Spring 5-11-2021

How the COVID-19 Pandemic Affected High School Student Mathematical Anxiety During Distance Learning.

Ryan Christiansen
rchristiansen@isd317.org

How the COVID-19 Pandemic Affected High School Student Mathematical Anxiety During Distance Learning.

A Project Presented to
The Graduate Faculty of
Minnesota State University Moorhead

By

Ryan Christiansen

In Partial Fulfillment of the
Requirements for the Degree of
Master of Science in
Curriculum and Instruction

April 2021
Moorhead, Minnesota

ABSTRACT

Mathematical anxiety is the stress associated with an insecurity in a student's own ability to solve a math problem (Beilock & Willingham, 2014). This stress can cause students to perform below their ability and put in motion a dislike for math that can last a lifetime. In the spring of 2020, a sudden interruption in learning, in response to the COVID-19 pandemic, caused students to be separated from their teachers, setting up a situation in which students were not as fully supported as usual, and mathematical anxiety potentially increased. The previous research on students being separated from their teachers on a large scale is nonexistent; so to inform this research, studies of post-Hurricane Katrina were used. This study attempts to determine how distance learning, and the subsequent learning models that followed, affected students' mathematical anxiety, and if there was anything that helped students cope with their anxiety. This study was conducted with mostly ninth-grade geometry students, who were surveyed about their mathematical anxiety levels pre-, during, and post-pandemic. The students also provided feedback on two specific strategies of self-assessment and self-regulated learning that the teacher had implemented during the following school year; the students also identified what alleviated or heightened their mathematical anxiety. These results provide us with a deeper understanding of how the pandemic affected students and inform us how we can better meet their needs in times of crises when the traditional learning model is disrupted.

DEDICATION

Thank you to my ever loving, longsuffering, grammar-correcting wife.

Table of Contents

Chapter 1

Introduction

Introduction

Mathematical anxiety is the negative emotion that a person experiences when attempting to solve a math problem (Mutlu, 2019). Mathematical anxiety is present in students as young as first and second grade; one study found that nearly half of the students in these grades experienced a medium to heavy amount of mathematical anxiety (Beilock & Willingham, 2014). When students were not given a chance to overcome their anxiety, it built up and continued to affect their ability to do math throughout their lives (Ramirez et al., 2013).

During the spring of 2020, COVID-19 forced American schools to close their doors. In Minnesota all schools were in a distance learning model for all of the fourth quarter. During this time education was forced to evolve and discover new ways to reach students. Keeping students at home was necessary at the time, but it was not ideal for both students and teachers. When students returned to school in the fall, it was noticed that students were very open about what they did not learn during the fourth quarter of the previous year. Students were very anxious about what they might have missed as they transitioned from eight grade algebra to geometry class.

These recent unusual circumstances, when combined with standard mathematical anxiety and exacerbated by their separation from their teachers, is sure to lead to heightened levels of anxiety. Determining how anxious students were during distance learning and the subsequent hybrid model implemented during the subsequent school year was the focus of the research. Identifying specific items that have been present in my classroom this year, such as self-

regulation, the process where before a test student evaluates their confidence level so that they have a clear picture of what is expected and how well they understand it. Retesting, the process of giving students the ability to retest after receiving feedback on a failed assessment, that have helped students feel less anxious about their mathematical ability. The feedback helped me determine if what I do is helpful to my students no matter the learning model. Students also had a chance to identify what other items have helped increase or decrease their mathematical anxiety during the school year. I hope the research can help build a picture of what students go through in a math class when they are faced with unforeseen circumstances.

Brief Literature Review

Mathematical anxiety is phenomena where a student's anxiety about solving a math problem causes him to perform below his ability (Ashcraft & Moore, 2009). Teachers are frequently addressing mathematical anxiety in their classroom and are in need of tools to combat it. According to Griggs (2013), mathematical anxiety and self-efficacy are connected, and improving self-efficacy can improve math anxiety. The added situation of a global pandemic may have caused a heightened amount of anxiety, which in turn may have contributed to what students were already feeling. While consulting the litterateur, there was not any current published literature about education during the 2020 distance learning and subsequent hybrid models that followed, but looking at other disasters, such as Hurricane Katrina, when student learning was interrupted along with their day-to-day lives can give insight to what students during the pandemic school year(s) felt. Several studies—Hensley (2008), Galea (2007), McLaughlin (2010), and Lamb (2013)—identified an increase in PTSD, stress, disruptive behaviors, as well as a decrease in mathematical ability, especially in poor/rural areas. Mathematical anxiety is a worthy subject of study during standard teaching practices, with the

added chaos of the pandemic to an imperative that teachers needed to address heightened levels of mathematical anxiety.

Statement of the Problem

The problem was that students were experiencing mathematical anxiety, and the disruption in learning caused by the pandemic contributed to anxiety. To be able to address mathematical anxiety, more needs to be learned about the students' situation. Determining when students felt the most anxious about their math abilities and what resources helped them feel less anxious about math. We know that mathematical anxiety cannot be eradicated, but understanding what students experienced with hybrid and distance learning will help educators meet their needs in the future.

Purpose of the Study

Determining student anxiety levels over the past year due to distance learning during the COVID-19 pandemic was the primary goal of this study. The second part was finding out what strategies students identified that helped lower their mathematical anxiety. I was curious about two small things that occur my classroom: self-regulation marking emojis that are tied to the learning target, and the ability for students after they have failed an assessment to get feedback on their results and reassess. The students were also be able to identify what has made them more or less anxious during the year.

Research Question(s)

Question 1: How did mathematical anxiety increase or decrease due to distance learning during COVID-19? Question 2: Have the strategies of self-assessment and feedback on

assessments eased the anxiety? Question 3: What other factors have improved or made math anxiety worse?

Definition of Variables. The following were the variables of study:

Variable A: Mathematical anxiety as reported by the student at various times during the year. Mathematical anxiety being "the feeling of tension and anxiety that interfere with the manipulation of numbers and the solving mathematical problems in a wide variety of ordinary life and academic situations" (Richardson & Suinn, 1972, p. 551).

Variable B: Student feelings toward self-assessment post learning, pre summative assessment. "Self-assessment enables students to establish objectives based on assessment criteria, during performance of the task it stimulates monitoring of progress, and during the self-reflection phase it promotes assessment of the results based on the pre-established criteria" (Zamora et al., 2018, p. 176).

Variable C: Student feelings toward being able to retake an assessment and its effect on mathematical anxiety.

Variable D: Student-identified practices that have contributed to alleviating mathematical anxiety.

Variable E: Student-identified practices that have increased mathematical anxiety.

Significance of the Study

Education was understandably forced to shift dramatically due to the pandemic. There is danger of letting many students in our populations suffer long-term damage in the math realm.

The study looked to determine how students felt toward math during the disruption and to determine what teaching methods have had the most student-perceived benefit.

Research Ethics

Permission and IRB Approval. In order to conduct this study, the researcher sought MSUM's Institutional Review Board (IRB) approval to ensure the ethical conduct of research involving human subjects (Mills & Gay, 2019). Likewise, authorization to conduct this study was sought from the school district where the research project took place (See Appendix A and B).

Informed Consent. Protection of human subjects participating in research is assured. Participant minors were informed of the purpose of the study via the Method of Assent (See Appendix C) that the researcher read to participants before the beginning of the study. Participants were aware that this study was conducted as part of the researcher's master's degree program and that it would benefit his teaching practice. Informed consent means that the parents of participants have been fully informed of the purpose and procedures of the study for which consent is sought and that parents understand and agree, in writing, to their child participating in the study (Rothstein & Johnson, 2014). Confidentiality was protected through the use of pseudonyms (e.g.: Student 1) without the utilization of any identifying information. The choice to participate or withdraw at any time was outlined both verbally and in writing.

Limitations. Limitations in the research were the students' ability to correctly understand and assess their mathematical anxiety since COVID-19 started. Students may also lack introspection to analyze what effects their mathematical anxiety. Thus, affecting the validity of the study. Another possible factor was that we did not know what the educational experience would be like for the rest of the 2021 school year. It could be difficult to gather data if we return

to distance learning. As my students' teacher, I was responsible for setting the tone of the classroom, this can affect student anxiety in many ways, for some students I may have a calming effect and for other students I might contribute to their mathematical anxiety. I personally identified the two strategies that I thought that are present in my classroom that would help reduce mathematical anxiety but I may not be assessing the situation correctly and might be missing something.

Conclusions

Mathematical anxiety is a real issue for students in a normal classroom setting. The onset of distance learning due to COVID-19 likely made the situation worse. Finding out how students felt about mathematical anxiety provided an opportunity to research how students felt, what made the anxiety worse, and what decreased it. Before solutions can be offered, the students' feedback must be analyzed. In the next chapter the literature related to mathematical anxiety is reviewed in depth as well as possible methods of reliving some of the anxiety.

Chapter 2

Literature Review

Review

My school like many others in the spring of 2020 was forced into a distance learning model to stop the spread of COVID-19. The Minnesota governor Tim Waltz ordered that all schools close for two weeks while teachers prepared to teach remotely. The teachers and students were not prepared for distance learning as it was done very hastily and with limited resources. The goal of the research was to determine how anxious our students were at various stages of interrupted learning; how mathematical anxiety currently affects them; and what things have made students less anxious. Since mathematical anxiety is associated with low self-efficacy, and self-efficacy can be improved with self-regulation techniques, we explored two elements of self-regulation that are present in my classroom.

Body of the Review

Context. While researching the literature surrounding mathematical anxiety it was discovered to be a plentiful topic. Much has been written about when it sets in, how it affects students and what its lasting effects are. The connection between math anxiety and turbulent learning experiences was not as well established. Hurricane Katrina provide the best examples of mass disruption in an educational system. While there was no shortage of articles on the effects of Katrina only a limited number of them focused on mathematical topics.

Mathematical Anxiety. Many people have probably experienced some nervousness associated with their mathematical performance. Nervousness can interfere with a person's

ability to solve a math problem so much that it causes them to perform below their ability. In education this phenomenon is referred to as mathematical anxiety (Ashcraft & Moore, 2009). Mathematical anxiety is not the same as standard test anxiety. They are not mutually exclusive, but the terms are not to be considered synonymous (Dew & Galassi, 1983). Anxiety surrounding math is a significant impediment to math achievement and it affects a large portion of the population (Ashcraft & Moore, 2009). It is often associated with students who perform poorly in math and have a low self-efficacy (Al-Shannaq & Leppavirta, 2020). It has also been discovered that students who have delayed their mathematics studies or took time off were also significantly more anxious about math. It has also been shown that "high levels of math anxiety will lead to destructive effects in many dimensions, primarily lack of working memory" (Mutlu, 2019, p. 473). Jameson and Fusco (2014) support this, adding that as the age of the learner increased, math anxiety increased, and self-efficacy decreased. The increase in math anxiety paired with the decrease in self-efficacy can be explained in part by the amount of time that has passed since the previous math course.

The students that are the most susceptible to math anxiety are, surprisingly, the ones that have the highest level of working memory. Working memory is where our brain stores information for short periods of time while it is problem-solving (Batool et al., 2019). Math anxiety commonly effects students that have some of the greatest ability. The reasons for this are not clear, but the students with more working memory tend to rely on advanced problem-solving strategies to solve problems, which in turn uses more of their working memory, which could be a cause of anxiety (Beilock & Willingham, 2014). Rameriez (2013) determined that working memory does play a part in poor math performance but does not tell the whole story of why students perform poorly in math.

Another predictor of mathematical anxiety is spatial processing ability, which according to Sokolowski, is the ability to "generate, recall, maintain and transform visual-spatial information" which can take the form of mentally manipulate objects in the third dimension (Sokolowski et al., 2018, p. 195). Glyde (2011) also describes it as the ability to focus on sounds coming from one direction while ignoring sounds that are coming from other directions. There is a negative association between math anxiety and spatial processing ability. Special processing develops early in a child's development, which would suggest that it precedes math anxiety (Maloney et al., 2012). The same study also identifies that differences in spatial processing ability between the sexes correlate with a higher level of math anxiety in female students. The relationship suggests that increased math anxiety levels seen in female students is directly correlated to lower levels of spatial processing ability and not as psychologists have traditionally attributed to social factors.

Previous Disasters. The pandemic prompted leaders around the world to close school buildings for the remainder of the 2020 school year. Nothing so extensive has ever happened in our history and so, thankfully has never been studied. Smaller, more localized disruptions in education such as the gulf coast during Hurricane Katrina in 2005 provides some idea of what happens when students miss a significant portion of a school year. It was discovered that PTSD symptoms increased for those that were exposed to or had their lives disrupted by the hurricane (Hensley & Enrique, 2008).

Respondents to a stress survey in New Orleans found that, understandably, 91% felt an increase in stress in at least one factor of their lives where housing adversity and property loss were the leading causes of stress but also included, injury and loss of a loved one (Galea et al., 2007). A study conducted over the four years post-Katrina showed that the mental health

problems among children and adolescents exposed to Hurricane Katrina eventually subsided, but even after two-thirds of the students had recovered, mental health problems remain elevated (McLaughlin et al., 2010). In another study by McLaughlin discovered that "In the first three to six months following the hurricane more than 50% of the children exposed to the disaster exhibited symptoms of posttraumatic stress disorder, disruptive behaviors or other manifestation of psychological distress" (McLaughlin et al., 2010, p. 1071). Hurricane Katrina caused a disruption in the learning that year. Achievement data in Louisiana showed that the poor/rural schools were hit the hardest, and of all the mathematical grades studied, Algebra 1 achievement was the hardest hit (Lamb et al., 2013).

The added trauma of disasters has an obvious effect on student well-being and contributes to general anxiety. With the final quarter of the 2019-2020 school year being full distance learning, our students experienced some levels of increased anxiety. Levels might not be on the level experienced post-Hurricane Katrina, and we may not know the current increase in anxiety, but we can be sure it has an effect on our students.

Reducing Anxiety

An experimental study post-Katrina showed that school-led interventions were able to reduce test anxiety symptoms and led to academic improvement. Showing the potential benefit of targeting general anxiety symptoms post-disaster. The decrease in anxiety led to decreased levels of other PTSD symptoms as well, which makes an even stronger case for anxiety interventions in schools (Weems et al., 2008).

In search of techniques that will help alleviate mathematical anxiety, I have identified things implemented in my classroom for the 2020-2021 school year that I intend to help reduce anxiety. As mentioned earlier, the research shows that one of the factors most closely related to

mathematical anxiety is the concept of self-efficacy. There seems to be an inverse relationship between the two.

Math anxiety and self-efficacy are connected. When students have strong self-efficacy, or belief in their ability, they will not feel as anxious about their abilities. Schools that implement social and emotional learning curriculum have been shown to reduce the relation between anxiety and low math self-efficacy for students that normally experience elevated levels of math anxiety (Griggs, 2013). When students are comfortable in a learning environment, their self-efficacy will improve and in turn mathematical anxiety will be reduced not because of any math strategy a teacher employed but by giving students the tools to approach learning in an anxiety-free way.

Self-efficacy plays an important role in mathematics, and when it is combined with assessment feedback, students are able to still feel good about their math ability while receiving feedback about their shortcomings. Which introduces us to self-regulated learning (SRL), where students have the confidence to construct and set goals for their learning and then proceed to monitor, regulate, and assess their learning (Grothérus et al., 2019). SRL can manifest itself in many forms, it can be student led or teacher prompted. Anything that engages the student with the goal, such as teacher feedback on a project, where after the feedback has been given the student, she is allowed to adjust and resubmit her work. Self-efficacy, when combined with self-regulation, has been shown to give students more agency over their academic lives, especially when they are taught it from a younger age. This combination becomes an important predictor in a student academic achievement (Zuffiano et al., 2012).

Students being able to self-assess before they take an assessment is designed to reduce anxiety by letting the student know clearly what the goals of the assessment are. When the goals

are known, students can reflect on how prepared they think they will be for the assessment. When they are able to self-report that they are confident in all aspects of the assessment, hopefully mathematical anxiety will be reduced. Students cannot always self-generate their own goals, so when they are provided with a tool that makes them aware of assessment criteria, it increases the accuracy of their self-assessment (Zamora et al., 2018). When students are trained in and practice self-assessment, it enhances the effectiveness of self-regulated learning (Kostons et al., 2012). While self-assessment has not yet been widely studied in direct connection to math-specific anxiety, studies have shown that it does affect factors directly connected to math anxiety.

An important part of SRL is receiving feedback on mistakes that have been made. With SRL, students know that they can try their best on an assessment, and that if they do not perform the way they would like, they can then learn from their mistakes, make corrections, and reassess. These skills learned through SRL promote mastery of content and give the student the opportunity to not be defined by their mistakes but to grow from them. All students need to be able to grow from feedback on their assessments (Rieg, 2007) whether the feedback is given by the teacher or, in a more SRL environment, the student himself is able to determine what he did wrong. Both forms of reflection are, as Rieg determines, helpful to students, but most important, the students themselves perceived the feedback to be helpful. When we decide to use summative tests in a formative manner, we are making the students the owners of their own learning (Grothérus et al., 2019), because they are now aware of their goals and have the tools they need to affect their own learning outcomes. One can conclude that these practices would be helpful in reducing mathematical anxiety.

Theoretical Framework

A theoretical framework that runs through the literature is that mathematical anxiety can when in concert with other bad habits such as low math ability, poor motivation, or low mathematical confidence cause students to underperform in the future and potential stunt their mathematical understanding. In the short term it can lead to students not putting energy into their current math class which can lead to lower math scores (Ashcraft & Moore, 2009). Once students have a mathematical avoidance, they avoid elective math courses in high school and do not purse math related fields in college. Adults that struggle with math anxiety have trouble with fundamental skills such as counting objects, discerning what quantities are larger, rotating three-dimensional objects in their mind (Maloney et al., 2009). The long-term effect of mathematical anxiety can lead to adults that are not mathematically literate and can lack what is referred to as a "critical filter through which individuals pass and go on to attain high-paying, prestigious, and technologically relevant careers" (Jameson & Fusco, 2014, p. 308).

Research Questions(s)

How has mathematical anxiety increased or decreased due to distance learning during COVID-19? Have the strategies of self-assessment and feedback on assessments eased the anxiety? What other factors have improved or made math anxiety worse?

This chapter reviewed literature about what mathematical anxiety is, whom it affects, and that it is associated with low self-efficacy. When students experience trauma, such as Hurricane Katrina, they are affected on all levels, and when combined with separation from their educational system for a quarter, the levels of anxiety over their math ability will be increased.

When students are able to improve their self-efficacy by SRL strategies of self-assessment and feedback on assessments, mathematical anxiety decreases.

Chapter 3

Methods

Introduction

This study shed light on how distance learning in the spring of 2020 and the following school year's hybrid learning affected students' mathematical anxiety and what, if any, strategies helped alleviate it or, conversely, heightened their anxiety. When Minnesota schools were all moved to distance learning in March of 2020, not all districts were prepared to deliver instruction online, much less meet students' needs. Many teachers did the best that they could, but the separation students felt from teachers resulted in students disconnecting from their learning. For multiple reasons it can be assumed that students would have experienced heightened anxiety during this time and as they prepared to enter a math class that they did not necessarily feel prepared for. This chapter will examine how we surveyed the students to get their feelings about their mathematical anxiety this past year.

Research Question(s)

Question 1: How has mathematical anxiety increased or decreased due to distance learning during COVID-19? Question 2: Have the strategies of self-assessment and feedback on assessments eased the anxiety? Question 3: What other factors have improved or made math anxiety worse?

Research Design

A cross-sectional design was used with my students as the participants. All of the questions in the survey were focused on mathematical anxiety. All of the students were in distance learning last year, and all of the students are currently in one of my geometry classes. It is understood that these students are not a random sample of the school's population but a convenience sample of most of the 9th graders and a few 10th and 11th graders in the school. The questions were able to be read exactly as they were written. The administrator of the survey (see Appendix D) explained the definition of anxiety to the students so that they were familiar with the terms. The students were comfortable self-reflecting on their feelings.

The implementation of a five-part Likert scale was modeled after other tools used by researchers studying mathematical anxiety. The tool seemed appropriate for high school students who may all experience mathematical anxiety differently but were able to compare how their own feelings changed during the pandemic. The qualitative feedback that the students gave in the open-ended questions was to get a better understanding of what helps students deal with mathematical anxiety and what aggravates it. The decision to have students reflect on the classroom strategies of self-regulation and self-assessment was to get specific feedback on things that are happening in their classroom so there would be feedback on some specific strategies that the students might not connect to mathematical anxiety.

Setting

The school where this research took place is a small town located in northern Minnesota just outside of the Leech Lake Reservation. The student body is made up of 31% Native American, 52% white, 5% Hispanic, 12% two or more races, and less than 1% African American

students. Of the 217 high school students, 65% receive free or reduced lunch. The student to teacher ratio is 14:1. The area is a popular destination for outdoor activities such as hunting and fishing. Many students and parents work for local resorts, which is a major industry for the community along with logging and healthcare.

Participants

The students involved in this study were primarily ninth grade but a few other grades mixed in. They are spread out in three geometry courses throughout the day. Based on registration information, they are 54% male and 46% female. Twelve percent of the students have an IEP and for several periods during the day a para is assigned to my class to provide support to those students. At the time of the survey, 37% of the students are virtual learning and do not physically attend school; the rest are in a hybrid model where they attend half of the time in person, and half online. There is a wide range of family structures represented in my school: traditional arrangements where the student lives with both parents, situations where the parents are separated and students live in two households, students who are being raised by a relative such as a grandparent, and a sizeable number of group-home students who have been introduced into our school from around the state.

Sampling. The students participating in this study were selected as convenience sample due to the fact that they were enrolled in my geometry class and that have all had similar distance learning experiences in the last year. To better understand the effects that distance learning had on mathematical anxiety, it is important that all students had similar experiences.

Instrumentation

The instrument that I used for data collection is a Google Form. The students rated their anxiety on a one to five Likert scale. There is no standard way of reporting anxiety in the literature; in Ramirez's (2013) study on elementary math anxiety, he used a sliding scale with three emojis that let students signify how they felt about their math ability. In Italy, test anxiety was measured by Poliandri (2011) using a four-point Likert-type scale so that it was in keeping with other assessments that the students have been given. Since my students are several years older than both of these groups, I have decided to use a five-point Likert scale that is used to measure a user's level of agreement on a scale of 1 to 5 and compared quickly. I am operating under the assumption that anxiety intensity is on a linear continuum from low to high anxiety. See appendix A for assessment tool.

Data Collection. The survey was given to three geometry classes. The terms were defined so that students knew what they were being asked to reflect on. Students were given time to complete the survey on their devices. This was a one-time cross-sectional survey and there was no follow-up; students were given the survey electronically and the data was stored in an online spreadsheet.

Data Analysis. Each question with a numerical answer had all numerical measurements (mean, median, standard deviation, percentages, and ranges) calculated. Vertical box and whisker plots with time as the x-axis are used to display anxiety levels as well as histograms to display students preference. The open-ended questions were compiled and organized by theme. Correlation between questions was analyzed to determine if there is any meaningful connection between retaking test, self-evaluating and a reduction in anxiety. Significant differences in the average scores were calculated with one-way analysis of variance (ANOVA), and when

significant difference in the means were found, a two-sample t-test assuming equal variances was employed to determine between what two groups the significant differences existed.

Research Question(s) and System Alignment

Table 1

Research Question(s) Alignment

Research Question	Variables	Design	Instrument	Validity & Reliability	Technique (e.g., interview)	Source
Q1	DV: Student mathematical anxiety. IV: Distance learning in the past year.	Cross sectional where data is collected from individuals at a moment in time. Action Research	Survey	For the purpose of this study, we will maintain group structure for the entire survey.	An online 5-part Likert scale survey with two open ended questions.	41 Geometry students.
Q2	DV: Student mathematical anxiety. IV: Self-assessment and feedback on assessments	Action Research				
Q3	DV: Student identified. IV: Student mathematical anxiety.	Qualitative feedback.			Open response questions.	

Procedures

The survey took place over a one-week period in which students were rotating into the classroom and could be given the survey in a face-to-face environment. Students who were fully online were given a special session where they could take the survey.

Once the data was collected and stored, and measure of center and spread calculated, a Wilcoxon signed-rank test was performed to determine if there was any significant difference in the means of the student anxiety over the past year. Student feedback on the open-ended questions was also compiled and sorted, and themes identified.

Ethical Considerations

Protecting students is of the utmost priority in this survey. Before we surveyed students, parents signed an informed letter of consent, which let them know that they may opt out at any time. Student identity is not attached to the data and there were no identifying questions that could reveal a student's identity. Both students and parents were made aware that the study is an attempt to get to know the students' needs and how we as teachers can better serve them.

Conclusions

In this chapter we have made an attempt to define our methods and explain how we collected, analyzed, and interpreted the data. The participants of the study were introduced along with their backgrounds. Consideration for the well-being of the participants has also been demonstrated. The next chapter will be dedicated to presenting the results of the survey.

Chapter 4

Data Analysis and Interpretation

The pandemic of 2020 forced schools to shift to a distance-learning model for the remainder of that school year and to use a hybrid model in the following fall. This provided a unique situation to better understand mathematical anxiety. This study gives the students a chance to report their anxiety levels and provide feedback to educators about what has affected their anxiety in the past year.

Data Collection

For the first three quarters of the school year, our school was operating in a hybrid model to reduce the possibility of the spread of COVID-19. The students were surveyed the first week that our school returned to full-time learning with only a fraction of the students remaining online. Waiting for this moment in the year helped ensure that the most students possible could complete the survey in person at the same time. Students had the concepts of mathematical anxiety explained to them (see Appendix E). Data were collected by a Google form and stored in a spreadsheet.

Results

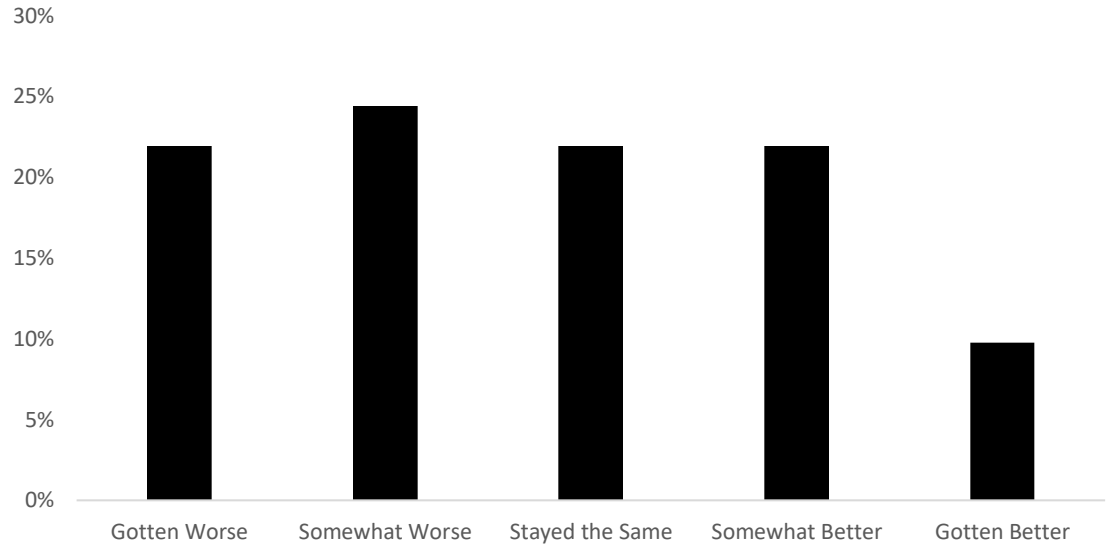
Students were asked to report their levels of mathematical anxiety (see Appendix D) experienced during the following periods: full distance learning for the spring quarter of the 2020 school year; hybrid learning in the fall of 2020; and hybrid learning through the winter in 2021. A population of $n = 41$ geometry students chose to participate in the survey.

Q1: How has mathematical anxiety increased or decreased due to distance learning during COVID-19?

When students were asked to respond to how their mathematical anxiety has changed this school year, the results varied. Of the students that participated in the study, 10% agreed that their anxiety was better this year, and 22% agreed that it was somewhat better this year, while 22% reported that their anxiety remained the same, 24% reported that their anxiety was somewhat worse, and 22% stated that it was worse. See Figure 1.

Figure 1

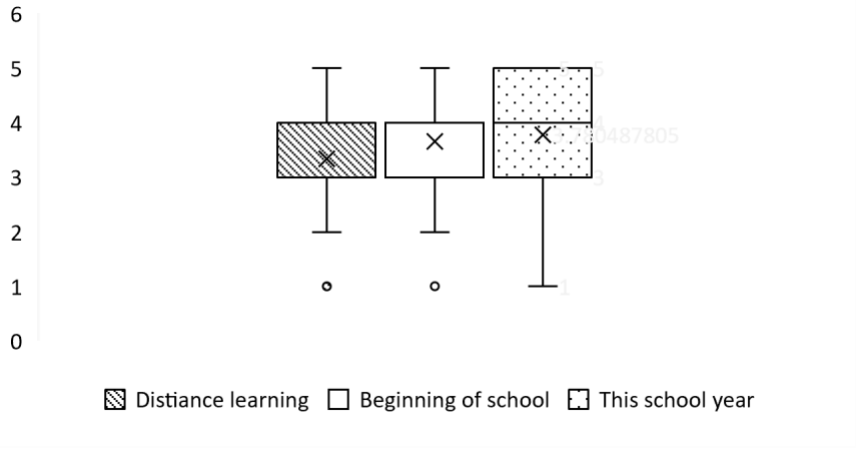
Change in Mathematical Anxiety This School Year



Students reported their anxiety on a five-point Likert scale, where one represented feeling no anxiety and five represented feeling very anxious. Students reflected on their anxiety in the spring of 2020 when school was full distance learning; when they returned to school in the fall of 2020; and in the winter of 2021. Figure 2 displays a box and whisker representation of students' anxiety levels during the pandemic where five represented very anxious and one was not anxious at all.

Figure 2

Distribution of Anxiety Levels during the Pandemic



Students reported an average anxiety level of 3.34 during the distance learning during fourth quarter in 2020. This average increased to 3.66 when students returned to school the following fall and has peaked during distance learning during the current school year at 3.78. This shows that for most students their anxiety increased over the duration of the pandemic, with the biggest increase happening between distance learning in the spring and returning to school in the fall. A one-way ANOVA test was run to determine if there was a meaningful difference in the means. No significant difference was found, and the increase in the average anxiety level of the students was not statically significant with a $p = 0.15$.

Table 2 continues to display descriptive data on student anxiety levels as reported by the five-point Likert scale. The data where $n = 41$ show that the average student anxiety level increased over the pandemic while the SD remained relatively the same.

Table 2

Comparison of Student Anxiety Levels Across Semesters

	Mean	Median	Mode	SD
Spring 2020	3.34	3	3	1.05
Fall 2020	3.66	4	4	1.00
Winter 2021	3.78	4	4	1.07

Increase in mathematical anxiety levels from the distance learning in the spring of 2020 compared to the following fall when students reported to school in a hybrid situation showed that 51% of the students reported feeling more anxious about their math ability where 20% had no change and 29% experienced less anxiety returning to school. When anxiety levels are compared between distance learning in the spring of 2020 and students' current situation in the hybrid model, only 49% report having higher anxiety, with 34% showing no change and 17% experiencing less anxiety. When back-to-school levels of anxiety are compared with current levels, only 27% are reporting more anxiety, 54% with no change, and only 20% with decreased levels. Table 3 displays the percentages of students that displayed more or less anxiety at various points during the pandemic.

Table 3

Comparison of How Anxiety Levels Changed

	Spring to Fall	Spring to Winter	Fall to Winter
Much More Anxiety	12%	20%	5%
More Anxiety	39%	29%	22%
Anxiety Stayed the Same	20%	34%	54%
Less Anxiety	27%	10%	20%
Much Less Anxiety	2%	7%	0%

Q1: Data Analysis

Mathematical anxiety increased for 51% of students from the spring of 2020 to the fall of 2020. The overall growth in anxiety may not be significant differences in the means but is identified as an issue that students struggle with. Mathematical anxiety is a complex phenomenon with multiple variables. Factors such as a majority of students graduating from 8th grade and moving up to the high school may have also played a factor in some of the changes in anxiety, as well as a student's preference for or against geometry. The increase of mathematical anxiety among the students parallels the experience of Louisiana students who experienced increased psychosocial distress (McLaughlin et al., 2010) and decreased mathematical grades (lamb et al., 2013). The data also show that student anxiety on average went up during distance learning, and during the hybrid teaching that followed but not at significant enough levels to be relevant.

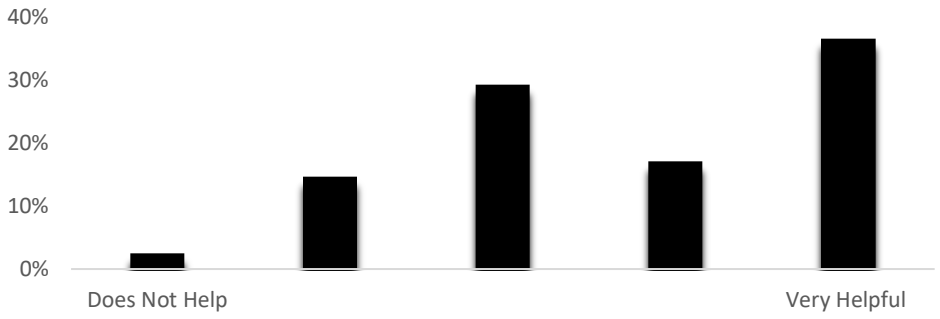
Q2: Have the strategies of self-assessment and feedback on assessments eased the anxiety?

When asked if the knowledge that they could retake an assessment if they failed it reduced their anxiety during the first assessment attempt, students responded with 54%

identifying that that was helpful in reducing their anxiety on the first attempt, with 29% undecided in its effect, and 17% identifying with the statement that it does not help their anxiety. Figure 3 displays student responses to how much of their anxiety is reduced by knowing that they can retake the assessment.

Figure 3

Student Attitude on Retaking Assessments



The students were grouped by how useful they thought retaking assessments was on their anxiety. Each group was then evaluated by their final average level of anxiety as reported in the winter of 2010. A one-way ANOVA test was run that showed a p-value of 0.198, which is not a significant enough of a level to show that students' feelings on retaking assessments had any meaningful effect on their final anxiety levels.

When students were asked to (1) reflect on the process of ranking themselves with emojis before new content so that they can self-assess their ability and then at the end of the chapter, (2) revisit the same scale on the review to determine how much they have learned, and (3) declare how confident they are, only 7% of the students identified this process as having any reducing effect on their anxiety, with 32% having no strong opinions and 61% reporting that the practice does not help as Figure 4 demonstrates.

Figure 4

Student Attitudes toward Emojis' Effect on Anxiety

While no students reported that emojis were very helpful, a running of a one-way ANOVA test found that the average anxiety level of each group was significantly different, with a p-value of 0.020. As Table 4 shows, the average anxiety level for students who did not consider the emojis as a valuable anxiety-reducing device also reported the highest average levels of anxiety, at 4.45. Upon further analysis, by performing post-hoc analysis to the ANOVA results using a t-test assuming equal variances and using a Bonferroni correction of 0.005, it was determined that the two groups with significantly different means in reported anxiety was between the students who claimed that emojis do not help at all with a mean anxiety level of 4.45 and the group that trended toward emojis not helping but not as strongly with an average anxiety level of 3.07 which was also the group with the lowest anxiety level.

Table 4

ANOVA Test of Emojis Reducing Anxiety Levels

Groups	*Count*	*Sum*	*Average*	*Variance*
(1) Very Helpful	0	0	-	-
(2)	3	11	3.67	0.33333333
(3)	13	52	4	0.83333333
(4)	14	43	3.07	1.45604396
(5) Does not help	11	49	4.45	0.47272727

Students were asked how well they have been able to self-evaluate their ability this year on the one to five Likert scale, the results were symmetrically distributed with the data clustering around the mean of 3.1 and *SD* = 0.92. Students did not have strong feelings about this, which is shown by the clustering of the data in Figure 5.

Figure 5

Ability to Self-Assess

Q2: Data Analysis

Upon post-survey analysis the process of students looking over their failed tests and having the ability to retake them has an anxiety-reducing component. Fear of failure should not be a factor when assessing a student's ability and letting students know that they can retake an

assessment after failing it. The research done by Grothérus et al., 2019. suggests that "the possibility to 'redo' the Pre-action phase when given the opportunity to supplement answers and rethink solutions made the students invest more time and effort re-evaluate their mathematical proficiency" (p. 684). This can have a positive impact on students' self-efficacy. Student agreement that the ability to retake an assessment would support the research that it can lower student anxiety by affecting self-efficacy.

Students did not view the process of rating themselves with emojis before an assessment as helpful. I am not surprised by this; this is a new process for my classroom, and I do not feel that I have implemented it successfully enough for students to see the benefit of the process. Grothérus's research showed that when implemented correctly it can reduce mathematics-related anxiety. I fear that in my classroom the students see it as a chore and not a useful resource. Anecdotally, I have had one-on-one conversations with students with some success explaining the process along with why it is useful. Those students seemed to understand the practice in theory but report no benefit in the study. The discovery that the students that reported that they do not find the emojis useful had a significantly higher anxiety level this school year is very interesting. It is not what I was expecting to discover but gives us a picture into how the high-anxiety students are processing this classroom routine.

The questions in this survey were very specific and narrow in their scope; further study could reveal more specifically what tools contribute to self-efficacy and self-regulation in order to decrease mathematical anxiety. Studying students over an extended period of time would increase the quality of the study as would of having pre-pandemic data to establish a baseline anxiety level.

Q3: What other factors have improved or made students math anxiety worse?

On the survey students were given open-ended questions where they were asked "what activities or resources have helped you be more confident in geometry this year?" Students were able to respond freely with their own words, and they provided responses ranging from one-word answers to multiple sentences where multiple helpful resources were identified.

The first category that student responses were clustered into has to do with their proximity to school and the interactions with their teacher. During the first three quarters of the 2020-2021 school year the majority of students were attending school 50% of the time while the school was in a hybrid model. There was also a group of students who were online the whole year and never physically attended class. Of the 41 students that participated in the survey, 16 identified being in school and spending more time in the classroom as a resource that made them more confident in geometry this year. Of those 16 students, 4 identified being back in school as a factor, and 12 students identified some social aspect of guided practice worktime in the afternoon math labs (which in-person students participated in once a week during hybrid learning). Having time with the teacher and other students to complete work was a major theme for the students.

The next major theme in the student responses was some resource provided to them by the teacher. Thirteen students identified the notes that accompany the lesson as a tool that made them more confident in geometry this year. Students noted that the examples in the notes were useful and could be referred to later. On a similar note, 2 students of the 13 identified the chapter reviews as helpful. These are the reviews where students were asked to rank themselves with the emoji scale to reflect on how well they understand the topic. Four students identified that the IXL app, where students go to practice new topics that they have learned, which also gives them

instant feedback as well as instructs them how to correctly do the problem, was a resource that made them more confident.

The rest of the feedback was not as focused. Two students appreciated the ability to retake assessments; student 16 was thankful that they could turn in late work: "Knowing that everyone screws up sometimes helped me get over the anxiety." Feedback that did not fit a particular trend included student 29's comment: "Being able to use a calculator whenever"; student 24: "Being able to look up on the internet a process to learn it fully"; student 40: "I'd rather have it in the afternoon because in the morning I'm the most tired and when I'm tired I usually space out a lot." Six students replied that nothing helped them feel more confident in geometry this year or had some other off topic comment. Table 5 outlines the frequency of the occurrence of the identified themes. Note that the survey had 41 participants, but multiple themes may have been recorded by a single student resulting in more that 41 occurrences.

Table 5

Occurrence of Themes in the Survey

Theme	Occurrence
Resources, IXL, notes, reviews, etc.	18
In-person learning, face-to-face help, math lab	16
Nothing helped	6
Retaking assessments	2

The next two questions focused on what things this school year have made students less confident in geometry this year. The students were also asked to reflect on how these things affected their anxiety. The first theme that emerged was based on items that are graded, either as practice or as an assessment. While many students credited the feedback they get from

homework and IXL, 8 students felt that amount of work overwhelmed them or the frustration of not knowing how to do the problems made them less confident in geometry this year. Three students identified tests as a contributing factor and one student identified the notes that we take in class.

The next theme that students brought up had to do with the schedule and distance learning this year. A total of nine students identified some aspect of the distance learning or hybrid model as a factor in being less confident in geometry this year. Responses varied from the class being too short, not able to ask questions when they are learning online, missing classes, changing schedule, and lack of teacher interaction.

Five students looked at themselves and focused on their ability. Four of them brought up that shortcomings in their math ability make them less confident in geometry, and in their minds, this causes them to perform poorly on assessments and increases their anxiety. One of the students identified that their lack of organization contributed to failing geometry.

Teacher interaction was also identified. Two students felt that the teacher watching them or hovering over them as they worked was making them less confident and contributing to their anxiety. A student identified that answering questions online caused a panic and made anxiety worse. A fourth student identified the way “the teacher teaches” as a factor in making them less confident in geometry. Twelve students declined to offer any items that made them less confident in geometry and stated that their anxiety got better this year. Table 6 outlines the frequency of the occurrence of the themes.

Table 6

Occurrence of Themes in the Survey

Theme	Occurrence
Nothing	12
Practice, homework, assessments	11
Distance learning	9
Student ability	5
Teacher interaction	4

Q3: Data Analysis

When analyzing the literature relevant to this study, I did not discover any time when students were asked open-ended questions about their experiences with mathematical anxiety during a major event. That said, I am sure there are many similarities in the response in this study that there would be in a similar study conducted in a normal school year. Students reported that being out of the classroom half or all of the first three quarters affected their anxiety and that having extra time in a math study hall or returning to full-time learning while not represented in the research was an expected result. The value of having a teacher to interact with face-to-face is demonstrated clearly. I did not predict that so many students would identify specific resources, such as notes, homework, and IXL, as both reducers *and* increasers of mathematical anxiety. More research into why the same resources can create such a varied response would definitely have value to the educational world. Having such a high percentage of students that could not identify any specific item that made them more anxious leads me to believe that there is more

research to be done on this topic. More focused questions written in less academic language could uncover more items that are affecting student anxiety.

Conclusions

The distance-learning model that was implemented in the spring of 2020, and the subsequent hybrid model that was implemented through the winter of 2021, gave us the chance to study what effect this unusual learning environment had on student mathematical anxiety. Until now, mathematical anxiety was not widely studied in combination with distance learning during a global pandemic. The data collected suggested that, in both situations, full distance and hybrid learning, mathematical anxiety increased for most students. This fact led me to be curious of strategies that I have implemented in my own classroom to improve student success. The process of letting students reflect on their learning before an assessment was identified as having no reducing effect on mathematical anxiety; however, the literature indicates that if done properly, it can be a helpful tool, and I will continue to improve the process. Letting students retake assessments was viewed as a helpful tool in reducing mathematical anxiety, and the use of it in my classroom will continue. The research would also suggest that having students reflect on their mistakes before retaking the assessment will show even greater results. The rest of the study was dedicated to giving students a voice to advocate for what increases or decreases their mathematical anxiety. The responses affirm the value of teachers interacting with students face-to-face and that some form of structured practice in the form of notes, guided practice, formative assessments, retakes are critical to lowering mathematical anxiety. This research is limited to the small sample size and the fact that most students were in 9^{th} grade. More research is warranted to explore other factors that affect mathematical anxiety and how they can be developed into best practices in a digital learning environment.

Chapter 5

Implications for Practice

Action Plan

After a year of distance learning and the prospect of having a percentage of our students continue with it in the future, I now better understand the students' situation related to mathematical anxiety. Whether the students are learning face-to-face or in an online class, the information that has surfaced will continue to affect my teaching in the future, continuing to be aware of what things affect my students' mathematical anxiety levels and what strategies can be implemented to reduce the anxiety. I will continue with the policy of offering second chances on exams. I have not given up on my emoji self-reflection strategies even though students do not see the benefit it is also clear that they are the ones that need it. More time devoted to the process of reflection on learned skills earlier in the year could benefit the students in the long run. Exploring ways to substitute the face-to-face interaction for students that are full distance learning and find ways to offer higher quality guided practice when they are not in the room will be the focus for future research. Now that all of my geometry lectures have been uploaded to the internet in the event of a return to distance learning, a switch to a flipped classroom model to increase time in which the teacher can interact with individual students would be considered. Throughout the process of this study, I have learned more about the concept of mathematical anxiety and what factors can affect it. Passing on this information to my students in a less technical vocabulary could provide them the ability to self-assess their anxiety and employ the tools to overcome it. This will open up multiple discussions with my students and their parents about how they learn.

Plan for Sharing

The first place that I will share the results of the study will be with my students, discussing what things have affected mathematical anxiety this past year and what solutions could be implemented with them in the future. At the beginning of next school year I will take time to help students understand the concepts associated with math anxiety and share with them the experiences of the previous class. Hopefully this will make them more aware of how they learn and what practices suit them best. In addition, I will share the results with my math department once normal meetings have resumed where we can compare experiences during distance learning and together discuss how we will support students differently if the situation arises again. While my whole school is not affected by mathematical anxiety, there are universal concepts that other disciplines represented in my school can use; this research can be a tool for improving student learning in a distance model in general. Finally, beyond my own school I have fellow educators in my family and friend groups that have discussed the topic and are interested in my research.

References

Al-Shannaq, M. M. M., & Leppavirta, J. (2020). Comparing Math Anxiety of Scientific Facilities Students as Related to Achievement, and Some Variables. *International Journal of Instruction*, 13(1), 341–352.

Ashcraft, M. H., & Moore, A. M. (2009). Mathematics Anxiety and the Affective Drop in Performance. *Journal of Psychoeducational Assessment*, 27(3), 197–205.

Batool, T., Habiba, U. e., & Saeed, A. (2019). The Relationship between Students' Working Memory Capacity and Mathematical Performance at Secondary School Level. *Bulletin of Education and Research*, 41(3), 177–192.

Beilock, S. L., & Willingham, D. T. (2014). Math Anxiety: Can Teachers Help Students Reduce It? Ask the Cognitive Scientist. *American Educator*, 38(2), 28–32.

Dew, K. M. H., & And Others. (1983). Mathematics Anxiety: Some Basic Issues. *In Journal of Counseling Psychology* (Vol. 30, Issue 3, pp. 443–446).

Galea S, Brewin CR, Gruber M, et al. Exposure to Hurricane-Related Stressors and Mental Illness After Hurricane Katrina. *Arch Gen Psychiatry*. 2007;64(12):1427–1434. doi:10.1001/archpsyc.64.12.1427

Glyde, H., Hickson, L., Cameron, S., & Dillon, H. (2011). Problems Hearing in Noise in Older Adults: *A Review of Spatial Processing Disorder. Trends in Amplification*, 15(3), 116–126. https://doi.org/10.1177/1084713811424885

Griggs, M. S., Rimm-Kaufman, S. E., Merritt, E. G., & Patton, C. L. (2013). The "Responsive Classroom" Approach and Fifth Grade Students' Math and Science Anxiety and Self-Efficacy. *School Psychology Quarterly*, 28(4), 360–373.

Grothérus, A., Jeppsson, F., & Samuelsson, J. (2019). Formative scaffolding: how to alter the level and strength of self-efficacy and foster self-regulation in a mathematics test situation. *Educational Action Research*, 27(5), 667–690.

Hensley, L., & Varela, R. E. (2008). PTSD Symptoms and Somatic Complaints Following Hurricane Katrina: The Roles of Trait Anxiety and Anxiety Sensitivity. *Journal of Clinical Child and Adolescent Psychology*, 37(3), 542–552.

Jameson, M. M., & Fusco, B. R. (2014). Math Anxiety, Math Self-Concept, and Math Self-Efficacy in Adult Learners Compared to Traditional Undergraduate Students. Adult Education Quarterly: *A Journal of Research and Theory*, 64(4), 306–322.

Kostons, D., van Gog, T., & Paas, F. (2012). Training Self-Assessment and Task-Selection Skills: A Cognitive Approach to Improving Self-Regulated Learning. *Learning and Instruction*, 22(2), 121–132.

Lamb, J., Gross, S., & Lewis, M. (2013). The Hurricane Katrina Effect on Mathematics Achievement in Mississippi. *School Science & Mathematics*, 113(2), 80–93. https://doi-org.trmproxy.mnpals.net/10.1111/ssm.12003

Maloney, E. A., Risko, E. F., Ansari, D., & Fugelsang, J. (2010). Mathematics Anxiety Affects Counting but Not Subitizing during Visual Enumeration. *Cognition*, 114(2), 293–297.

Maloney, E. A., Waechter, S., Risko, E. F., & Fugelsang, J. A. (2012). Reducing the Sex Difference in Math Anxiety: The Role of Spatial Processing Ability. *Learning and Individual Differences*, 22(3), 380–384.

McLaughlin, K. A., Fairbank, J. A., Gruber, M. J., Jones, R. T., Osofsky, J. D., Pfefferbaum, B., Sampson, N. A., & Kessler, R. C. (2010). Trends in Serious Emotional Disturbance

among Youths Exposed to Hurricane Katrina. *Journal of the American Academy of Child & Adolescent Psychiatry*, 49(10), 990–1000.

McLaughlin, K. A., Fairbank, J. A., Gruber, M. J., Jones, R. T., Lakoma, M. D., Pfefferbaum, B., Sampson, N. A., & Kessler, R. C. (2009). Serious Emotional Disturbance among Youths Exposed to Hurricane Katrina 2 Years Postdisaster. *Journal of the American Academy of Child & Adolescent Psychiatry*, 48(11), 1069–1078.

Mutlu, Y. (2019). Math Anxiety in Students with and without Math Learning Difficulties. *International Electronic Journal of Elementary Education*, 11(5), 471–475.

Poliandri, D., Cardone, M., Muzzioli, P., & Romiti, S. (2011). A Rating Scale Model for a Scale of Test Anxiety in Italy. Working Paper N. 11/2011. *In Online Submission. Online Submission.*

Ramirez, G., Gunderson, E. A., Levine, S. C., & Beilock, S. L. (2013). Math Anxiety, Working Memory, and Math Achievement in Early Elementary School. *Journal of Cognition and Development*, 14(2), 187–202.

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

Rieg, S. A. (2007). Classroom Assessment Strategies: What Do Students At-Risk and Teachers Perceive as Effective and Useful? *Journal of Instructional Psychology*, 34(4), 214–225.

Sokolowski, H. M., Hawes, Z., & Lyons, I. M. (2019). What explains sex differences in math anxiety? A closer look at the role of spatial processing. *Cognition*, 182, 193–212. https://doi-org.trmproxy.mnpals.net/10.1016/j.cognition.2018.10.005

Weems, C. F., Taylor, L. K., Costa, N. M., Marks, A. B., Romano, D. M., Verrett, S. L., & Brown, D. M. (2009). Effect of a School-Based Test Anxiety Intervention in Ethnic Minority Youth Exposed to Hurricane Katrina. *Journal of Applied Developmental Psychology*, 30(3), 218–226.

Zamora, Á., Suárez, J. M., & Ardura, D. (2018). Error Detection and Self-Assessment as Mechanisms to Promote Self-Regulation of Learning among Secondary Education Students. *Journal of Educational Research*, 111(2), 175–185.

Zuffiano, A., Alessandri, G., Gerbino, M., Kanacri, B. P. L., Di Giunta, L., Milioni, M., & Caprara, G. V. (2013). Academic Achievement: The Unique Contribution of Self-Efficacy Beliefs in Self-Regulated Learning beyond Intelligence, Personality Traits, and Self-Esteem. *Learning and Individual Differences*, 23, 158–162.

Appendix

Appendix A: IRB Approval

Institutional Review Board

MINNESOTA STATE UNIVERSITY MOORHEAD

DATE:	February 2, 2021
TO:	Ximena Suarez-Sousa, Principal Investigator Ryan Christiansen, Co-Investigator
FROM:	Lisa Karch, Chair Minnesota State University Moorhead IRB
ACTION:	**DETERMINATION OF EXEMPT STATUS**
PROJECT TITLE:	[1709819-1] How the COVID-19 Pandemic Affected Student Mathematical Anxiety During Distance Learning.
SUBMISSION TYPE:	New Project
DECISION DATE:	January 25, 2021

Thank you for your submission of New Project materials for this project. The Minnesota State University Moorhead IRB has determined this project is EXEMPT FROM IRB REVIEW according to federal regulations under 45 CFR 46.104.

We will retain a copy of this correspondence within our records.

If you have any questions, please contact the Minnesota State University Moorhead IRB. Please include your project title and reference number in all correspondence with this committee.

This letter has been issued in accordance with all applicable regulations, and a copy is retained within Minnesota State University Moorhead's records.

Appendix B: School Approval

Deer River High School

JOSEPH G. AKRE
Principal – Ext. 60253
jakre@isd317.org

BRENT SCHIMEK
Dean of Students – Ext. 60210
bschimek@isd317.org

ISD #317
101 1st Avenue NE
P.O. Box 307
Deer River, MN 56636
(218) 246-8241
(218) 246-8717 - Fax

December 23, 2020

To Whom It May Concern,

This letter is to grant Ryan Christiansen permission to conduct an action research study at Deer River High School during the 2020-2021 academic year. I understand that this study poses no risk to those involved or to ISD 317. I also understand that all information will be kept confidential and will only be used for the purpose of this study.

Sincerely,
Joseph Akre
Principal

Appendix C: Letter Home

MINNESOTA STATE UNIVERSITY MOORHEAD

Teaching and Learning
Dr. Ximena Suarez-Sousa
218.477.2007
suarez@mnstate.edu

January 16, 2020

Ryan Christiansen
101 1st Ave NE,
Deer River, MN 56636

Dear Parent or Guardian,

Your child has been invited to participate in a study about mathematical anxiety due to distance and hybrid learning during COVID-19. This information will be used to help me complete a master's in math curriculum and instruction as well as to understand how to better help students post-COVID.

Your child was selected because he or she is a student in my geometry class. If you decide to let your child participate, he or she will be asked a series of questions about how they feel about math this school year. They will also be encouraged to respond with what else contributed to their mathematical anxiety, if any, during this year.

Principal Joe Akre has granted me permission to conduct this survey, and I will use this information in my final paper required to complete a master's degree at Minnesota State University Moorhead. Since this is official research, I do need your signature before your student can participate. If you sign this form, you are giving me consent to use the information that I gather in the survey. All information gathered will be confidential; no names will be used. Please note that your child can choose to not participate in the survey at any time without consequences.

Please feel free to ask me any questions you have regarding this study. You may contact me at school (218) 246-8241 or email me at rchristiansen@isd317.org. You may also contact the principal investigator Dr. Ximena Suarez-Sousa at suarez@mnstate.edu 218-477-2007 or my adviser, Dr. Belma Sadikovic, EdD, at belma.sadikovic@mnstate.edu.

You will be offered a copy of this form to keep. You are making a decision whether or not to participate. Your signature indicates that you have read the information provided above and have decided that your child may participate. Again, your child may withdraw without prejudice at any time after signing this form should you choose to discontinue participating in this study.

_____ _____
Signature of Parent or Guardian Date

_____ _____
Signature of Investigator Date

mnstate.edu
1104 Seventh Avenue South • Moorhead, Minnesota 56563

Appendix D: Survey

How anxious about your math ability were you during distance learning last year?

Not Anxious at All 1 2 3 4 5 Not anxious at all

How anxious about your math ability were you entering geometry this fall?

Not anxious at all 1 2 3 4 5 Not anxious at all

How anxious have you been when taking Geometry tests this year (or most recent test)?

Not anxious at all 1 2 3 4 5 Not anxious at all

Has knowing that you can retake an assessment if you fail it reduced your anxiety during the first attempt?

Very helpful 1 2 3 4 5 Does not help

How has the process of ranking yourself with emojis before you start a lesson and then reflecting on it when you take the review?

Very helpful 1 2 3 4 5 Does not help

How well have you been able to self-evaluate your ability this year?

Very well 1 2 3 4 5 Not at all

How has your mathematical anxiety changed this school year?

- Gotten worse
- Somewhat worse
- Stayed the same
- Somewhat better
- Gotten better

What activities or resources have helped you be more confident in Geometry this year?

Why do you feel these resources have helped you?

Has anything specific made you less confident in Geometry this year?

How do you feel that these items have made your anxiety worse?

Appendix E: Script

Script to read to students before survey

Good morning/afternoon, students. Today we are going to take a survey about mathematical anxiety.

Mathematical anxiety is that nervous feeling you may get when you are put on the spot to solve a math problem.

The feeling of being overwhelmed by the problem can make you perform worse on the math problem than what your ability is.

This can happen when a teacher calls on you, during a big quiz or test, or when you have a 79 on an IXL and you don't want to miss the problem.

This feeling can affect how your memory works. It may cause you to make a mistake on the problem that you would not have made otherwise, if you had been relaxed.

This survey is going to ask you some questions about how anxious you have been about math during distance learning last spring, returning to school in the fall, and now during hybrid learning.

This survey is also going to ask for feedback on what has affected your anxiety this past year.

Do you have any questions about what mathematical anxiety means?

This survey will also ask you about retaking assessments and self-evaluation with the emoji scale.

Have you retaken an assessment this year? Has knowing that you are allowed to retake an assessment helped to reduce your anxiety this year?

Before a lesson is introduced, you are asked to rank yourself with emojis based on how much you know about the topic before a lesson, and then again on the review before the assessment. The idea is to make you think about how much you have learned, and to make you more confident about your ability to solve that type of problem on the test.