Mind Over Math

Morgan Grey

Georgia College & State University

December 10, 2021

Abstract

Mindset is defined as a mental attitude toward something. Often, people believe their mindsets are predetermined or fixed, and, unfortunately, this is a common assumption within math education. However, according to Carol Dweck and Jo Boaler, a person's ability to learn can significantly change with proper exposure to teaching strategies that foster growth mindsets. In my research, I will analyze the math mindsets of K-12 students as well as their respective math teachers' mindsets. Teachers will be asked additional open-ended questions that will analyze their teaching strategies. Ultimately, my goal is to understand which teaching strategies that help foster more growth mindsets are actively being used in the math classrooms and if they corollate with the mindsets of students and teachers.

Introduction

I, like some people, grew up always knowing I enjoyed math and was relatively "good" at it. No specific mathematics subject was too difficult to me because I just got it. Unfortunately, that is not the case for most people, especially my younger brother. He had a much different outlook on math. I remember my brother getting frustrated that he could not understand his math homework and whenever I would try to help him, as a big sister could, I often got responses such as, "Can you just show me how to get the answer?" or "I am just not a math person like you are." It hurt to see my brother become so frustrated at such a young age and to see that his mentality over math was already a defeated one. I tried to help as much as I could, though I was a kid myself then, but he continued to use phrases such as those over again to the point where I wanted to understand why. How could someone with such potential already feel helpless? What causes people to think this way? As it turns out, my brother and many others have what researchers call a fixed mindset (Dweck, 2016, p. 6).

Mindset is defined as a way of thinking of something, and it is habitual. Often, people assume their cognitive abilities are pre-determined; however, that is not the case. "With the right mindset and right teaching, people are capable of a lot more than we think," says psychologist, Dr. Carol Dweck (2016, p. 11). Extensive research has been done over the idea that we are not subjected to a certain way of thinking. Though, there must be a trend or reason as to why we naturally default to such ways. In my research, I wanted to understand when and where these mindsets appear among students and teachers in the mathematics classrooms. I also dove deep into the current environments to determine whether certain teaching techniques fostered certain mindsets. Our procedure is constructed around the framework of both Jo Boaler and Carol Dweck. Carol Dweck has conducted psychology research providing evidence that when people

change their mindset towards a certain area in life, they create opportunities for learning how to reach their full potential. Jo Boaler has taken Dweck's research and has studied the impact of growth mindsets and how educators can implement a growth mindset in mathematics classrooms.

The goal of this study was to analyze K-12 mathematics students' and teachers' current mindsets to obtain some time frames of mindset change, as well as determine what teaching techniques foster growth mindsets in students. Our research questions are:

- Do students have fixed mindsets or growth mindsets in mathematics?
- What mindset do teachers have?
- What type of teaching strategies are educators doing to either foster growth mindsets or fixed mindsets?

Our research is crucial for the future of mathematics education, and truly, education in general. Researchers, such as Dr. Boaler (2016) and Dr. Dweck (2006), have found that there are ways to effectively teach concepts to better grow ourselves as learners. With the help of past research and our own research, we can determine more about growth mindsets and how to continue their spread.

Literature Review

Growth and Fixed Mindsets

The big topic of conversation in this study is the difference between fixed mindsets and growth mindsets. Dr. Carol Dweck (2006, p. 6-7) discovered these two very different matters. She demonstrates how what we believe about our own skills and abilities affects our performance in school, employment, sports, and practically every other aspect of our life. People who have a fixed mindset feel that their fundamental abilities, intelligences, and talents are

predetermined. To put it another way, people believe they are born with a set amount of intelligence and that is it. People with a growth mindset think that by putting forth effort, receiving appropriate instruction, and persevering, their qualities and abilities may be improved. They don't believe everyone is the same or that anybody can be Einstein, but they do believe that anyone can grow (Dweck, 2016, p. 7).

Nevertheless, there is a misconception that math is exclusively for a select few. When children believe that only certain people can learn arithmetic, they are more likely to accept that they will fail, which leads to a negative attitude toward math. One of the biggest issues in math education is that some teachers categorize pupils as either good or terrible at arithmetic. "If it's not simple for you, you don't belong here," pupils are told all too often. It's no surprise that students dislike math or declare they aren't "math people." The topic of what educators can do to ensure that all kids understand arithmetic is critical. How can teachers persuade pupils that their math skills may be improved?

Teaching Strategies that Foster a Growth Mindset

Jo Boaler, a math professor at Stanford University, has studied the impact of attitudes on mathematics instruction. According to neuroscience research conducted by Boaler and others, "there is no such thing as a “math brain” or a “math gift”, as many believe” (Boaler, 2016, p. 5).

Consequently, mathematics should be taught in such a way that every student has a chance to succeed. We will focus on teaching approaches found by Jo Boaler that can assist educators build and sustain a development mindset in math classrooms in this study:

1. Believing in All Students
2. Valuing Struggle and Failure
3. Opening-Up Mathematics

Believing in All Students

It is in our nature to desire to be loved and appreciated. Adults who believe in them, particularly instructors, are what children need. “A lot of scientific evidence suggests that the difference between those who succeed and those who don’t is not the brains they were born with, but their approach to life, the messages they receive about their potential, and the opportunities they have to learn” (Dweck, 2016). When students have someone who believes in them, they are more likely to succeed. “The best opportunities to learn come about when students believe in themselves” (Dweck, 2016). Students may begin to think that they are capable of learning mathematics if teachers are deliberate about supporting them, delivering the correct signals, and giving praise in the appropriate manner. Therefore, it is critical for teachers to explicitly tell their students that they are valued and capable.

Valuing Struggle and Failure

As humans, we are prone to make mistakes, and we make a lot of them during our lifetimes. We especially do not like making mistakes in math courses, because we often feel that making mistakes in math indicates a lack of intelligence. Students are unaware that struggle and failure have worth. Teachers who encourage students to make mistakes and establish classroom settings in which students are not scared to make mistakes might alter students' perceptions of mathematics. Students' minds are challenged when they struggle and fail, and it is at these times that the brain learns the most (Dweck, 2016). Thus, it is critical for instructors to understand the importance of struggle and failure.

Opening-Up Mathematics

Unfortunately, one of the most serious issues in mathematics education is the testing and performance culture. Many students assume that the goal of math lessons is to solve problems

and learn information and formulae. "Students seldom believe they are in math classes to appreciate the beauty of mathematics, to ask profound questions, to explore the subject's rich network of connections, or even to learn about the subject's application" (Boaler, 2016, p. 180). Jo Boaler has found successful teaching strategies for developing and maintaining a development mindset, including:

- Assuring students that they can solve problems
- Demonstrate how mathematics is a study of patterns and relationships.
- Make use of visual aids and numerical modeling.
- Encourage deep thought among students
- Prioritize depth above speed.
- Encourage students to ask, reason, and justify questions.
- Use technology and manipulatives to teach.
- Allow students to work in groups and stimulate class discussions by allowing them to work in groups.

When educators take responsibility for discovering methods to open mathematics, students' attitudes about mathematics can alter, and enthusiasm in learning math can grow. “When teachers are designers, creating and adapting tasks, they are the most powerful teachers they can be. Any teacher can do this; it does not require special training. It involves knowing about the qualities of positive math tasks and approaching tasks with the mindset to improve them” (Boaler, 2016, p. 186).

Methods

Participants

In this study, we surveyed 1,141 students (K-12) and 100 math teachers from Buford City Schools. One school system was chosen because each school would operate under the same mission statement and values, thus eliminating any potential outliers that would have large effects on the data. Their responses to the surveys were then analyzed and categorized into either growth mindsets or fixed mindsets. Teachers were asked additional open-ended questions in which their responses gave insight into their teaching strategies.

Procedure

The prospect of this study is to explore the mindsets of students and their teachers, and to find correlations between those mindsets and ages. To explore this, we have designed a survey of 20 Likert Scale statements (see Appendix A, B, and C) where participants indicate their level of agreement/disagreement. Because we collected data from a vast age range, parental consent forms, individual consent forms, and minor assent forms were sent out first. Once all consent and assent forms have been received, we then sent the surveys for the K-12 students to complete as well as the teachers. We did take into consideration the reading level of the younger grade levels (K-5), and thus revised the survey specific for them (see Appendix B). For both student surveys, a Google Slides presentation was made so that teachers can project it onto the board for students to follow along. This allowed teachers to read each statement aloud to the class as students completed their surveys. For teachers, a similar survey was given to evaluate their mindset and additional open-ended questions were added to evaluate whether their teaching strategies foster more growth mindsets or fixed mindsets (see Appendix C and D). Similarly, the teacher surveys were not sent until all individual consent forms were received.

Analysis

The Likert-scale statements were given four answer options for participants to chose from: strongly disagree, disagree, agree, and strongly agree. As stated in the Literature Review portion of this essay, both Dweck and Boaler have determined that growth mindsets are the key to successful learning. Therefore, when scoring these surveys, I was simply looking for the percentages of growth mindsets. On both versions of student surveys, if statements 1, 2, 4, 6, 9, 10, 12, 15, 16, and 17 were answered with either strongly disagree or disagree, then they exhibit growth mindsets. As for statements 3, 5, 7, 8, 11, 13, 14, 18, 19, and 20, they had to be answered as either strongly agree or agree, to be counted as a growth mindset. If the statements were answered with respect to a growth mindset, they got a score of one. For example, statement 3 in the student survey says, "*It is always possible to get better at Math*." According to both Dweck and Boaler, if a person either strongly agrees or agrees with this statement, they exhibit a growth mindset, thus receiving a score of one. If they strongly disagree or disagree with statement 3, they will receive no score for that statement as it would not indicate a growth mindset.

Once all statements were reviewed and scored for a student, they received a total score out of 20 (where 20 was the number of statements within the survey). The scores out of 20 were then converted into percentages which indicated the growth mindset percentage of that individual. Most surveys were completed via Google Forms, so the data was easily transferred to and excel sheet where these calculations were made with the help of some computer science. For the students who completed the surveys via hard copies, their scores were entered manually into the excel sheet provided by Google Forms. After each student was individually scored, they were then organized into their grade levels for further analysis. For each grade level, the average of the

students' growth mindset percentages was calculated so that they may be later compared to all K-12 grade levels' averages.

In a similar fashion, the teachers' survey consisted of 20 Likert Scale statements (see Appendix C) with the same four responses: strongly disagree, disagree, agree, strongly agree. The statements, however, were not the same as the ones given to the students. Half of the statements strictly measured the teacher's growth mindset while the other half measured both their mindset and how growth mindset-oriented their teaching beliefs were. If a teacher responded to statements 1, 4, 5, 8, 9, 10, 12, 15, 16, 18, & 20 with strongly agree or agree, and statements 2, 3, 6, 7, 11, 13, 14, 17, & 19 with strongly disagree or disagree, then they got received a score of 1 for those statements because their responses reflect a growth mindset. Individual percentages and average percentages (based on grade level taught) were collected the same way the students' data was collected. As stated earlier, teachers additionally completed eight open-ended questions that analyzed their teaching strategies (see Appendix D). These responses were compared to the works of Dr. Boaler as she states them in her research. This portion of data collection ensured the third research question would be answered.

Findings

Question 1: Do students have fixed mindsets or growth mindsets in mathematics?

A big motivator behind this research question was not only to analyze the mindsets of each individual student in K-12 but was to also look for any possible correlations amongst grade levels and determine if there were any significant trends. The growth mindset percentage of each student was averaged, with respect to their grade levels, so that they could be compared. Figure 1 shows the growth mindset averages amongst the K-12 grades.

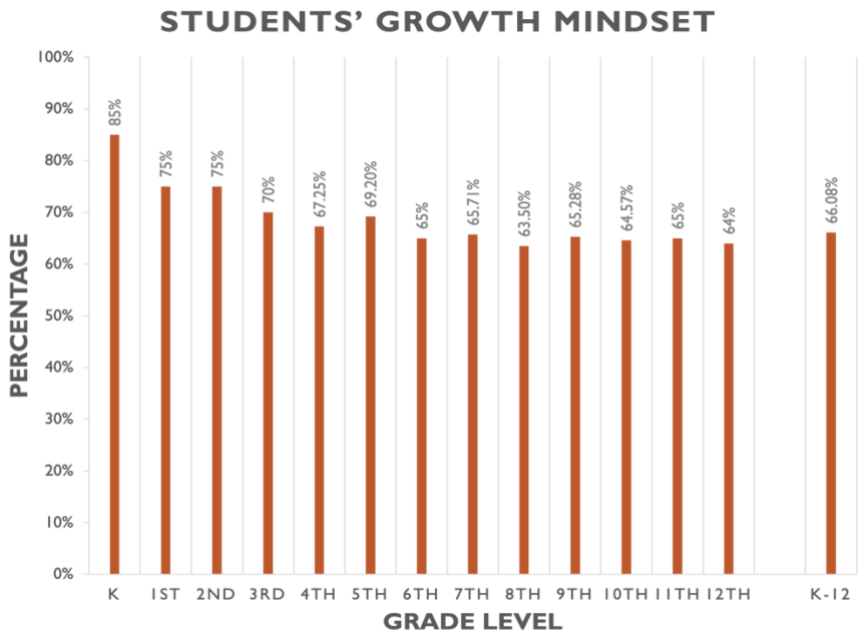

Figure 1: Mindsets of Students

This visualization of the data illustrates a clear picture as to what is occurring among the growth mindsets of each grade level. As the grade levels increase, the percentage of growth mindsets, unfortunately decreases. There is a distinct difference between the mindsets of Kindergarteners versus those of 10th, 11th, and 12th graders. The significance in age difference is worth mentioning and may explain why there is nearly a 20% change, however, the comparison between the younger and older grades was all that surprising. Negative connotations tend to become more vocalized from older students as the mathematical concepts only become richer in connections and deep thought. What is striking, is that this stereotype does not hold true for the notable drop in growth mindsets from kindergarten to 1st grade.

Timed multiplication tables are first introduced in the 1st grade as opposed to kindergarten. These are short multiplication assessments in which student must complete as many simple times tables as possible within a short amount of time (traditionally 5 minutes). According to the Buford City Schools curriculum, kindergarten math focuses on building a

foundation of addition and subtraction while beginning to introduce the ideas of simple multiplication and groupings. Thus, for incoming 1st graders, not only is the math curriculum increasing in difficulty, but now the idea of valuing speed over depth is introduced. "But mathematics learning is not a race, and it is mathematical depth that inspires students and keeps them engaged and learning mathematics well, setting them up for high-level learning in the future. We know that students who are pushed to go through content faster are usually the ones to drop out of mathematics when they get the opportunity," (Boaler, pg. 192). Dr. Boaler stresses the importance of not using mathematical speed as a way of measuring our mathematical ability. Dr. Dweck also discusses how using speed as a measurement to "see what you've got" will lead adolescents into what she calls 'The Low-Effort Syndrome' where their intelligence becomes disconnected from his schooling (Dweck, pg.58).

In the case of the 1st grade's average mindset, it should be noted that just because a curriculum suggests increasing mathematical content rather suddenly into a student education, should not equivalate to a sense of cramming knowledge for the purpose of being able to memorize and move forward. Memorization does not have the same definition as retention. The same argument can be made for all grade levels as their growth mindsets percentages also showed a relatively constant decline as the grades increased. In further review, both K-5 grades and 6-12 grades had a strong majority in disagreeing with the survey statement, "If you answer questions quickly, then you are good at math." Consider the figures below from the google form survey responses:

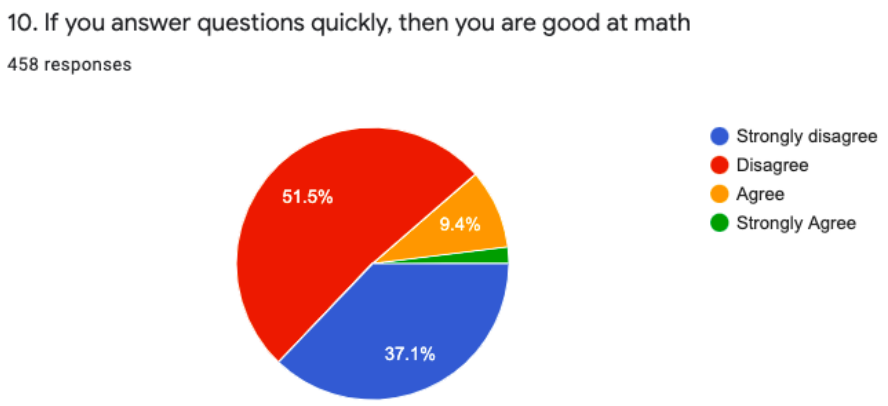

Figure 2: Grades K-5 response to statement 10.

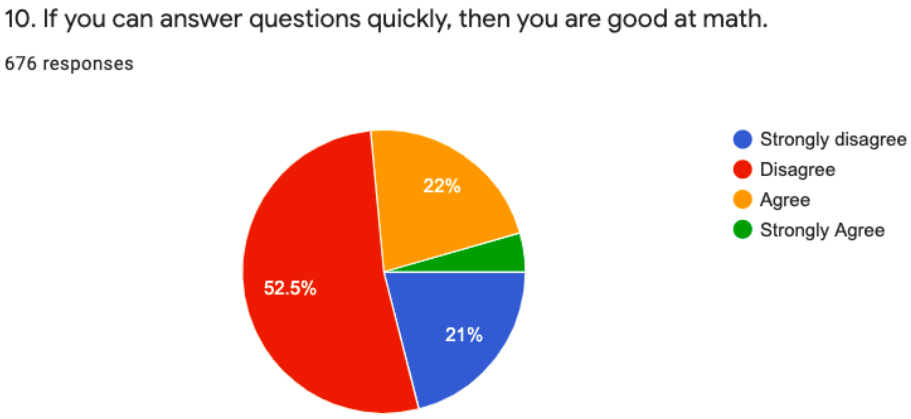

Figure 3: Grades 6-12 response to statement 10.

The comparison of these two pieces of data does a wonderful job of showing the decline in growth mindsets as grade levels increase. As stated earlier, to receive a score of 1, indicating a growth mindset, for this statement, participants had to respond with either of the disagree options. Here, it is clear most K-12 students disagreed with this statement which does reflect the overall high percentages of growth mindsets, but that was not the shocking aspect of this data comparison. Taking a careful look at grades K-5 in Figure 2, we see that 9.4% of students agreed with the statement and 2% strongly agreed. In Figure 3, 22% of 6-12 students agreed and 4.5% strongly agreed. Now, by taking into consideration the number of responses for this statement

were different, the percent difference of the two agree option percentages was calculated and came out to be 38.4% difference. Though majority still resides with a growth mindset, it is clear fixed mindset traits still increase.

Living in an instantaneous world, such as the 21st century, will provide challenges and pressures on those receiving their education as they will be expected to accelerate through their endeavors. Each new grade level will have expectations; however, students must recognize they will only weaken their chances of success in learning if they believe being fast at math is what makes you good at it as that is a trait of a fixed mindset.

Question 2: What mindset do teachers have?

It is equally, if not more important, to understand the mindsets of teachers since they are the ones making the most impact on students' learning. After each of the 100 teachers who participated in the teacher survey were individually scored with a growth percentage, they were organized by the grade level they taught and then averaged the same way the students were averaged.

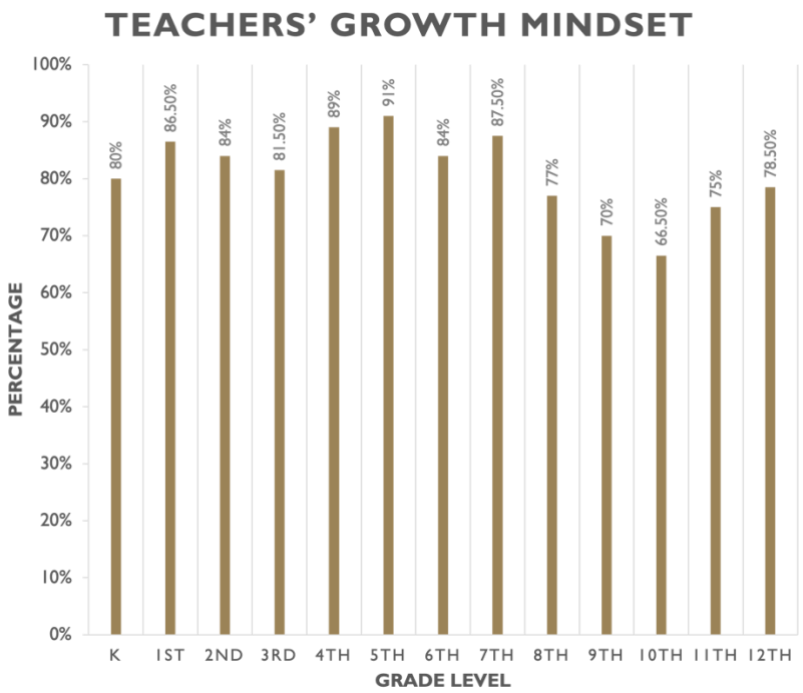

Figure 4: Mindsets of Teachers

Studying the trends of this graph, we fortunately see much higher growth mindset percentages throughout the K-12 grade levels; however, our eyes are almost immediately taken to the right side of this bar graph. The most notable area is found amongst 8th-12th grade teachers. This was a discouraging statistic to review as it correlates with the lower growth mindsets of the 8th-12th grade students. It is important to note that not every teacher, whose student complete the survey, had the time to complete the survey, and thus they cannot share that correlation with their students.

Reasons as to why specifically 8th-12th grade teachers received averages almost identical to their corresponding students are not as clear. To further understand the decline, consider these statements from the teacher survey:

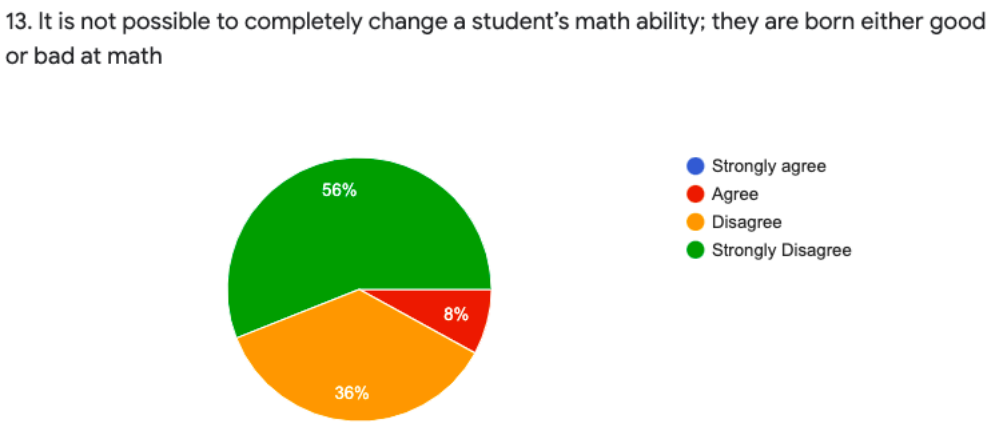

Figure 5: Summary of teachers' responses for survey statement.

In Figure 5, teachers were essentially given the definition of fixed mindsets regarding math. Fortunately, a large majority strongly disagreed with this statement, but what is still alarming is 8% of teachers agreed with the definition of a fixed mindset. In further investigation, 5 out of the 8 teachers who responded with agree, taught in the 8th-12th grade level. Clearly, if a teacher of the 8th-12th grade levels does not believe in their students' ability to improve their intelligence, then their students will most like carry on that same belief.

Recalling the importance of valuing depth over speed, teachers were asked to respond to a statement that would gather their opinions on this idea.

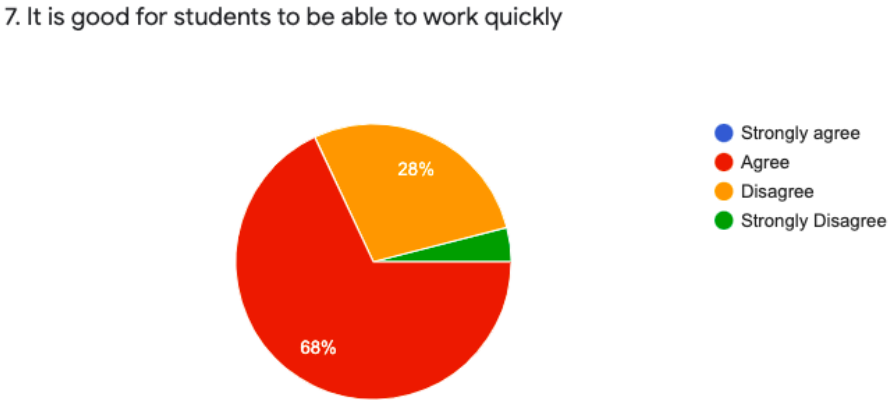

Figure 6: Summary of teachers' responses for survey statement.

Majority of teachers agree that it is beneficial for students to be able to work quickly. Whether that was answered with respect to good time-management skills or with respect to valuing speed over depth, it will be unknown for now. Yet, being of such high majority, it is fair to consider it as a fixed mindset trait among teachers.

Benefit of posing this research question is that we can see a definite correlation between the mindsets of students and teachers. As predicted, it seems that teachers' mindsets have more effect on their students' than they probably realize, and now leaves us to wonder what else teachers can control that effect their students' mindsets.

Question 3: What type of teaching strategies are educators doing to either foster growth mindsets or fixed mindsets?

Survey responses can only go so far in analyzing teaching strategies; thus, the open-ended questions come into play (see Appendix D). As a reminder, each teacher survey also included eight free response questions that dove deeper into the successful teaching strategies for growth mindsets as stated by Dr. Boaler: Believing in All Students, Valuing Struggle and Failure, and Opening Up Mathematics.

Believing in All Students

Something that often gets overlooked is the knowledge of believing in students. Dr. Boaler, however, makes this loud and clear that this will lead to growth mindsets in students. To determine if teachers believe in their students, we simply asked them: "What are some ways you encourage your students?" Many responses to this question were the following:

- "Positive encouragement, tangible rewards like candy, verbal recognition..."
- "Words of praise, to try to find something they are doing right, breaking "hard" problems into steps and discussing that "hard" and requiring more effort aren't the same"

- "I encourage students in multiple ways... I praise the for progress, not necessarily perfection. In math, the goal is to improve. As long as, a student is working hard and making improvements, that's all we can ask."

Simple praise is a great way to encourage students and it lets them know that you believe in them, and from the 100-responses, it's safe to say these teachers understand that. "Some students give the impression that math is a constant struggle for them, and they may ask a lot of questions or keep saying they are stuck, but they are just hiding their mathematical potential and are likely to be suffering from a fixed mindset. Some students have had bad math experiences in messages from a young age or have not received opportunities for brain growth and learning that other students have, so they are at lower levels than other students, but this does not mean they cannot take off with good mathematic teachings, positive messages, and perhaps most important, high expectations from their teacher." (Boaler, 2016, p. 177).

Though the data collection did not reflect praise in students who get correct answers, it is important encourage persistence and hard think rather than accuracy. Student who are continuously receiving praise for only their accuracy may lead them into "effortless achievement" (Boaler, 2016, p. 178). If a student buys into the myth that is effortless achievement, then when they struggle and fail, they will shut down and become lost in a fixed mindset. For the students who visibly struggle, praise for their hard work, effort, and their accuracy is crucial for building their growth mindsets. What Dr. Boaler says is deeply reflected among the teachers' responses from this question, proving they are using one of the strategies that foster growth mindsets.

Valuing Struggle and Failure

Teachers are made to help students with their educations, but they should not overstep their helpfulness as it may lead away from growth mindsets. To analyze teachers' opinions towards valuing struggle and failure, I asked questions such as: "What is the most important idea about learning math that you want your students to understand?" and "How do you approach a student who has made a mistake or is struggling on a problem?" According to Dr. Boaler, responses to these questions that would indicate growth mindsets would fall along the lines of "struggle is the key to success", "taking on a challenge will help you more than repeating something you already know", etc. There was an overwhelming number of responses that followed these guidelines.

- "I encourage them by telling them about my experience in college failing Abstract Algebra. The second time I took it, I made a 99."
- "If at first you don't succeed, you need to keep trying and practicing difficult math concepts."
- "Math takes practice, determination and a strong work ethic, all of which will better them in the future. The power of overcoming a struggle is magical!"
- "No one is perfect. I make mistakes all the time and share with my students how and why. I feel we learn through mistakes."
- "I make real world connections. For example, how do you get better at soccer...practice. Practice makes permanent, not perfect. We talk about how they leaned the ABCs and now they can read. Making connections helps students see how to persevere and grow."

After reviewing all 100 responses of both questions there was not a single response that reflected a fixed mindset. In fact, the survey statement that reflected this teaching strategy proves this outcome as well:

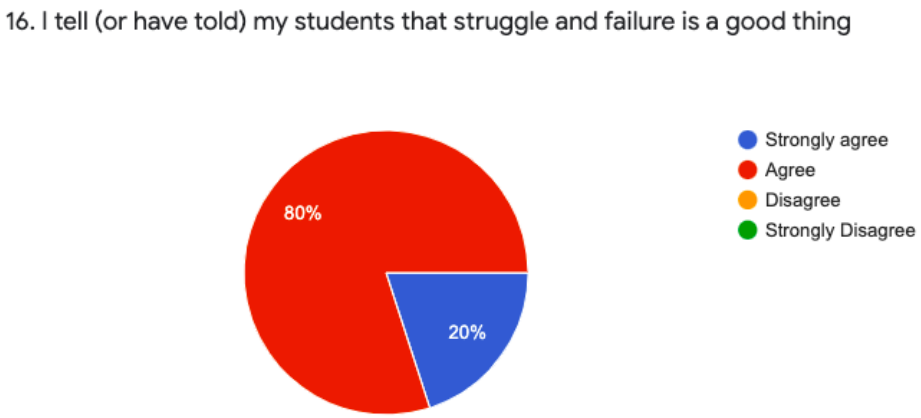

Figure 7: Valuing struggle and failure statement response

Another technique for valuing struggle is to incorporate what Dr. Boaler calls 'low floor, high ceiling' tasks. These types of problems allow all students to access the ideas of the problem and then take those ideas to higher levels of thinking (Boaler, 2016, p. 178). The open-ended question that tested this technique was, "How do you introduce a new math concept or unit you are teaching?" Responses were, again, in line with Dr. Boaler's strategy:

- "I like to sometimes just throw a problem out there to see what students already know. Allow independent think time, partner share, then class share. Sometimes I tell a story (word problem) or use models/videos to introduce new skills also. "
- "Display a question on the board and have students think about how they could solve it. Then, they talk with a partner. Next, we discuss the responses, and I model it. Last, students can model how they got their answer."
- "I start small with something that they already know and build from there."

Opening-Up Mathematics

Mathematics is quite beautiful if it is taught more open and creatively. Recall the Dr. Boaler's numerous techniques in which math may be taught to not only foster a growth mindset but also a creative one:

- Assuring students that they can solve problems
    - Demonstrate how mathematics is a study of patterns and relationships.
    - Make use of visual aids and numerical modeling.
    - Encourage deep thought among students
    - Prioritize depth above speed.
    - Encourage students to ask, reason, and justify questions.
    - Use technology and manipulatives to teach.
    - Allow students to work in groups and stimulate class discussions by allowing them to work in groups.

We asked teachers specific questions that would prompt them to answer with responses that would fall into one of the open mathematic techniques; however, we found that other questions used to analyze the prior strategies also helped these responses. Some of the responses that demonstrated opened-up mathematics are the following:

- How often do you allow group work, and do you think it is beneficial for students to debate over solutions?
    - "I allow group work probably 3-4 out of the 5 days of the week. The higher-level English speakers are a good influence on the lower-level English speakers in my classroom, and it has proven to be effective to do group work very often. I think it is good for students to discuss and argue over solutions because they are talking out their thought processes. Eventually one side will conclude that they are wrong, or they will both conclude that maybe there is more than one solution to a problem."

    - "Almost daily. Yes- working together is a life skill and I have heard students phrase things differently than I would that have helped classmates."

- In your most recent unit, did you us any visuals or models to represent the concepts being taught?
    - "Yes. Finding triangles within the classroom helped recognize the importance of triangles in everyday life when we started the Pythagorean Theorem."
    - "Yes. We just studied multi-digit multiplication, so we used the area model, partial product model, and basic math fact drawings to do this unit."
- How long do you wait to respond to a student's answer to a question and why?
    - "I tend to respond to their question with a question that helps them head in the right direction of the answer."
    - "I wait a little and ask them to first explain or show their thinking before I give corrections or help."
- Do you encourage students to become mathematicians when they are problem solving, and why?
    - "Yes, because mathematicians ARE problem-solvers. I tell my students all the time that they probably won't grow up and do most of the stuff we learn in high school math, but learning math teaches your brain to 'think' and how to problem solve...which you will do in life."
    - "Yes. I encourage them to think through problems multiple ways and prove that when following all math "rules" they can find the correct answer multiple ways...that is what makes math beautiful!"

As stated earlier, the responses were overwhelmingly positive and reflect the qualities of growth mindsets teaching. I believe most, if not all, teachers' pedagogies revolve around the benefits of growth mindsets as there is a wide variety of techniques that can be implemented into the curriculum to foster growth mindsets. Here, we see that the questions that we originally designated to opened-up mathematics were not he only questions that gathered those responses. It goes to show how creative and connected mathematics can become! When asked if they encourage their students to be creative, all 100 teachers agreed:

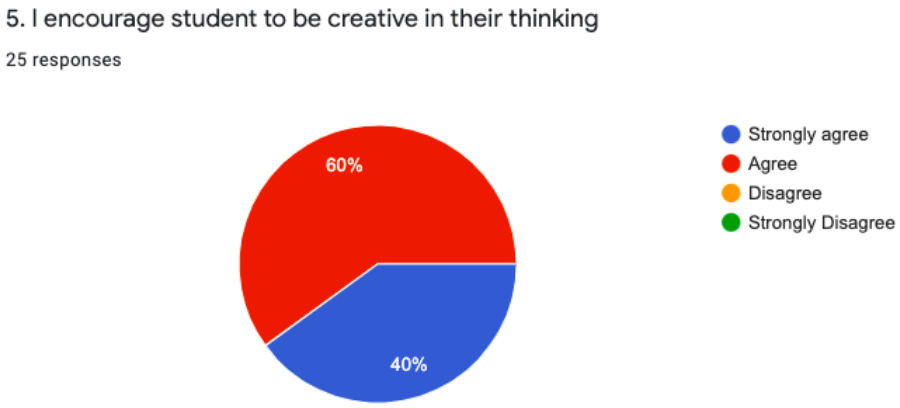

Figure 8: Creative encouragement in math

Conclusions

After analyzing growth mindsets among teachers and students while also diving deep into the teaching strategies the foster growth mindsets, we have determined that to continue to see positive change in mathematics education, we must educate ourselves on growth mindsets and how we can maintain them. With that, we concluded that a majority of our participants had growth mindsets among both students and teachers, but that does not mean every student and teacher think with a growth mindset.

We found that as grade level increased, growth mindset percentages decreased which may be due to valuing speed rather than conceptual depth. Yes, it is always impressive to finish

first in a race, but what about mathematical race? What are the benefits to learning subjects quickly, only to turn right back around and get rid of them even faster so that new information may fit? Mathematics is deeply rooted in connections and relations, and thus cannot be treated as basic conceptual problems, or else it would not truly be mathematics.

In addition to the inverse correlation, we found that both upper grade levels and their corresponding teachers had significantly lower growth mindset percentages, proving the impact of teachers' mindsets on their students' mindsets. No matter the age of the student, their mathematical mindset is very impressionable, and a teacher's influencing may have great impact. Math teachers can lead students toward the path of growth mindsets by executing teaching strategies discussed in this. By showing students the creative and beautiful side of math, while also encouraging them in all aspects of life, they will soon realize their math lessons can apply about every endeavor they face. "The view you adopt for yourself profoundly affects the way you lead your life. It can determine whether you become the person you want to be and whether you accomplish the things you value" (Dweck, 2016).

Growth mindsets are not always easy to develop, and it takes great practice and perseverance to maintain one. However, once a student walks through the doors of a growth mindset, they will understand their potential is never-ending and their future is bright. Math educators simply hold the keys to these doors as well as hold the tools to fix it if it ever breaks. Every student has a right to their own key, and every teacher has a duty of gifting it to them.

References

Boaler, J. (2016). Mathematical mindsets: Unleashing students' potential through creative math, inspiring messages, and innovative teaching. San Francisco, CA: Jossey-Bass & Pfeiffer Imprints.

Dweck, C. (2006). Mindset: The new psychology of success. New York: Random House.

Statements:	**Circle Your Answers:**
What grade are you in?	6th 7th 8th 9th 10th 11th 12th
1. A person always knows whether they are a math person or not.	Strongly Disagree Disagree Agree Strongly Agree
2. We are born either good at math or bad at it.	Strongly Disagree Disagree Agree Strongly Agree
3. It is always possible to get better at Math.	Strongly Disagree Disagree Agree Strongly Agree
4. I learn math best when my teacher shows me how to work a problem.	Strongly Disagree Disagree Agree Strongly Agree
5. I learn math best when I struggle and make mistakes in math class.	Strongly Disagree Disagree Agree Strongly Agree
6. If you struggle too much in math, then you are not a math person.	Strongly Disagree Disagree Agree Strongly Agree
7. You can do a lot to change how well you understand math.	Strongly Disagree Disagree Agree Strongly Agree
8. Trying a problem you do not know how to solve is the best way to learn new math skills.	Strongly Disagree Disagree Agree Strongly Agree
9. Smart people do not need to try hard.	Strongly Disagree Disagree Agree Strongly Agree
10. If you can answer questions quickly, then you are good at math.	Strongly Disagree Disagree Agree Strongly Agree
11. Practice exercises are the best way to learn new math skills.	Strongly Disagree Disagree Agree Strongly Agree
12. You can learn new things, but you can't really change your basic math intelligence.	Strongly Disagree Disagree Agree Strongly Agree

13. You can always substantially change how intelligent you are.	Strongly Disagree	Disagree	Agree	Strongly Agree
14. I appreciate it when teachers give me feedback on my math performance.	Strongly Disagree	Disagree	Agree	Strongly Agree
15. I often get frustrated when I get feedback on my math assignments.	Strongly Disagree	Disagree	Agree	Strongly Agree
16. I felt pressured to know how to do math quickly.	Strongly Disagree	Disagree	Agree	Strongly Agree
17. I am afraid to ask questions in math class because I do not want to look dumb.	Strongly Disagree	Disagree	Agree	Strongly Agree
18. It is ok to use your fingers to count or work out math problems.	Strongly Disagree	Disagree	Agree	Strongly Agree
19. Using manipulatives (such as blocks, wooden shapes, or 2-color counters) is beneficial to learning math.	Strongly Disagree	Disagree	Agree	Strongly Agree
20. Working with other students helps me to learn a math concept better.	Strongly Disagree	Disagree	Agree	Strongly Agree

Statements:	**Circle Your Answers:**
What grade are you in?	Kindergarten 1st 2nd 3rd 4th 5th
1. You always know if you are good at math or if you are bad at it.	Strongly Disagree Disagree Agree Strongly Agree
2. You are born good at math, or you are born bad at math.	Strongly Disagree Disagree Agree Strongly Agree
3. You can always get better at math.	Strongly Disagree Disagree Agree Strongly Agree
4. I learn math best when my teacher shows me how to work a problem.	Strongly Disagree Disagree Agree Strongly Agree
5. I learn math best when I struggle and make mistakes in math class.	Strongly Disagree Disagree Agree Strongly Agree
6. If you struggle in math, then you are not good at math.	Strongly Disagree Disagree Agree Strongly Agree
7. There are lots of ways to change how much you know about math.	Strongly Disagree Disagree Agree Strongly Agree
8. The best way to learn math is to try super hard math problems.	Strongly Disagree Disagree Agree Strongly Agree
9. Smart people do not need to try hard at math.	Strongly Disagree Disagree Agree Strongly Agree
10. If you answer questions quickly, then you are good at math.	Strongly Disagree Disagree Agree Strongly Agree
11. The best way to learn math is by doing a lot of practice problems.	Strongly Disagree Disagree Agree Strongly Agree
12. No matter how much you learn, you cannot change how smart you are.	Strongly Disagree Disagree Agree Strongly Agree

13. I like when my teacher tells me what I did right or wrong in a math problem.	Strongly Disagree	Disagree	Agree	Strongly Agree
14. You can always change how smart you are.	Strongly Disagree	Disagree	Agree	Strongly Agree
15. I do not like it when my teacher tells me what I did wrong on a math problem.	Strongly Disagree	Disagree	Agree	Strongly Agree
16. I feel like I have to do math problems quickly.	Strongly Disagree	Disagree	Agree	Strongly Agree
17. I am afraid to ask questions in math class because I do not want to look dumb.	Strongly Disagree	Disagree	Agree	Strongly Agree
18. It is ok to use your fingers to count.	Strongly Disagree	Disagree	Agree	Strongly Agree
19. Using counting blocks helps me learn math.	Strongly Disagree	Disagree	Agree	Strongly Agree
20. Working with my classmates helps me to learn math better.	Strongly Disagree	Disagree	Agree	Strongly Agree

Statements:	**Circle Your Answers:**
What grade do you teach?	Kindergarten 1st 2nd 3rd 4th 5th 6th 7th 8th 9th 10th 11th 12th
1. I explicitly encourage my students often	Strongly Disagree Disagree Agree Strongly Agree
2. It is good to change the rigor of individual assignments based on the student's ability	Strongly Disagree Disagree Agree Strongly Agree
3. I am not doing a good job if my students struggle in class	Strongly Disagree Disagree Agree Strongly Agree
4. I make students explain their work no matter the accuracy of their solution	Strongly Disagree Disagree Agree Strongly Agree
5. I encourage student to be creative in their thinking	Strongly Disagree Disagree Agree Strongly Agree
6. It is easier for students to learn concepts one way rather than multiple	Strongly Disagree Disagree Agree Strongly Agree
7. It is good for students to be able to work quickly	Strongly Disagree Disagree Agree Strongly Agree
8. It is ok if it takes students longer to grasp a subject such that we do not get to later subjects on time	Strongly Disagree Disagree Agree Strongly Agree
9. I make use of modeling in math often	Strongly Disagree Disagree Agree Strongly Agree
10. I often make use of real-world connections in my math lessons	Strongly Disagree Disagree Agree Strongly Agree
11. It is bad for students to be skeptical about what they are learning	Strongly Disagree Disagree Agree Strongly Agree

12. It is ok to take time to explain the benefits of group work, even if it means taking all day to do so	Strongly Disagree	Disagree	Agree	Strongly Agree
13. It is not possible to completely change a student's math ability; they are born either good or bad at math	Strongly Disagree	Disagree	Agree	Strongly Agree
14. My students are most successful when I show them how to work out a problem	Strongly Disagree	Disagree	Agree	Strongly Agree
15. It is good for students to talk amongst themselves about a problem before they come to you	Strongly Disagree	Disagree	Agree	Strongly Agree
16. I tell (or have told) my students that struggle and failure is a good thing	Strongly Disagree	Disagree	Agree	Strongly Agree
17. I only praise students when they correctly answer questions	Strongly Disagree	Disagree	Agree	Strongly Agree
18. Using visuals is an essential part to teaching math concepts	Strongly Disagree	Disagree	Agree	Strongly Agree
19. Mathematic speed is more important than depth	Strongly Disagree	Disagree	Agree	Strongly Agree
20. I encourage students to be skeptical	Strongly Disagree	Disagree	Agree	Strongly Agree

Appendix D

Open-ended, Free Response Questions

1. What is the most important idea about learning math that you want your students to understand?
2. How, as a teacher, would you introduce a new math concept/problem?
3. How long do you wait to respond to a student's answer to a question and why?
4. Do you encourage students to become mathematicians when they are problem solving, and why?
5. What are some ways you encourage your students?
6. How do you approach a student who has made a mistake on a problem and/or struggling?
7. How often do you allow group work, and do you think it is beneficial for students to debate over solutions?
8. In your most recent unit, did you us any visuals or models to represent the concepts being taught?