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The Effect of Growth Mindset on Mathematical Performance in Algebra Support at Minnetonka Middle School East

Chelsie R. Anderson

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An Action Research Report

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St. Catherine University

St. Paul, Minnesota

Advisor_____ Date_____

Abstract

All teachers work hard to better meet the needs of each of their students. Despite new learning styles and individual needs that each new year brings, teachers continue to plan and strategize to come up with new ways to support them. My focus was to implement growth mindset strategies that students could utilize in their mathematics classroom that would help them learn how to manage their way through difficult concepts. By teaching students these strategies, I wanted them to move away from fixed mindset characteristics and understand how they can become better learners. I am an 8th grade teacher at a district in a western suburb of Minneapolis, MN. The data that I collected was derived from student surveys and teacher observations. Through my research I found that students not only began to shift their mindsets but also began to feel a more positive relationship with mathematics.

Introduction

Developing a meaningful connection between low achieving eighth-grade algebra students and mathematics. There is a common misconception that only "math people" are capable of being successful in math. Evidence has shown that the combination of proper teaching in mathematics and growth mindset can result in success for every student (Chestnut, Lei, Leslie, and Cimpian, 2018). Everyone is capable of learning mathematics to the best of our abilities, and having a proper mindset that teaches how to learn from mistakes is invaluable (Oldridge, 2016).

This paper will review the research related to the importance of making meaningful connections between low achieving students and mathematics. It will be organized by identifying some of the causes of low academic achievement among students, learning gaps among genders and minorities, and discussing possible strategies to create connections. Upon reviewing the literature, this paper will indicate whether or not meaningful connections can increase engagement and performance in low-achieving, eighth-grade algebra students.

Theoretical Framework

Causes of Low Academic Achievement

Low academic achievement can be identified by looking into students behavioral characteristics and psychological factors, attitudes or motivation, and abilities in a particular subject (Al-Zoubi and Younes, 2015). Many also believe the myth that "math people" are successful in math simply because they were born with a gift. This myth has been challenged in recent years by studies showing that people can create new mathematical pathways through the brain through hard work and practice (Anderson et al., 2018).

Students that suffer from medical or psychological issues may be considered "at-risk" in academic achievement. Major depression disorder, generalized anxiety disorder, exam phobia, obsessive-compulsive disorder, attention disorder, and learning disabilities are all possible medical or psychological reasons why a student may not be successful in their academics (Al-Zoubi and Younes, 2015). Students that possess a high fear of failure have a higher risk of avoiding challenges and therefore risk underachieving in their coursework (Reiss, 2009). Students may also have test anxiety. The finality of a test does not encourage students to continue trying or keep learning the material. A final score can result in students losing their desire to learn new content because they fear they will be unsuccessful on the unit test at the end (Ask Assessment Abby, 2014). Mathematics anxiety can be detrimental to students and has been known to reduce performance. This anxiety can be passed on from teachers and parents to their students. It is also found throughout our culture in movies, television shows, and even on clothing (Anderson et al., 2018). Students with high math anxiety are likely to avoid challenging math courses, which results in less math practice. When students are practicing fewer math concepts than their peers, they risk becoming low-achieving in mathematics (Erturan & Jansen, 2015). Mental health can have a severe effect on students behavior, academic motivation, relationships, social-emotional learning, and academic achievement (Blackman et al., 2016).

Students with low abilities have also been found to struggle with mathematical content. Students with low skills may suffer from low achievement due to their lack of experience within the content (Al-Zoubi and Younes, 2015). If students have not mastered specific benchmarks, they will find it challenging to move on with their peers to the next level. Interventions are needed quickly as this may cause lower success rates in the future.

Without proper goal setting, students may be unaware of the learning targets they are expected to meet. If students do not create goals, they may find it challenging to achieve success. A flexible plan, or goal, is one way to manage through coursework (Al-Zoubi and Younes, 2015). Personal learning goals that are related to student performance goals can result in higher academic achievement (Degol et al., 2018). Failing to make math connections to real-life may contribute to low achievement from students (Cornell, 1999).

Learning Gaps

Gaps in gender, cultural, and environmental situations have been studied for many years. Research has found that over the last decade, the gaps in these areas still exist and there is only a slight trend of its closing.

The gender gap is the most common focus of many researchers. Several studies have been conducted to identify the cause of the difference between genders and what can be done to close it. Females tend to have a fixed mindset when it comes to their mathematical abilities. A study found that males had stronger coping skills when faced with challenging math problems. This same study also indicated that females are more likely to perform lower than males due to a fixed mindset (Degol et al., 2018). Another factor in gender differences is the way students are spoken to by the adults in their lives. Parents and teachers might inadvertently use their language to indicate gender differences. Adults must use their language carefully so that students can understand that their mathematical abilities are not related to their gender (Chestnut et al., 2018). There has also been a notable difference between genders and their emotional connection to mathematics. Erturan and Jansen performed a study to collect data on the emotional experiences of math within a group of students in grades 3-8. This study showed that males had lower test

anxiety than females. However, the results of mathematical performance are mixed. Females were found to get better math grades than males, but females did not outperform males on achievement tests; some females underperformed (Erturan & Jansen, 2015). Recent studies have found that there is no longer a gap in achievement tests, but females still possess a stronger negative attitude towards math. These negative attitudes may prevent females from giving their best work and cause them to avoid math-related course work or careers in the future (Gunderson et al., 2012).

Cultural differences are also a factor when comparing the gaps in education. Studies show the comparisons that have been made between Black, White, and Hispanic students of both genders to have significant gaps in their academic success. Gender differences are relatively consistent between Black, White, and Hispanic students when it comes to the enrollment of higher-level math courses and lower-level math courses. In these studies, more females enroll in higher-level, and more males join in lower-level. It was found that the African American and Latino students of both genders were overrepresented in the lower-level classes (Catsambis, 1994). In a study from 1972 to 1992, it was reported that African American and Latino students had decreased the gap between white students by 34% and 20% respectively, but the gap remains (Ketterlin-Geller et al., 2008).

Many low-achieving students come from environments that are not conducive to their academic success. Students' attitudes towards math are formed within their environment. If a parent or teacher has a negative attitude towards math, the student will likely develop similar feelings (Gunderson et al., 2012). Those from a high socioeconomic background may have parental support that encourages the pursuit of high-ability math courses. Students from a low

socioeconomic background may not have the same support and therefore, may not be placed in higher-level math courses (Catsambis, 1994). In a study by Paschall, Gershoff, and Kuhfeld, of students between 13 and 14 years of age, it was found that non-poor white students maintained the highest ranking in math over time. Poor white students only slightly increased their rankings. The scores of the Black 13-14-year-olds decreased over time, but again, the non-poor Black students were still higher than those of the poor Black students. Hispanic students included in the study were also observed and compared based on their socioeconomic status. It found that poor Hispanics' scores declined over time while non-poor Hispanic scores remained around the average during that time (Paschall et al., 2018). Low-achievement in academics can be related to factors occurring outside of schools. Factors such as basic health care, access to food, pollution, family violence, and the neighborhood that the child is growing up in (Berliner, 2009). However, a study by Paul Peterson has shown that teacher quality, school accountability, and school choice has a more significant impact on academic success than family income (Peterson, 2012). Another study in 2018 discussed the strong connection between a family's socioeconomic status and a students' achievement level. Reports show that students coming from a low-income home have a higher risk of having low success rates in school (Önder & Uyar, 2018). Based on these studies, it seems that socioeconomic status may not have as much of an effect on a student's academic success as the overall environment that the student is learning in.

Learning Strategies

Once a student has been identified as low-achieving, it is critical to determine an intervention to set in place that will support him or her to be successful. Studies have shown that a growth mindset and a classroom that promotes social constructivism can be beneficial to those

that struggle with mathematical concepts. A recent study by Erik Laursen shows that traditional educational practices deplete curiosity for learning in many students before they enter middle school (Laursen, 2015). When students adopt a growth mindset, they are developing critical learning skills, using feedback, and facing challenging problems. The attitude and belief about one's abilities define their mindset. Those with a fixed mindset believe they are born with specific skills and are unable to change them. Those with a growth mindset believe that through practice and work, they can improve their abilities. Students with fixed mindsets are likely to give up if the task is challenging, unlike students with growth mindsets. Students with a growth mindset enjoy challenging tasks and believe they can accomplish it with effort and additional time (Robinson, 2017). Many students need to be shown the differences between growth and fixed mindsets to understand how they work. To encourage students to become independent learners, it's essential that we, as educators, model a growth mindset and reinforce these habits continuously (Ciobanu, 2014). Teachers that share their mistakes with students can model how a growth mindset can be used to overcome challenges. Mistakes and failures are experienced regularly. As educators, we must show students how to be successful by overcoming these obstacles (Robinson, 2017). Teachers can support a growth mindset classroom by demonstrating risk and mistakes and learning how to cope with them, giving appropriate feedback within a timely manner, encouraging strong effort rather than correct outcomes, and having high expectations for all students (Barnes, Fives, 2016). Mistakes are an essential part of learning, and students should be encouraged to embrace them rather than fear them. Classrooms need to be a safe environment where mistakes and challenges are welcome. Mistakes and challenges are critical to learning new material (Ciobanu, 2014). One way to create a safe environment is by

changing the vocabulary we use in classrooms. Positive self-talk is a useful strategy when encouraging a growth mindset. Students are taught to replace fixed mindset statements such as "I don't get it," to a growth mindset statement such as "What am I missing?" (Robinson, 2017). Using the word "yet" lets students know that if they remain focused on their work, they can eventually understand the material. When students are comfortable with making mistakes, they are more likely to want to fix them. Students that can point out exactly where they became confused or lost within a lesson are showing a high level of motivation for success. When students are motivated to do well, their engagement levels become deeper and allow a meaningful connection to their learning. Students have a higher chance of being motivated when a growth mindset is encouraged within the classroom and at home (Ciobanu, 2014). As educators, we can promote a growth mindset by using appropriate vocabulary, giving valuable feedback, and assisting students with goal setting. Teachers should provide students with tools such as benchmark assessments so that students can actively watch their growth over time. When students can chart their progress, they can make connections with how their abilities will grow with their effort. Collecting visual data that represents their progress can motivate them to push further (Robinson, 2017). Students with a growth mindset possess an understanding that effort and practice are linked to academic success. With a growth mindset, they are more likely to persevere through challenging material and use coping skills to do so. They are also more resilient and lack a fear of failure when faced with challenging problems. Students with fixed mindsets are more likely to avoid a challenging problem because they fear failure and lack the coping skills needed to continue (Degol et al., 2018). When students have a growth mindset, they

understand that learning is a process that is built from attempting challenging tasks, making mistakes and adjustments, and continuous effort.

Vygotsky's social constructivist theory emphasizes the importance of social interaction playing a critical role in the development of cognition. In a learning community, such as a classroom, language between a student and teacher facilitates the construction of knowledge (Hirtle, 1996). Vygotsky's theory also includes the Zone of Proximal Development, or ZPD, which compares the differences between what a student is able to do with assistance and without (Hirtle, 1996). When a teacher is able to use the correct language within the ZPD, a student is able to make meaningful connections with the content and further their understanding.

Growth mindset uses specific language and guidance to improve learning. Students learn to communicate to their teachers and peers that they may struggle with a specific topic at first and will continue to practice and develop new neurological pathways overtime. Students will then have the opportunity to work with a teacher's assistance to learn from mistakes and make corrections.

Students with a growth mindset can make progress and achieve success at a pace suited to each individual. This practice encourages students to grow from mistakes and dig deeper into their learning resulting in meaningful connections with content.

Creating a space where students can collaborate and learn from each other is also a highly effective strategy. John Dewey describes social constructivism as a way learners can become members of a community by constructing knowledge socially so that they are fully participating within the community. By encouraging learners to create knowledge socially, they can collaborate and share their thoughts and feelings (Hirtle, 1996). Working with others in a group

setting can be beneficial for both academic and social development among students. Students enjoy having another person to lean on for assistance when needed (Ares & Gorrell, 2002). Group work provides opportunities for students to experience different teaching styles from one another and also learn about alternative methods for problem-solving (Cornell, 1999).

Growth mindset and social constructivism are two of the many strategies that can be implemented to help low-achieving students, but many other options may work for different learners as well. To engage learners and create an interest in content, teachers can and should use authentic, real-world problems. This will create a more in-depth, meaningful connection and understanding of the problem and also prepare students to work with real-world issues. Giving students opportunities to develop goals and work towards completing them is another useful strategy to find success (Laursen, 2015). Also, incorporating projects that students can relate to within their world can make the connection between math and their everyday lives more valuable (Chestnut et al., 2018). Capturing students attention to real-life problems and demonstrating how to explore mathematical techniques can promote student engagement, as well as allowing them to explore using hands-on materials. These techniques can develop abilities and create positive attitudes towards mathematics (Cornell, 1999). Several studies have been conducted to find potentially beneficial instructional strategies to help students with disabilities. Ketterlin-Geller et al. summarized them to six specific procedures such as visual and graphic representations, systematic and explicit instruction, student think-aloud, peer-assistance, formative data provided to teachers, and formative assessments given to students. Students that struggle with mathematical concepts can also benefit from detailed instruction first, using hands-on manipulatives that are focused on concepts or procedures. From there, they may gradually learn

how to model concepts using representations such as pictures and eventually develop fluency with abstract symbols (Ketterlin-Geller et al., 2008).

Conclusion

This literature review was intended to review the research and studies that explored the effects of meaningful connections to mathematics and engagement and performance in low-achieving eighth-grade algebra students. It was found that making real-world connections for students allows them to engage in the material on a deeper level. When a student can relate to the problem they are trying to solve, they are more motivated to use various tools to find a solution.

After reviewing the literature, questions still arise as to why our current system continues to move children forward in a math sequence when they have not mastered concepts of their current level. Are students able to be successful with later content if they have not mastered previous skills? Would students be able to grasp challenging content at a mainstream pace if they were given more time and practice with basic skills they may have struggled with? There are also some discrepancies within the literature regarding whether or not socioeconomic status affects academic achievement.

Making meaningful connections to mathematics can help students develop their problem-solving skills, increase the number of females and minorities moving forward into mathematical courses or careers, and create a positive attitude towards logic and reasoning.

Methodology

This study used an experimental design. Data was collected from teacher created student surveys, classroom observations, and assessments. Lessons created by me were given to students

to educate them on growth mindset and how their brain can process new material. These lessons were used as a baseline for students to apply growth mindset behaviors in our math class.

An initial survey was given to students to gather baseline data about student's mathematical mindsets. At the start of each following week, twenty minute lessons on growth mindset were given to students for a portion of their forty-two minute Algebra Support course. These lessons educated students on how learning affects the brain and how the brain grows when receiving new information. After two weekly lessons, students were given anonymous surveys about their mathematical mindset. This sequence of two weekly lessons followed by a survey continued until 4 surveys had been completed. Students completed these surveys after various units were completed in their Algebra course.

Students were given lessons via Google Slides about growth mindset during their Algebra Support course. Each lesson was designed for students to learn about growth mindset and how the brain works when learning something new or challenging. Several of these lessons were given at the start of a new unit in their Algebra course. During the unit, the teacher would make observations in their journal as they noticed students using different growth mindset strategies during their Algebra Support course. At the end of the unit, students completed a growth mindset survey in their Algebra Support course. The teacher will review the students' end of unit test scores, survey averages, and journal notes.

The population for this action research study was a select group of eighth grade students enrolled in a suburban middle school located in the Midwestern United States. The sample includes 22 eighth graders that are enrolled in an Algebra Support class. This class was an additional course to their concurrent Algebra course. This course was an elective recommended

for students struggling with mathematical concepts.The class meets on alternating days for the students. Eleven students meet on A days and the other eleven students meet on B days. The sample featured twelve males and ten females.

Data

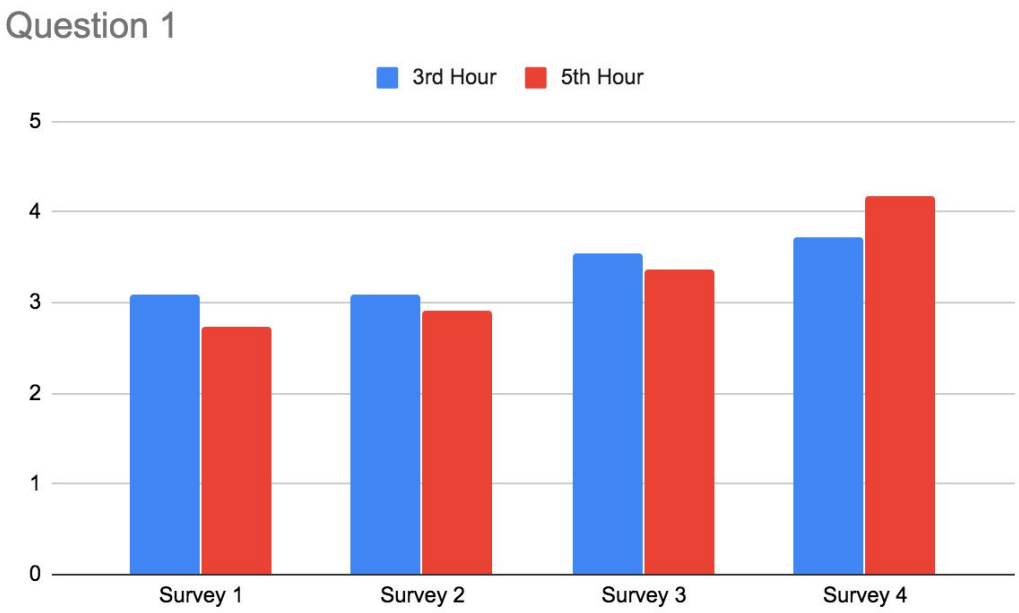

Figure 1. Question 1 Survey Results. Question 1 asked students to rate how they felt when math feels hard. In both classes, students' feelings grew much closer to students saying they love a good challenge and that it makes them feel as if they are growing as learners.

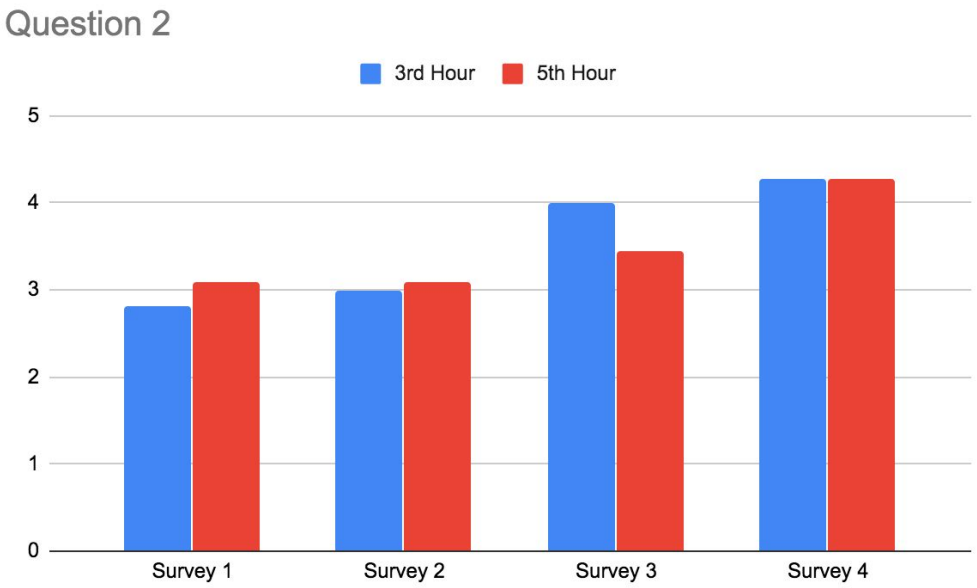

Figure 2. Question 2 Survey Results. Question 2 asked students how they feel when they don't do well on a math assessment. Over time, students began to note that they knew they can continue to improve as long as they keep trying.

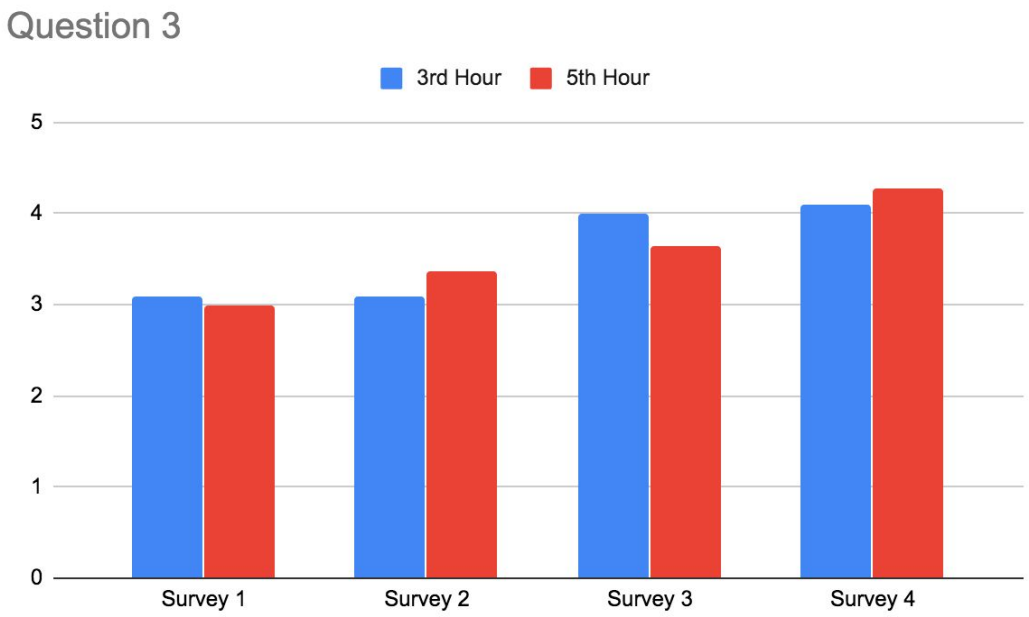

Figure 3. Question 3 Survey Results. Question 3 asked students how they felt when they noticed their peers being more successful. Students in both classes grew to have a stronger belief that they weren't at the same level YET but over time they could be.

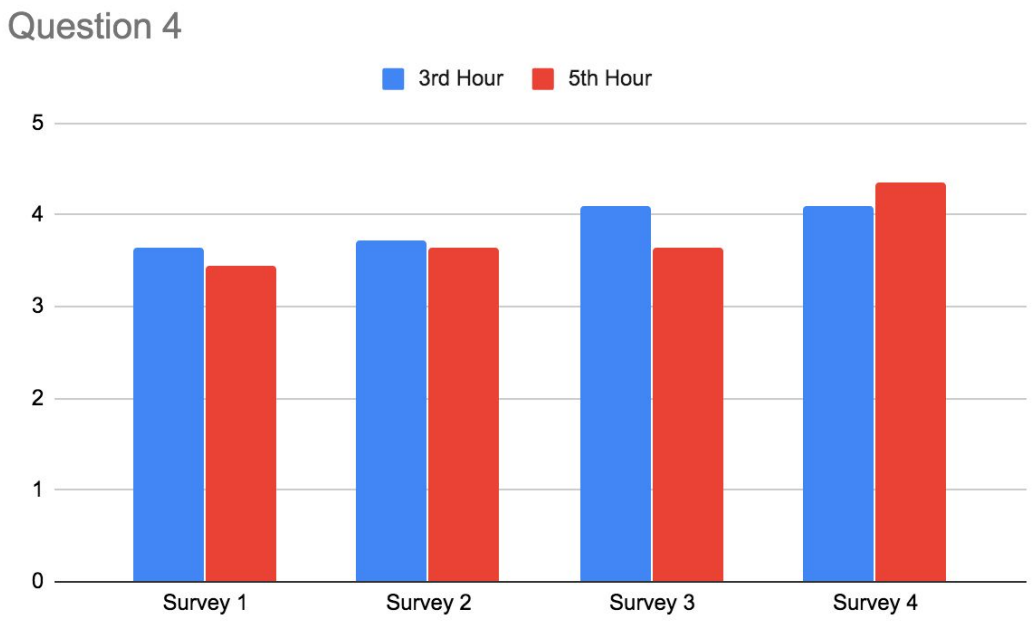

Figure 4. Question 4 Survey Results. Question 4 addresses how students feel when they knowingly have to work hard on a topic. Many students already felt strongly that hard work meant they were learning something new. Several students felt even stronger about this as we progressed through our growth mindset lessons.

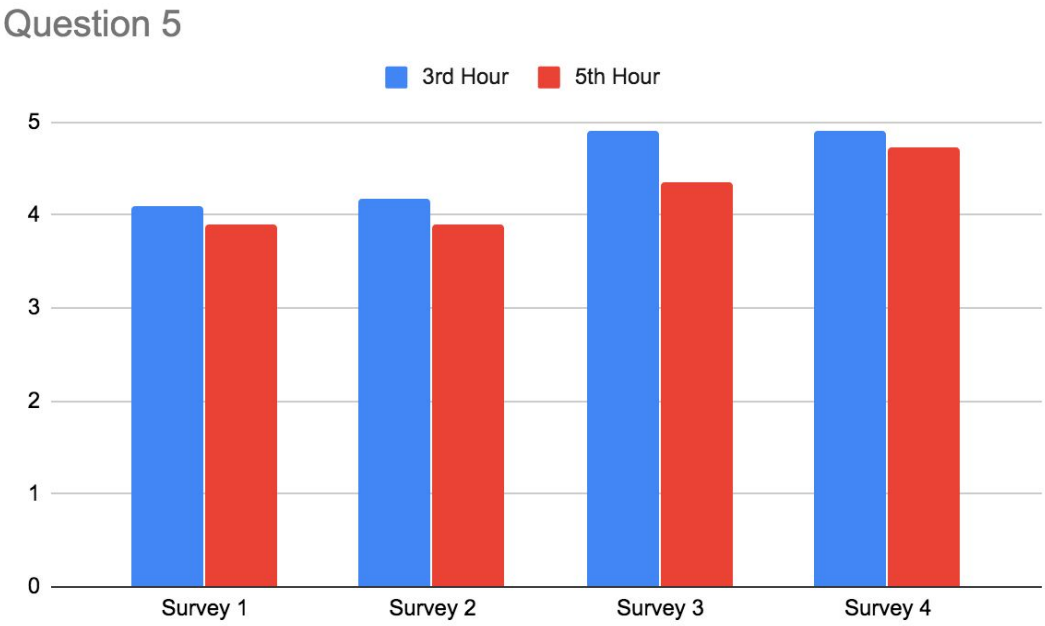

Figure 5. Question 5 Survey Results. Question 5 asked students how they felt when they made mistakes. Many students already had strong feelings that they don't like making mistakes but also understood that it's a critical part of learning. This concept also improved throughout the project period.

Before the start of the action research project, students in this Algebra Support course were able to access a variety of ways to be supported in their current Algebra course. Students had access to 1:1 help from a teacher, small group instruction, additional time for assessments (both formative and summative), and extension activities that developed skills for current content. During the course of the action research project, we would start our Algebra Support class with a lesson on growth mindset. After the lesson, students were observed by the teacher for use of growth mindset skills. The record keeping of these observations were very informal. Students would be notified verbally by the teacher when they used a growth mindset skill. This

created conversations between students and would cause them to make conscious efforts to noticeably use growth mindset skills regularly. The results of these informal observations were inconclusive to the study, however they were valuable within the classroom community. Though the observations were informal, students were able to practice using growth mindset in their daily math activities.

Data Analysis

The data collected was from multiple surveys and teacher observations of students. The initial survey (see Appendix A) was given to students to gather baseline data for the action research process. The results indicated that students had a variety of different thoughts and feelings towards their math progress. The results also showed that a portion of students in one particular group held much stronger feelings that they aren't able to do well in math and are more likely to give up. Despite the negativity in some of the results, the message was quite valuable.

After administering lessons on growth mindset, the students were given the survey again on several occasions. The results indicate that students began to shift their thoughts and feelings from one end of the survey spectrum to the other. Students in both classes showed a mid to low average number in their response to how they respond with math feels hard and how they feel when they don't do well on a math test/quiz (see Figures 1 and 2). These thoughts and feelings were prominent at the start of the school year, prior to the start of the action research project. Figures 1 and 2 indicate that students were able to shift their mindset from fixed to growth over the course of the project.

The areas that showed less change were those that involved thoughts towards others success when compared to their own, effort put into a new skill, and how mistakes are handled. The results to these three questions had a higher initial average but Figures 3, 4, and 5 show visually how each area improved on each survey.

Though students still found new math concepts to be challenging, they were able to shift their mindsets towards a more positive, growth mindset by using the skills they were shown in weekly lessons. Students were observed using strategies such as embracing mistakes, making corrections, and attempting challenging problems without being asked by me. These observations, along with the survey data made it possible for me to track students as they shifted their mindsets.

Action Plan

The action research project allowed me to understand my student's thoughts and feelings towards math. This experience has gotten me excited to create more content and further my own understanding about how our minds work when presented with a challenge. Starting each school year off with the lessons that were created for this project will be helpful for struggling students to achieve success in an otherwise difficult concept. Reflecting back on my experience, I plan on beginning the school year with lessons on growth mindset, implementing surveys to gauge students' thoughts and feelings towards math, and observing their use of new techniques.

The initial student survey was helpful to get baseline data of students thoughts and feelings for mathematical challenges. I feel that it allowed me to see that my two different courses were significantly different in how they approached math. Had I had this information at the start of the year, I might have found alternate ways to better serve students with their specific

needs. Even so, after reviewing the initial survey data mid-year was still very helpful and allowed me to make appropriate adjustments for both groups.

The growth mindset lessons truly were the most valuable piece of the action research project. The students learned so much about how the brain worked and how to handle difficult concepts. I intend on continuing the course with a growth mindset lesson at the start of each week for both course sections. Keeping the lessons short, with time to discuss and reflect made the lessons much more engaging and also allowed students a large portion of class time to apply their new strategies to their current Algebra work. The next step for me is to create more growth mindset lessons to continue through a school year. When students continue to learn about growth mindset, they can continue to apply it as the year progresses and content becomes more challenging.

The surveys given to students were helpful to gauge each group's overall thoughts and feelings about math. It indicated a trend showing that students were developing more of a growth mindset versus a fixed mindset. One thing I would change about the student survey was the frequency in which it was given. Since students received the same survey with minimal time in between, students may have made choices because the lessons and previous survey were so fresh in their minds. I think for future use, I'd like to give the initial survey at the start of the year, one at mid-quarter, one at the end of quarter 1, and continue with mid-quarter and end of quarter dates for the remainder of the year. I feel that this will space things out and give an accurate view of how each class's mindset changes over the course of a school year.

Informal observations were a favorite for both myself and my students. I enjoyed seeing my students use the new strategies they had learned about growth mindset and students

welcomed being validated for using them. When a student would use specific growth mindset phrases such as “I can’t do this yet” it was noted by myself and other members of the class. Students would begin to encourage each other which created a stronger classroom community. Another phrase that was often blurted during work time was “Great job! You worked hard on that!” whenever a student exclaimed that they understood a concept or found success on a challenging problem. At times it was obvious that students would use certain growth mindset strategies and/or phrases with a bit of sarcasm but I feel that it made it easier for students to participate when they felt allowed to be a little silly. Overall I felt that the informal observations allowed students to use growth mindset strategies naturally which made them more meaningful.

In summary, I feel that my action research project has restructured the way I teach my Algebra Support course. I believe teaching students that they can become better at new things by changing their mindset is a critical skill that can be used in mathematics as well as many other aspects of their lives. Consistent lessons on brain development, changing the way we speak, and moving away from a fixed mindset are valuable topics for students to engage in. The data collected from this project shows that student mindset can be changed in a very short period of time so I am hopeful that more change will come with more time. With a few adjustments and additional lessons, I feel that I have developed an effective model to successfully teach students about growth mindset.

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Appendix A

Growth Mindset Survey

This survey is completely anonymous. Please be honest with your answers because I will be using this information to make our classroom better.

1. When math feels hard, I

Mark only one oval.

	1	2	3	4	5	
feel like I'm not smart and want to give up.	◯	◯	◯	◯	◯	love a good challenge! It makes me feel like I'm growing as a learner!

2. When I don't do well on a math test/quiz, I

Mark only one oval.

	1	2	3	4	5	
feel like I just can't do math and I won't get any better.	◯	◯	◯	◯	◯	know I can always improve so I'll keep trying.

3. When I see other kids being more successful than me, I think

Mark only one oval.

	1	2	3	4	5	
they're smarter than me and I'll never be that smart.	◯	◯	◯	◯	◯	I'm not at that level YET but I'm going to figure out how to get there.

4. When I have to work hard on a math skill, I think

Mark only one oval.

	1	2	3	4	5	
it's because I am not good at it.	◯	◯	◯	◯	◯	it's because I'm learning something new.

5. When I make a mistake, I

Mark only one oval.

	1	2	3	4	5	
don't like making mistakes, so I make excuses.	◯	◯	◯	◯	◯	don't like making mistakes, but I know it's a critical part of learning so I try to