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Investigating Correlations Among a Growth-Mindset Intervention, Students' Math Anxiety, and Students' Math Self-Efficacy

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Abstract

This paper details the methodology, data, and conclusions of a research study investigating the correlations among a growth-mindset intervention, math anxiety, and math self-efficacy. The study found that teaching students about mindset through an intervention approach did not make a significant difference in students' math anxiety or math self-efficacy. Teacher-centered factors are discussed as having a greater impact on students' math anxiety and math self-efficacy.

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The Implicit Theory of Intelligence states that there are two types of *mindsets*, fixed and growth, that individuals hold about the nature of their intelligence and abilities (Alvarado, Ontiveros, & Gaytan, 2019). An individual with a *fixed mindset* believes that intelligence is a "dispositional attribution" (Samuel & Warner, 2021). They believe that everyone is born with a certain amount of intelligence that cannot be changed throughout the course of their life. They believe that any and all mistakes, perceived as failures, are evidence of inadequate intelligence (Samuel & Warner, 2021). On the other hand, an individual with a *growth mindset* believes that skills, abilities, and intelligence can be developed and grown through perseverance and hard work. To someone with a growth mindset, mistakes are not seen as failures, but rather an opportunity to try a different approach and learn from that experience (Samuel & Warner, 2021).

While mindset is not a popular topic of conversation, anxiety is a hot topic known to almost everyone. Contrary to popular belief, *math anxiety* is a unique type of anxiety that differs from test anxiety (Chang & Beilock, 2016). Specifically, math anxiety refers to a negative emotional response that occurs when both thinking about math and doing math (Samuel & Warner, 2021). Math anxiety is also defined as "a feeling of tension and anxiety that interferes with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (Ahmed, 2018, p.158). Quite opposite to math anxiety, *math self-efficacy*, a measure of self-confidence, is the degree to which one thinks he or she has the ability to be successful at a given task regarding math (Samuel & Warner, 2021).

Math anxiety, a global phenomenon, is one of the most prevalent types of anxiety in schools (Ahmed, 2018). The 2012 Programme for International Student Assessment found that

33% of 15-year-old students feel helpless when solving math problems (Chang & Beilock, 2016). In a world where jobs in the fields of science, technology, engineering, and math (STEM) are increasingly in demand, this statistic raises a startling question regarding the future and the large role played by today's youth. When students experience anxiety when encountering math, they are more likely to have a decreased interest in math-related fields (Samuel & Warner, 2021). In fact, one study found that students categorized in a consistently low math anxiety category were 7.4 times more likely to pursue a career in a STEM field compared to students in a consistently high math anxiety category (Ahmed, 2018). Researchers from the University of Chicago's Department of Psychology concluded that "the widespread negative relation between math anxiety and performance…demonstrates the importance of addressing math anxiety in order to advance math performance, and STEM achievement more broadly" (Foley et al., 2017, p.55).

If students do not get the help and support they need to be confident in their mathematical abilities, they will continue to shy away from challenges and mathematics altogether, not only in their educational journeys but in their career choices, as well. Society needs math-confident and math-eager individuals to pursue careers in the ever-growing STEM fields to accommodate the changing and developing world.

Literature Review

To begin addressing this problem, it is important to become familiar with the current research that exists. Several studies have been done over the past few decades regarding the connection between mindset and well-being, mindset and achievement, mindset and stereotypes, and the three-way relationship between anxiety, self-efficacy, and mindset.

Mindset and Well-Being

A recent study of 1,240 randomly selected undergraduate students from a large, private university in Mexico found that a growth mindset had a strong, positive correlation to academic performance as well as a moderate, positive correlation to overall well-being (Alvarado et al., 2019). The students completed a subjective survey that measured well-being in the domains of positive emotions, relationships, engagement, accomplishment, and meaning.

Mindset and Achievement

In addition to being studied on their well-being, the undergraduate students who participated in the study by Alvarado et al. also completed a survey to assess the relationship between their mindset and academic performance. Mindset was studied as being either growth or fixed, and academic performance was measured by semester grades. The study suggests in its discussions that developing growth mindsets in students is a powerful way to increase achievement in emerging countries where educational inequality abounds (Alvarado et al., 2019). This idea could be applied to any area with little access to resources, even certain areas within the United States. Perhaps most important to the issue at hand, the authors discuss previous research that suggests students can shift from a fixed mindset to a growth mindset, thus implying that the achievement correlated with a growth mindset is attainable for *all students* (Blackwell, Trzesniewski, & Dweck, 2007).

Among all research that has been done on mindset, Carol Dweck is a psychologist who stands out in her field of such studies. She has conducted much research throughout her career and concluded that "it is precisely because of their focus on learning that growth mindset students end up with higher performance" (Dweck, 2009, p. 5). This is attributed to taking charge of the learning process, managing time efficiently, studying more deeply, staying motivated, and following the growth mindset's cardinal rule: "learn, learn, learn!". Dweck also found that praising students' strategies or efforts, as opposed to praising their performance, helped students to develop a growth mindset and stay motivated even through difficulty or setbacks (Dweck, 2009). These findings are applicable to fields outside of educational achievement and are often used in athletics, as well.

Mindset and Stereotypes

Stereotypes, biases, and prejudices play a role in mindset, as well. A study done by researchers in Seoul, South Korea, worked with 238 fourth-grade students. The experimental group of students participated in six biweekly sessions about growth mindset and anti-stereotyping. The anti-stereotyping emphasis was on equal ability between males and females. The researchers found that "the students in the intervention condition demonstrated a growth mindset, perceived competence, and persistence in math that were significantly stronger than those reported by the students in the control condition" (Lee, Lee, Song, & Bong, 2021, p. 9) as revealed on pre-intervention and post-intervention surveys. The study did not find a significant difference in the mathematical achievement of the students from either group, but the achievement of the students in the control group did fall significantly over time (Lee et al., 2021). This finding seems to beg the question of the necessity of a control group given a study done in a shorter period of time. Additionally, one might wonder if depriving the students in the

control group of the intervention would actually have a negative effect on their achievement and well-being. Another question that this study raises is the influence of gender on mindset. Students who participated in the intervention were found to have weaker math-gender stereotype beliefs (Lee et al., 2021), but it is unclear whether or not there was a significant difference between genders and the mindset they held.

Mindset, Anxiety, and Self-Efficacy

Combining several of these mindset factors, Kaskens, Segers, Goei, van Luit, and Verhoeven (2020) conducted a study with 610 fourth-grade students in the Netherlands. In attempting to understand how the development of their academic fluency and problem-solving skills were influenced by their math self-concept, math anxiety, and math self-efficacy, they found interesting results. They measured arithmetic fluency by the child's ability to add, subtract, multiply, and divide basic numbers quickly and accurately. Mathematical problem-solving was defined as a child's ability to apply mathematical knowledge, skills, and procedures in order to solve real or hypothetical problems (Kaskens et al., 2020). The researchers concluded that math self-concept was the only predictor of a child's mathematical development in terms of arithmetic fluency. It is interesting to note that a child's math anxiety was not predictive of their mathematical development, as one expects students who are highly anxious about math to be less successful in the subject. However, the discussion attributes this finding to the fact that anxiety tends to increase during childhood, so the fourth-grade participants were less likely to experience anxiety or math anxiety to the extent that it influenced their development. Another interesting finding from this study was the negative relationship between the teacher's self-efficacy and the students' mathematical development of problem-solving. The researchers suggest that teachers may not understand how complex it is for children to understand problem-solving and the

instructional skills it requires (Kasken et al., 2020). This finding demonstrates how important the teacher's role is in the development of a student's self-efficacy and mathematical development.

A final study, conducted by Tashana S. Samuel and Jared Warner at Stella and Charles Guttman Community College in New York, emphasizes just how much teachers and their classroom environment make a significant impact on the amount of math anxiety a student experiences and the amount of math self-efficacy that student possesses. This study followed 32 first-year undergraduate students through their required, two-semester introductory statistics course. The experimental cohort participated in routine mindfulness and growth mindset intervention at the beginning of each class session, while the control group did not receive this intervention. The instructor-led intervention consisted of deep breathing exercises and reciting positive affirmations about mathematics. Throughout the course of the day's lesson, the instructor continued the intervention by encouraging students to be engaged and take a deep breath if they were feeling overwhelmed, emphasizing openness to feedback, and offering students praise to create an environment of positivity and perseverance. When students were overheard making fixed mindset comments, the instructor helped the student reframe their thinking to shift toward a growth mindset perspective. In order to evaluate the effectiveness of the interventions, students took pre and post-surveys to assess their levels of math anxiety and math self-efficacy. Math anxiety and math self-efficacy were measured by the Revised Math Anxiety Scale (RMAS) and the Math Self-Efficacy Scale (MSES), respectively. The results of the study suggested that by the end of the semester, the students who received the intervention, the experimental group, had lower levels of math anxiety and higher levels of math self-efficacy. The students also reported that beginning the class with deep breathing exercises and positive

affirmations gave them a boost of confidence and a fresh start to begin the class (Samuel & Warner, 2021).

After examining the research that has been done, there are many studies that discuss the relationship between either anxiety and achievement or achievement and mindset, in addition to the study by Stella and Warner that examines the three-way relationship between mindset, anxiety, and self-efficacy in college students. However, I was unaware of research that examined the three-way relationship between mindset, anxiety, and self-efficacy in the adolescent age group, specifically middle school or high school. Specifically, my research question was, *"How does a growth-mindset intervention correlate with middle school students' math anxiety and math self-efficacy?"*.

Methodology

Subjects

The subjects of my research were middle school students at Danbury Middle School in Lakeside-Marblehead, Ohio. Specifically, the study consisted of 33 seventh-grade math students, divided into two class sections, and 34 eighth-grade math students, also divided into two class sections.

Pre-Survey

All students were given a pre-survey in November to assess their math anxiety and math self-efficacy. Students responded on a Likert scale from one to five (one = *strongly disagree*, five = *strongly agree*) with how much they agreed with the following statements, adapted from the RMAS and MSES surveys:

1. I feel nervous when I go to math class.
2. I am afraid to ask and answer questions in math class.
3. I feel uneasy when I am asked to go to the board or present my work to the class.
4. I am worried that I will not be able to keep up with the rest of the class.
5. I am worried about being called on in math class.
6. I feel uneasy when thinking about an upcoming math test.
7. I feel nervous when we start a new topic in math class.
8. I am afraid of my math teacher giving a pop quiz.
9. I feel uneasy when I am waiting to get a math test grade.
10. No matter how much effort I put in, I cannot understand math.
11. I know I can do well in math class.
12. I have the ability to become a good student in mathematics.

13. I feel confident when I am doing math.
14. I doubt that I will do well in math class, even when I study.
15. Usually, I feel unable to solve math problems.
16. I am not one of those people who was born to do math.
17. I do not think I could handle more difficult math.

Anxiety and Self-Efficacy Scores

Student responses from questions 1-9 were used to give students an *anxiety score* where a maximum score of 45 indicated the highest possible level of math anxiety. Their score was determined by the sum of their responses on the Likert scale. Student responses from questions 10-17 were used to give students a *self-efficacy score* where a maximum score of 40 indicated the highest possible level of math self-efficacy. Questions 10, 14, 15, 16, and 17 were reverse-coded when determining the self-efficacy score. For example, if a student responded with a 1 (*strongly disagree*) to question 17, that response indicates that the student believes he or she would be able to handle more difficult math. In this case, the student was demonstrating high self-efficacy, so the response of 1 (*strongly disagree*) was reverse-coded to a 5 for the purpose of determining the self-efficacy score. Similarly, responses of 5 (*strongly agree*) were coded as a 1, responses of 2 (*disagree*) were coded as 4, and responses of 4 (*agree*) were coded as a 2. Responses of 3 (neutral) stayed the same. The sum of the coded responses and the raw responses from the uncoded statements determined each student's self-efficacy score.

Growth-Mindset Intervention

At the beginning of March, one seventh-grade math section and one eighth-grade math section participated in a growth-mindset intervention. The intervention consisted of two 30-minute sessions over two weeks. In the first session, students were introduced to the concept

of a mindset, learned about the differences between a fixed and a growth mindset, and did a self-assessment for the type of mindset they held at the time. In the second intervention session, students recapped what they had previously learned about fixed and growth mindsets, examined the benefits of having a growth mindset, and were introduced to various strategies to develop and maintain a growth mindset.

Post-Survey

Following the intervention, all students in the study were again given the anxiety and self-efficacy survey and given an anxiety score and self-efficacy score based on their responses. The same process for determining the pre-scores, including the reverse coding, was followed to determine the post-scores.

Analysis Process

The first step of the analysis process was looking at each individual student's pre-scores and post-scores for anxiety and self-efficacy to determine if there were increases, decreases, or no changes from November to March. This was important in order to understand how many students had improvements in the areas of anxiety and self-efficacy. Specifically, a reduced anxiety score, increased self-efficacy score, or a combination of both, indicated improvements. The next step was to determine how much those scores increased or decreased. The differences were calculated between each student's pre- and post-scores in order to calculate this change. This was important to understand which students had the greatest change and the mean score changes for both the experimental and the control group. For the purpose of this research, the greatest focus was on students who experienced a larger change, more than just a few fluctuating points, in either anxiety or self-efficacy.

Follow-Up Interviews

After analyzing the changes in anxiety and self-efficacy within each group, students whose scores increased or decreased by more than 20% were pulled aside for a short interview. In this interview, students were first presented with the conclusion, more or less anxious and/or more or less confident in their ability to do math, and asked if they thought it was an accurate representation of their math feelings. Students were then asked to explain why they felt more or less anxious or more or less confident in their ability to do math. If the interviewee was in the experimental group, he or she was asked whether or not the mindset intervention had an influence on their anxiety or confidence in math. Lastly, the student was asked what a teacher could do to make them less anxious or more confident in their ability to do math. The interviews were analyzed to look for patterns in whether or not the students said the intervention was helpful. Additionally, the interviews were analyzed for common themes in the students' explanations of being more or less anxious and/or more or less confident in their ability to do math, and what a teacher could do to help them in those areas.

Data and Analysis

Pre- and Post-Survey Scores

The results of the pre-survey indicated a mean anxiety score of 25.4 and a mean self-efficacy score of 27.6. This data represents all four sections of students. The students who did participate in the mindset intervention, the experimental group, had mean pre-survey scores of 25.9 and 27.5 for anxiety and self-efficacy, respectively. The students who did not participate in the mindset intervention, the control group, had mean pre-survey scores of 25 and 27.6 for anxiety and self-efficacy, respectively.

The results of the post-survey indicated that the experimental group had mean scores of 27.9 and 26.2 for anxiety and self-efficacy, respectively. The control group had mean post-survey scores of 22.9 and 28.8 for anxiety and self-efficacy, respectively.

These calculations show that the mean anxiety for the experimental group increased by 2 points, and the mean self-efficacy score increased by 1.3 points. The mean anxiety for the control group decreased by 2.1 points, and the mean self-efficacy score increased by 1.2 points.

Score Changes

Each student's pre-scores and post-scores were analyzed to determine whether their survey responses indicated an increase, decrease, or no change in their levels of math anxiety and math self-efficacy. Figure 1 shows the collective data for the experimental group, and Figure 2 shows the collective data for the control group.

Figure 1

Two-Way Frequency Table of Anxiety & Self-Efficacy Changes in the Experimental Group

	Decreased Anxiety	Same Anxiety	Increased Anxiety	Total
Decreased Self-Efficacy	4	1	11	16
Same Self-Efficacy	0	0	2	2
Increased Self-Efficacy	9	1	5	15
Total	13	2	18	33

Figure 2

Two-Way Frequency Table of Anxiety & Self-Efficacy Changes in the Experimental Group

	Decreased Anxiety	Same Anxiety	Increased Anxiety	Total
Decreased Self-Efficacy	5	1	5	11
Same Self-Efficacy	2	3	1	6
Increased Self-Efficacy	11	1	5	17
Total	18	5	11	34

As seen in Figure 1, nine out of 33 students showed a decrease in anxiety and an increase in self-efficacy following the mindset intervention. Ten additional students showed either a decrease in anxiety or an increase in self-efficacy. Five students showed an increase in anxiety and a decrease in self-efficacy.

The same data can be pulled from Figure 2 to examine the control group. 11 out of 34 students showed a decrease in anxiety and an increase in self-efficacy from November to March. 13 additional students showed either a decrease in anxiety or an increase in self-efficacy. As with the experimental group, five students showed an increase in anxiety and a decrease in self-efficacy. Three students in the control group did not show a change in either of their scores.

Magnitude of Score Changes

While the previous section analyzed how many students reported either increases or decreases in their scores, it is important to determine *how much* their scores changed. In Figure 3, each student in the experimental group is represented by a data point that is plotted to show how much their anxiety and self-efficacy changed from the pre- and post-surveys. Figure 4 displays the same data for the control group.

Figure 3

Magnitude of Score Changes in the Experimental Group

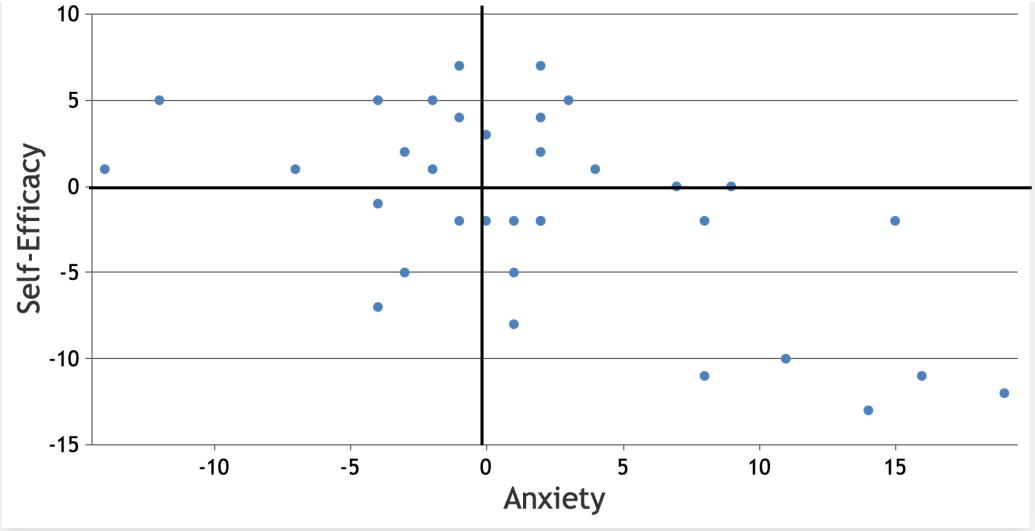

Figure 4

Magnitude of Score Changes in the Control Group

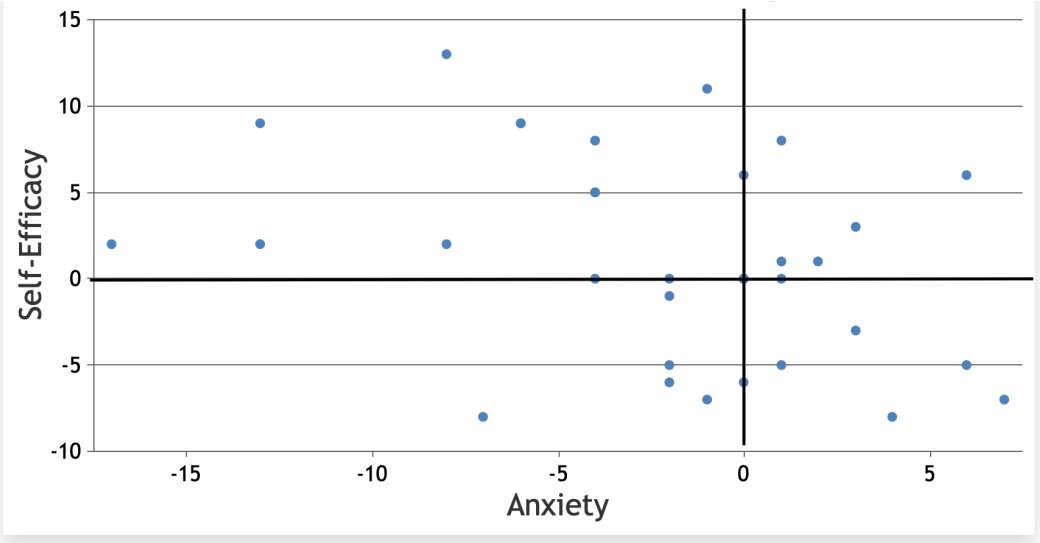

Figure 3 shows that the student data points are more clustered around the origin compared to the student data points in Figure 4. This reveals that the students who participated in the intervention had smaller changes between their pre- and post-survey scores. The majority of the students from the experimental group are within a five-point range for both anxiety and self-efficacy. There also appears to be a small cluster of students, shown in the bottom right-hand corner of the fourth quadrant, who had large increases in anxiety and large decreases in self-efficacy. The greatest score changes from the experimental group were an anxiety increase and decrease of 19 and a self-efficacy increase and decrease of 13.

The student data points in Figure 4 do not reveal a pattern in how much anxiety and self-efficacy changed for the students in the control group. However, there is a much larger range for the students whose anxiety decreased than those whose anxiety increased. The greatest

self-efficacy change in the control group was an increase of 13. The greatest anxiety change in the control group was a decrease of 19.

Digging Deeper into the Score Changes

When analyzing the interview responses, none of the students who reported being less anxious and more confident in their ability to do math attributed their feelings to the growth-mindset intervention. In fact, when asked if the intervention had made a difference, all of the students reported that it had not. Instead, there was a different pattern that emerged. Almost all of the students who confirmed they were less anxious or more confident explained that it was due to the teacher's approachability, teaching pace, teaching style, and explanation of difficult topics. A pattern also emerged for the students who confirmed they were more anxious or less confident. Almost all of those students attributed their change in feelings to the fact that the content they are learning has gotten more difficult as the school year has gone on. One student said that he was more anxious because all of the due dates for various assignments makes him feel like he cannot stay on top of everything. Another student said he felt less confident in math because he did not feel like he is smart enough to take on the challenge.

Conclusions, Implications, and Limitations

Conclusions

The general conclusion of my research, relating back to the initial research question, is that educating students about a growth mindset through an intervention does not correlate to significant changes, positively or negatively, in their self-reported math anxiety or math self-efficacy levels. The data analysis in the previous section does not reveal significant differences between the control group and the experimental group. However, what the study does show, specifically through the student interviews, is that students' anxiety and self-efficacy is largely impacted by the teacher and the classroom environment. The data and input from the students tells me that a teacher can incorporate aspects of a growth mindset, such as taking on challenges, persistence, and not being afraid to make mistakes, into their classroom environment and their teaching style. Doing such things would likely have a greater impact on students' anxiety and self-efficacy than explicitly teaching them about the differences in mindsets and how to develop a growth mindset.

Implications for Future Teaching

In terms of how this research will impact my future teaching, this research shows me that relationships with students and approachability should be some of my biggest areas of focus. Creating an environment of respect, where it is safe to make mistakes, will hopefully allow more students in the future to feel less anxious about math and grow to appreciate it, even when challenges arise. I still believe it is important for students to learn about mindsets and understand what a fixed versus a growth mindset looks like, but it is more important for them to be able to put that knowledge into action. I can help my future students in this way by modeling what a growth mindset looks like and encouraging them to find it within themselves. We may still have

discussions about mindset, but a short intervention is not going to make a significant impact. A growth mindset explains that learning is a process, therefore developing a growth mindset is also a process, and cannot be expected to develop in a short amount of time.

Limitations

There were a few limitations in this study, one of the biggest being the number of subjects. Teaching at a small school meant that even though I studied all of my students, all seventh- and eighth-grade math students, it was still less than 70 students. This factor was out of my control as these are the students I have in class on a daily basis. Another limitation of the study was the timeframe. As explained in the previous section, developing a growth mindset takes a lot of time, as does learning in general. Therefore, it can not be expected that students would develop a growth mindset in a matter of a few weeks between the intervention and the post-survey. If this research is continued, possibly in my own classroom in the future, I would stretch out the process and do several more sessions of the intervention so that students get more exposure to the information and have more time to internalize it. A third limitation is due to the structure of methods and student teaching and how that impacts students in the classroom. When students took the pre-survey in November, I was new to the classroom and not their primary teacher. As the end of the fall semester approached, and into the spring semester when they participated in the intervention and took the post-survey, I became their primary teacher. The students often felt, as shared in the interviews, that my mentor teacher, their primary teacher up until November, was not approachable, taught too fast, and embarrassed students for making mistakes or being wrong. This factor largely contributes to how students feel about math, as explained in some of the interviews. If this research was continued in my future classroom, along

with more frequent interventions, students would have the same teacher who would implement a consistent teaching style and pace and maintain a learning-friendly environment.

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