

REDUCING MATH ANXIETY IN ELEMENTARY STUDENTS

Master Capstone Project

Reducing Math Anxiety in Elementary Students

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I give permission to City University to store and use this MIT Project for teaching purposes.

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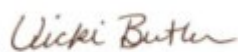


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Abstract

This classroom action research study sought to determine strategies for alleviating math anxiety in fourth grade students. The study used a survey, math assessment data, and observational field notes to analyze the effectiveness of affirmations and intentional interactions with students in reducing anxiety. Through comparing survey results and observation notes taken over a four-week period, this study found that intentional interactions alleviated anxiety during a task but did not have a long-term effect. Classroom environment and relationships with instructors, however, were found to have an effect over the course of the school year.

Keywords: Mathematics anxiety, instruction strategies, intervention strategies

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Introduction

The first time I was aware of math anxiety in my fourth-grade students was when I noticed that one student would cover his workbook whenever my mentor or I would walk by. I knew that he was hiding that he hadn't written anything during group work time, but when we asked if he needed any support, he would say no. I began noticing behaviors in other students during math as well. One student would become visibly frustrated when called on, while others would be hesitant to answer questions or ask for help. Although these behaviors appeared during instruction of other subjects, they always seemed more severe during math instruction.

These students were also returning from virtual and hybrid learning due to the COVID-19 pandemic. The affect this disruption to their learning would have both in the short term and the long term was still unknown. Predictive models suggest that the COVID-19 pandemic will widen the achievement gap (Bailey, et al., 2021). The effects on student anxiety are still unknown. I wondered if the anxiety I was seeing in my students was heightened by the pandemic, or if it was something students experienced before the pandemic.

In this action research study, I sought to determine factors affecting levels of student mathematics anxiety and intervention strategies to alleviate it.

Problem Statement

The concept of mathematics anxiety (MA) has existed for more than 60 years (Dowker, et al., 2016). This anxiety interferes with students' ability to solve mathematic problems. The COVID-19 pandemic has interrupted learning for a year and a half, exacerbating anxiety for students trying to catch up with the widening achievement gap (Bailey, et al., 2021).

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Observing my fourth-grade students, math anxiety manifests in several ways. The most common ways are hesitation to share ideas or write answers and frustration. These behaviors continue even when instructors confirm that students are correct or on the right track.

Baseline data shows that students observed to have anxiety during math instruction placed one to three grade levels below their actual grade on the iReady diagnostic test. These students have also been identified as needing small group intervention. They perform well on math problems that involve only calculation, but struggle during whole-class instruction and with more complex word problems.

Rationale

As I've seen with my own students, math anxiety can have a negative impact on student learning and achievement. Researchers have found that when students are not proficient in grade-level math in the elementary grades, it can lead to a lack of proficiency through the rest of their education (Pool, et al., 2012). There is also a high negative correlation between MA and self-efficacy, or one's belief in their own abilities, and growth mindset (Rozgonjuk, et al., 2020). Self-efficacy and growth mindset are related to achievement in all subject areas, not just math, and can impact a student's ability to succeed throughout their education as well as through their adulthood and career. Therefore, alleviating MA in elementary students may have a lifelong impact.

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Literature Review

Students face a widening achievement gap due to the COVID-19 pandemic (Bailey, et al., 2021). For elementary students to be proficient in math later in their education, they must bridge the growing gap and become proficient during their elementary years (Pool, et al., 2012). Mathematics proficiency is becoming increasingly important in the age of technology, however only 7% of Americans have reported positive experiences with math (Harari, et al., 2013). A barrier to this proficiency is math anxiety (Dowker, et al., 2016).

Math anxiety was first documented over 60 years ago and can be defined as “a feeling of tension and anxiety that interferes with the manipulation of numbers and the solving of mathematical problems in [...] ordinary life and academic situations” (Dowker, et al., 2016). Though not totally separate from other forms of anxiety, MA is closely related to math performance (Dowker, et al., 2016). This is significant because researchers have found that failing to develop math skill proficiency in primary grades leads to difficulty later in education and may cause students to need targeted intervention in math (Pool, et al., 2012).

MA is affected by various internal and external factors (Rubinsten, et al., 2018). One internal factor is the type of motivation students have (Skaalvik, 2018). Students with extrinsic motivation – motivated by rewards – often demonstrate MA because they are motivated by appearing competent or not appearing incompetent (Skaalvik, 2028). Other internal factors include anxiety- and numerosity-related brain functions, genetic expression of anxiety, and anxious cognitive style such as General Anxiety Disorder (Rubinsten, et al., 2018).

An example of an external factor that may play a role in MA is teacher math anxiety. Higher teacher math anxiety is associated with lower achievement and a reduction in process-oriented – rather than ability oriented – teaching practices (Ramirez, et al., 2018). This impact on

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achievement can push students off track in elementary school, leading to difficulties later (Schaeffer, et al., 2020). Another external factor is parenting style. A student whose parents feel insecure about math or have deficient math skills is more likely to have higher MA (Rubinsten, et al., 2018).

Language & Math Anxiety

Another factor that effects math achievement and therefore may be linked to MA is English proficiency (Henry, et al., 2014). Researchers in one study of elementary students found that English proficiency is a “statistically significant predictor of mathematics scores” (Henry, et al., 2014). In this study, it was discovered that math scores increased simultaneously with English proficiency. This does not mean that English language learners are less proficient at math, rather that their language proficiency correlates with scores on state assessments that are administered in English. That correlation may be due to the complexity of the language used in the assessments and the ability of ELLs to access the questions (Martiniello, 2008). By looking at the linguistic complexity of a state math assessment and analyzing student think-aloud transcripts, Martiniello found that “greater linguistic complexity increases the difficulty of English math items for ELLs compared to non-ELLs of equivalent math proficiency” (2008). MA encompasses negative reactions and confidence around math concepts and skills (Harari, et al., 2013). Additional complexity due to language proficiency may link to higher MA in ELLs, but language background is not a determiner of MA (Harari, et al., 2013). Since language background does not correlate with MA but proficiency does correlate to math proficiency (Henry, et al., 2014), more research needs to be done on how ELLs experience MA and how language interacts with other contributing factors.

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Gender & Math Anxiety

Many studies have looked at the role of gender and its influence on MA (Dowker, et al., 2016). The general consensus is that although females tend to show little or no difference in math performance, they typically rate themselves lower and exhibit more MA (Dowker, et al., 2016). For example, Rozgonjuk, et al., found that females with lower self-efficacy typically had higher levels of MA (2020).

There are multiple possibilities for why this difference has been observed. One possible source is the role of gender stereotypes as well as the influence of MA in female teachers (Dowker, et al., 2016). In their research, Dowker, et al., also point to more general differences in anxiety between males and females, explaining that females tend to show higher levels of general anxiety and clinical anxiety disorders (2016).

The difference in levels of anxiety between genders seems to occur more in adolescence and not during the primary grades (Dowker, et al., 2016; Harari, et al., 2013). In their research, Harari, et al., found that differences between genders and MA do not emerge even until adulthood (2013). These studies point to gender as not being a factor when examining MA in elementary students.

Age & Math Anxiety

Research into MA thus far seems to indicate that MA is more prevalent in adolescence than the primary grades (Dowker, et al., 2016). Harari, et al., determined that past research saw MA as typically emerging around sixth grade, because children have had time to internalize negative feedback, the math curriculum is difficult enough to elicit strong emotions, and children have developed the ability to report on their MA (2013). In the same study, however, researchers looked further into the potential for MA in students as early as first grade (Harari, et al., 2013).

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They found that even young children exhibit MA, but that at this age, MA is not related to performance and negative feedback, but rather preconceived ideas around math that students have learned from peers, families, and society (Harari, et al., 2013). Harari, et al., point to a need for further research into MA in early grades as their evidence is still preliminary (2013).

Symptoms of Math Anxiety

Math anxiety is non-static in nature, meaning students experience varying degrees of MA in different situations, caused by differing factors (Kelly, 2016). It is a “dynamic interplay between environmental [...] and intrinsic factors [...]” (Rubinsten, et al., 2018). This mix of factors can either prevent or promote MA’s effects on the development of adaptive or maladaptive behaviors as symptoms (Rubinsten, et al., 2018). Researchers Rubinsten, et al., determined that these behaviors fit into five continuums: physiological (relaxed to aroused), emotional (confident to anxious), educational (success to failure), attitude (positive to negative beliefs), and behavioral (pursuit to avoidance) (2018). It is important to note that while negative attitudes may correlate to MA, they alone cannot be equated to MA, and thus should not be considered separate from the other continuums (Dowker, et al., 2016).

In another study, Skaalvik, et al., determined that maladaptive behaviors aim to direct other people’s attention away from failure or perception of low abilities (2018). This is accomplished through self-handicapping such as procrastination or lack of effort as well as concealing one’s results and shortcomings. The former happens prior to the learning process or assessment, meaning the student begins the process already having lower self-efficacy. The latter happens during or after the learning or assessment. Both approaches align with the findings of Dowker, et al., that “people who think they are bad at mathematics are more likely to be anxious” (2016).

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Students with MA also display learned helplessness, feeling discouraged or having given up on trying to learn math (Yates, 2009). These students give up when math tasks become too difficult and respond badly to failure (Yates, 2009). Therefore, MA may be characterized by motivation to appear competent or hide incompetence (Skaalvik, 2018) or lack of any motivation (Yates, 2009).

While learned helplessness and fixed mindset are often characterized by statements verbalized by students, MA is also communicated through non-verbal behaviors (Kelly, 2016). In her research, Kelly found that students displayed MA through behaviors such as keeping their head down, avoiding eye contact, and frequently erasing their work (2016). Although multiple students may exhibit similar behaviors such as these, their experiences with MA may still be very different from one another (Kelly, 2016).

Assessment of Math Anxiety

The most common method of measuring MA in research is the use of questionnaires and rating scales, such as the Mathematics Anxiety Research Scale and the Mathematics Attitude and Anxiety Questionnaire (Dowker, et al., 2016). These scales and questionnaires have generally been found to be reliable, however their accuracy may be influenced by the accuracy of the student's self-reporting and their truthfulness (Dowker, et al., 2016). To address this issue, some studies have attempted to look at more physiological measures, such as heart rate and cortisol secretion (Dowker, et al., 2016).

Another form of rating scale or questionnaire is those that are completed by the teacher or researcher, such as a student behavior checklist (Yates, 2009). These are completed by an observer of the students and reflect observed behavior rather than self-perceptions. Similar to

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student-completed questionnaires, these measures may be influenced by the accuracy of the one doing the reporting and their bias towards the student and behavior (Dowker, et al., 2016).

Instructional Interventions

One route of addressing MA is through intervention targeting math skills. Small group instruction with visuals, step-by-step process, and explicit instruction has shown to alleviate math anxiety (Kelly, 2016). To determine the function of student learning difficulties and match effective interventions with their needs, instructors can use brief experimental analysis (McKevett & Coddling, 2021).

There are two aspects to targeted intervention that make it the less ideal method for alleviating MA. First, although intervention can lead to student growth, the amount of growth varies by the breadth of content being taught, the target operation, initial student performance, and other features of the intervention and the people involved (Solomon, et al., 2020). The effectiveness of the intervention in alleviating MA is dependent on the students receiving the intervention and what is covered in the intervention (Solomon, et al., 2020). Because students may have a unique range of factors contributing to their MA (Kelly 2016), intervention success varies with the role of these factors and how they are addressed (Solomon, et al., 2020).

The second aspect is that student engagement in the intervention has a positive association with math performance, while the quality of the intervention does not (Nelson, et al., 2020). If a student is not engaged in the intervention, whether intentionally or not, their performance will not benefit from the instruction, regardless of its quality.

Environmental & Social-Emotional Interventions

Another means of alleviating MA has to do with classroom environment and mindset. Math anxiety has a high negative correlation with math self-efficacy, or a student's belief in their

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ability to perform well in math (Rozgonjuk, et al., 2020). Some researchers found the implementing social-emotional learning (SEL) practices was one method of promoting self-efficacy and reducing anxiety (Griggs, et al., 2013). Researchers in this study compared the self-efficacy in students in schools that implemented SEL practices from Responsive Classroom (RC) to students in other schools and found that students in the RC schools exhibited higher self-efficacy. RC classrooms focus on four areas: engaging academics, positive community, effective management, and developmentally responsive teaching (Responsive Classroom, 2022). These domains support building a classroom environment that promotes self-efficacy and growth mindset (Responsive Classroom, 2022). RC practices also benefit students who exhibit learned helplessness, as these students typically show a lack of motivation and RC practices promote building up self-efficacy (Responsive Classroom, 2022; Yates, 2009).

Different kinds of motivation and associated coping strategies influence self-efficacy and MA. For example, one researcher determined that students had three different goal orientations (Skaalvik, 2018). Skaalvik found that students with the mastery goal orientation focused more on task completion than outcomes and typically used less maladaptive coping strategies when faced with difficult problems. Students with the performance-approach goal orientation were focused on demonstrating competence, and those with performance-avoidance goal orientation were focused on not demonstrating incompetence. Both performance focused orientations correlated with higher use of maladaptive coping strategies (Skaalvik, 2018). The mastery goal orientation is similar to the idea of intrinsic motivation, which is the internal drive to be successful. Lv, et al., found that higher intrinsic motivation correlates with higher achievement (2019). The results of these two studies support the idea that students with higher intrinsic motivation and a mastery goal orientation are likely to have higher achievement and lower MA.

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Cognitive-behavioral therapy (CBT) may be a means for teaching positive coping strategies and reducing MA. For example, one intervention called “the Coping Cat” strategy was found to reduce the math anxiety in an elementary school student (Guimarães, et al., 2021). This strategy involves teaching calming and relaxation techniques such as breathing techniques as well as reframing of negative thoughts and self-talk. Another group found that CBT can reduce MA when focused on cognitive math anxiety, which consists of negative expectations and self-deprecatory thoughts toward an anxiety-causing situation in math (Bicer, et al., 2020).

Summary

Overall, the literature on MA points to the need for a classroom environment that is safe and conducive to learning (Gerstner, 2017) that promotes growth mindset in students and teachers. Student self-efficacy can be promoted through SEL practices as well as CBT. Instructional interventions may be effective, but this depends on factors regarding individual students. Intervention strategies that include SEL practices, CBT, and promoting growth mindset appear to be the most effective means of alleviating MA.

Where more research needs to be done is in the direction of the relationship between self-efficacy and MA. In their study, Dowker, et al., pose the question: “does anxiety lead to a lack of confidence in one’s own mathematical ability, or does a lack of confidence in one’s mathematical ability make one more anxious?” (2016). All the literature reviewed seems to suggest that this relationship is bidirectional, meaning self-efficacy and MA affect each other, however more research needs to be done to be certain.

More research also needs to be done on the roles of language, gender, and age on MA. Overall, the literature points to all three factors as not having significant roles in elementary

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student MA. However, this research is still preliminary and may provide starting points for further research of MA in young children.

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Question

The question this research is attempting to find solutions for is the following: *What intervention strategies support fourth-grade students who struggle with mathematics anxiety?*

Methodology

Context

This action research study was conducted in a fourth-grade classroom at a suburban elementary school in Bothell, Washington. There were 527 students enrolled at the school during the 2021-22 school year. About 44% of students were White, 23% Hispanic/Latino, 19% Asian, 5% Black/African American, and 8% as two or more races. Roughly 27% of students were English Language Learners (ELLs). 39% of students came from low-income households, with many of them living in a nearby low-income housing apartment complex.

Participants

The participants of this study were 28 fourth-grade students ages 9 and 10. 11 were male and 17 were female. Two students had IEPs and one had a 504 plan. Four students were active ELLs and three were monitor ELLs, meaning they were no longer receiving services, but their progress is monitored in case further support is needed.

Intervention

A list of math affirmations will be presented to students before two state math assessments and the iReady math diagnostic. Students will be asked to choose one that fit them or create their own. Students who feel comfortable will share the affirmations they chose or created with the class. The researcher will also share an affirmation.

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The researcher will focus on intentional interaction with students when behavior is observed that may be related to MA. These interactions include reframing negative self-talk (e.g., reframing “I’m not good at math” to “I’m still learning”) and fixed mindset (e.g., reframing “This is too hard” to “I can try a different strategy”). Interactions will also include encouragement and instructional scaffolding.

Data Gathering Instruments/Assessments

Assessment #1: Math Interest Inventory (Appendix A). The researcher administered this survey to gauge student attitude toward math. The survey was administered on paper.

Assessment #2: iReady Diagnostic. Students took the iReady diagnostic tests for reading and math in the fall, winter, and spring of the school year. The diagnostics were taken on the computer on the iReady website.

Assessment #3: Behavior Observation. The researcher recorded field notes of behavior relating to math anxiety and behavior after intervention over a period of four weeks, starting during the math state assessment.

Action Research Cycles

This action research study began with a math interest inventory survey (see Appendix A). The 28 students completed the survey independently. The surveys, which were not anonymous, would be compared with behavior observations collected later in the study. At the beginning of the observation period, students were introduced to a list of math affirmations and instructed to pick one that resonated with them or to create their own affirmation to better fit their needs. The students were shown this list two more times during the observation period before they were about to take the state math assessment or the iReady math diagnostic. The observation period took place over four weeks. During this time, intervention focused on intentional interactions

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with students at the time of behavior related to math anxiety. These interactions included encouraging students, reframing their negative self-talk or fixed mindset, and scaffolding their learning to help them be successful at a math task.

Results

On the math interest inventory (see Table 1), most students were either neutral or felt negative about working by themselves during math. Most students also felt neutral about being called on by the teacher or answering questions. The only students who did not show these responses to either statement were students who exhibit little to no behaviors indicating MA.

iReady diagnostic results showed that 25 of the 28 students met their typical growth goal. 19 of those students also met their stretch growth goal. On the fall diagnostic, 19 students placed one or more grade levels below fourth grade, while on the spring diagnostic 22 students placed at or above grade level. Of the students who exhibited MA, only two showed very little growth.

Behavior field notes during the observation period show that many students exhibited less anxiety after interactions and were able to complete tasks. This behavior, however, seemed temporary and would not carry over to later tasks.

Conclusions

The math interest inventory showed no correlation to observed math anxiety. There were trends in how all 28 students responded to the statements. For example, 24 of the 28 responded positively to item 12, “I like playing games about math” (see Table 1). One possible reason the survey results do not correlate to observed MA is that students were concerned about the lack of anonymity and pleasing the teacher. Although students were told to be honest and there were trends of negative attitudes towards specific statements, students may have worried about how the teacher would view their responses. This reason seems likely when looking at the survey

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completed by a student who exhibits anxiety in math as well as other subjects. On his survey, he selected the smiley face for all the statements except “I like working by myself in math class.” However, on two of the statements, he initially selected neutral answers but erased those and changed his answer to the smiley. One explanation for this may be that the student was worried about what the teacher would think about him if he answered in a way that might be perceived as negative. Another explanation is that the survey statements were not specific enough to situations that lead to MA. For example, students may agree with item 1, “I like answering questions during math class”, except when they are uncertain about the answer. One student wrote on his survey that he only felt positive on this statement when he knows the answers to the questions. This suggests that the statements need to be more specific to correlate to situations that cause MA. A third explanation is that observational data may be flawed. Since there were 28 students being observed, more disruptive and obvious behaviors were noted while other behaviors could easily be missed. It is also possible that behaviors may have occurred but the connection between those behaviors and MA (or lack thereof) was not made.

The results collected from the iReady diagnostics did not seem to correlate with MA. Most students showed growth in their overall placement over the whole year, regardless of their level of MA.

Field notes reveal that positive encouragement, reinforcement, and reframing had a positive short-term effect on MA. For example, one student who frequently voiced negative self-talk or a fixed mindset became more successful when her statements were reframed and when she received encouragement. Upon completing the task, she would become excited, however she would typically return to her prior behavior when she was given another task she perceived as

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difficult. Similar behavior with the other students was noted, suggesting that interventions were successful in the short-term but not the long-term.

Though observation notes suggest no long-term effect of the interventions, overall behavior change does. Promoting growth mindset and an environment where students feel safe to make mistakes was a goal throughout the whole year of myself and my mentor, and many students have shown growth in their mindsets and self-efficacy. For example, the student who used to cover his work every time we walked by eventually began asking for help and stopped hiding his work. Though this is the same student who seemed to have severe anxiety beyond just math, he made progress in his willingness to ask for help. A similar trend was seen in other students as well. Many who were hesitant to seek help or share ideas at the beginning of the year became less so as the year progressed and showed significant academic progress as well. This suggests that promoting self-efficacy and growth mindset does have a long-term effect.

Implications

The implication of this research is that the intentional structuring of the classroom environment and routines at the beginning of the year as well as relationship building with students may reduce student math anxiety. There is a wide range in the level of MA students have, the factors that contribute to it, and the behaviors they have because of it. Therefore, the way a student experiences MA is unique to them and their background. Although targeted intervention can help students progress with specific skills or concepts, the best way to address MA throughout the whole class is through building an environment where students feel safe to make mistakes and building relationships of trust and support between the students and the instructor.

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Limitations

A limitation of this study was the time frame. Only short-term impacts of the interventions were noticed in the four-week period, but long-term effects could not be studied. Furthermore, growth over the whole year was noticed. Observations of this growth could not be validated since notes were not being kept over the whole year, so this growth is anecdotal.

Recommendations

Further research might look at the results of these interventions over the course of a full school year. For example, students could be introduced to the affirmations at the beginning of the year. Observation of behavior over a full year may also provide more insight into how students change in the long term.

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Appendix A

Math Interest Inventory

Directions: Color the face that matches your feelings.	
☺ ☹ ☹	1. I like answering questions during math class.
☺ ☹ ☹	2. I like when the teacher calls on me.
☺ ☹ ☹	3. I like working by myself in math class.
☺ ☹ ☹	4. I like working with a partner in math class.
☺ ☹ ☹	5. I like working with a group in math class.
☺ ☹ ☹	6. I like doing math homework.
☺ ☹ ☹	7. I like having someone help me with math.
☺ ☹ ☹	8. I like helping other people in math.
☺ ☹ ☹	9. I like learning something new in math.
☺ ☹ ☹	10. I like using manipulatives to help me learn.
☺ ☹ ☹	11. I like drawing pictures to solve problems.
☺ ☹ ☹	12. I like playing games about math.
☺ ☹ ☹	13. I like telling how I solve problems.
☺ ☹ ☹	14. I like writing about math.
☺ ☹ ☹	15. I like working on the computer or Active Board.

Note: This survey was created by Shae Hare and retrieved for free from

<https://www.teacherspayteachers.com/Product/Math-Interest-Inventory-Back-to-School-Activity-for-Teachers-and-Students-254449?st=20612026582ed84229e85b569be27b28>

Manipulatives were explained to students as items used to model in math, such as fraction tiles and base-ten blocks. Students were told that an “Active Board” meant interactive panel, which is the terminology used for the one used in the classroom.

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Appendix B

Table 1

Math Interest Inventory Response Distribution

Item	Number of ☺	Number of ☹	Number of ☹
1	15	12	1
2	12	13	3
3	8	11	9
4	18	8	2
5	18	8	2
6	19	6	3
7	15	12	1
8	20	7	1
9	23	4	1
10	10	13	5
11	17	9	2
12	24	3	1
13	14	9	5

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14	13	10	5
15	19	9	0

Note: Item refers to the numbered statement from the survey. The remaining three columns indicate the number of students who selected each response for each item.

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Author's Note

I am a graduate student in the Department of Education at City University of Seattle, working towards a Master's in Teaching degree. I've lived in Washington my whole life, and I hope to one day teach in the same school district I attended as a student. My own experiences with anxiety and education inspired this study, and I hope to continue this research after seeing the substantial role of anxiety in my student teaching placement.

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Dissemination Plan

I recommend more research be done on specific practices for addressing the unique factors contributing to student math anxiety. However, I believe this study provides enough evidence to recommend focus on SEL practices that address growth mindset and self-efficacy as well as practices of intentional relationship and environment building at the beginning of each school year.