b. Yes, limited a little
   c. No, not limited at all
21. Lifting or carrying groceries
   a. Yes, limited a lot
   b. Yes, limited a little
   c. No, not limited at all
22. Climbing several flights of stairs
   a. Yes, limited a lot
   b. Yes, limited a little
   c. No, not limited at all

23. Climbing one flight of stairs
    a. Yes, limited a lot
    b. Yes, limited a little
    c. No, not limited at all
24. Bending, kneeling, or stooping
    a. Yes, limited a lot
    b. Yes, limited a little
    c. No, not limited at all
25. Walking more than a mile
    a. Yes, limited a lot
    b. Yes, limited a little
    c. No, not limited at all
26. Walking several blocks
    a. Yes, limited a lot
    b. Yes, limited a little
    c. No, not limited at all
27. Walking one block
    a. Yes, limited a lot
    b. Yes, limited a little
    c. No, not limited at all
28. Bathing or dressing yourself
    a. Yes, limited a lot
    b. Yes, limited a little
    c. No, not limited at all

For questions 25 – 28. During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of your physical health?

29. Cut down the amount of time you spent on work or other activities
    a. Yes
    b. No
30. Accomplished less than you would like
    a. Yes
    b. No
31. Were limited in the kind of work or other activities
    a. Yes
    b. No
32. Had difficulty performing the work or other activities (for example, it took extra effort)
    a. Yes
    b. No

For questions 30 – 32. During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems (such as feeling depressed or anxious)?

33. Cut down the amount of time you spent on work or other activities
    a. Yes
    b. No
34. Accomplished less than you would like
    a. Yes

  b. No
35. Didn’t do work or other activities as carefully as usual
  a. Yes
  b. No
36. During the past 4 weeks, to what extent has your physical health or emotional problems interfered with your normal social activities with family, friends, neighbours, or groups?
  a. Not at all
  b. Slightly
  c. Moderately
  d. Quite a bit
  e. Extremely
37. How much bodily pain have you had during the past 4 weeks?
  a. None
  b. Very mild
  c. Mild
  d. Moderate
  e. Severe
  f. Very severe
38. During the past 4 weeks, how much did pain interfere with your normal work (including both work outside the home and housework)?
  a. Not at all
  b. A little bit
  c. Moderately
  d. Quite a bit
  e. Extremely

For questions 36 – 44. These questions are about how you feel and how things have been with you during the past 4 weeks. For each question, please give the one answer that comes closest to the way you have been feeling.

How much of the time during the past 4 weeks…

39. Did you feel full of pep?
  a. All of the time
  b. Most of the time
  c. A good bit of the time
  d. Some of the time
  e. A little of the time
  f. None of the time
40. Have you been a very nervous person?
  a. All of the time
  b. Most of the time
  c. A good bit of the time
  d. Some of the time
  e. A little of the time
  f. None of the time
41. Have you felt so down in the dumps that nothing could cheer you up?
  a. All of the time
  b. Most of the time

c. A good bit of the time
d. Some of the time
e. A little of the time
f. None of the time

42. Have you felt calm and peaceful?
    a. All of the time
    b. Most of the time
    c. A good bit of the time
    d. Some of the time
    e. A little of the time
    f. None of the time
43. Did you have a lot of energy?
    a. All of the time
    b. Most of the time
    c. A good bit of the time
    d. Some of the time
    e. A little of the time
    f. None of the time
44. Have you felt downhearted and blue?
    a. All of the time
    b. Most of the time
    c. A good bit of the time
    d. Some of the time
    e. A little of the time
    f. None of the time
45. Did you feel worn out?
    a. All of the time
    b. Most of the time
    c. A good bit of the time
    d. Some of the time
    e. A little of the time
    f. None of the time
46. Have you been a happy person?
    a. All of the time
    b. Most of the time
    c. A good bit of the time
    d. Some of the time
    e. A little of the time
    f. None of the time
47. Did you feel tired?
    a. All of the time
    b. Most of the time
    c. A good bit of the time
    d. Some of the time
    e. A little of the time
    f. None of the time

48. During the past 4 weeks, how much of the time has your physical health or emotional problems interfered with your social activities (like visiting with friends, relatives, etc.)?
    a. All of the time
    b. Most of the time
    c. A good bit of the time
    d. Some of the time
    e. A little of the time
    f. None of the time

For question 46 – 49. How TRUE or FALSE is each of the following statements for you.

49. I seem to get sick a little easier than other people/
    a. Definitely true
    b. Mostly true
    c. Don't know
    d. Mostly false
    e. Definitely false
50. I am as health as anybody I know
    a. Definitely true
    b. Mostly true
    c. Don't know
    d. Mostly false
    e. Definitely false
51. I expect my health to get worse
    a. Definitely true
    b. Mostly true
    c. Don't know
    d. Mostly false
    e. Definitely false
52. My health is excellent
    a. Definitely true
    b. Mostly true
    c. Don't know
    d. Mostly false
    e. Definitely false

Sheehan Disability Scale (SDS) (Copyright © Sheehan, 1983)

For the next 5 questions, the symptoms being referred to are those associated with math anxiety, some common symptoms when in a math based situation are:

- Feelings of helplessness, lack of confidence, and/or fear of getting things wrong
- Heart racing, irregular breathing, sweatiness, and/or nausea
- Frustration from trying but being unsuccessful
- Not knowing where to start
- Stressed before and during
- Embarrassed of potential judgement
- (Marshall, Mann & Wilson, 2016)

53. The symptoms have disrupted your work:
    a. Extremely
    b. Markedly
    c. Moderately
    d. Mildly
    e. Not at all
    f. I have not worked at all in the past week for reasons unrelated to my symptoms
54. The symptoms have disrupted your school work:
    a. Extremely
    b. Markedly
    c. Moderately
    d. Mildly
    e. Not at all
    f. I have not studied at all in the past week for reasons unrelated to my symptoms
55. The symptoms have disrupted your social life/leisure activities:
    a. Extremely
    b. Markedly
    c. Moderately
    d. Mildly
    e. Not at all
56. The symptoms have disrupted your family life/home responsibilities:
    a. Extremely
    b. Markedly
    c. Moderately
    d. Mildly
    e. Not at all
57. How many days in the last week did your symptoms cause you to miss school or work or leave you unable to carry out your daily responsibilities?

______

58. How many days in the last week did you feel so impaired by your symptoms, that even though you went to school or work, your productivity was reduced?

______

59. What situations in your work life cause you to experience math anxiety?
60. What situations in your personal/social life cause you to experience math anxiety?
61. Have you had experiences where you math anxiety has impacted your daily life outside of the math classroom?