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Teaching Growth Mindset in a Secondary Mathematics Classroom

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by

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DEDICATION

To my husband, my family, and my colleagues for all of your support. I could not have completed this project without your continued encouragement.

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Introduction

Introduction

It is not very often that I meet someone new who is excited by the description of my job. I tell individuals that I am a high school math teacher, and I am usually met with a grimace or a version of the line, *I am not a math person*. With a single prompt, people automatically assume that learning math or doing something mathematical is not for them. They have decided that mathematics is unattainable, and they lose a bit of confidence. I may resign not to argue with adults about how they feel about mathematics, but I see and hear these same excuses in my students, too. Fourteen-year-olds should not be deciding if they absolutely can or cannot be successful in mathematics. In fact, I would strongly argue that anyone, regardless of age or perceived ability, can be a math person.

In this chapter, I will discuss my experiences with math learning as a student and as an educator. These experiences have led me to understand that there may be a profound impact on student mathematics learning from their own confidence and perceived abilities. This leads to my research question: *How can teaching high school students about growth mindset affect their attitudes toward mathematics learning and academic achievement?*

Personal Experiences as a Student

We all have educational experiences that lead us to great moments of change, thought, and attitude. I remember as a student in my fifth grade math class being tested on multiplication skills in timed tests. With each test you learned or memorized the

multiplication rules for a number between 1 and 12. With each assessment I grew confident because I passed after one or two attempts. The last assessment in which I was asked to multiply with the number 12 challenged me in a way that I had not been challenged before. I attempted the test at least four times. After the fourth attempt I remember running to the bathroom in tears because I was so frustrated with my work. I did not know how to move forward; I did not understand how I was supposed to get it right. Eventually I moved on and passed the assessment but that was a distinct moment in my mathematical learning journey.

The struggle I experienced was not productive, and I had no skills to help keep myself in the right mindset to be able to move forward in my learning. At the time, I heard my teacher say that learning meant memorization. I thought that meant that if I could not memorize these facts, I would be unable to learn. There should have been a different way to teach these skills or another approach to help me and other students understand that making mistakes did not mean that we were not learning or incapable of getting better.

As an adult learner, I came to understand the value of productive struggle. I learned how to seek out resources, like professors and classmates, that would help me reach a goal. Instead of looking at small setbacks as failures, I learned to see them as opportunities to seek out a different perspective. With these perspectives, I was able to create a plan without feeling stuck or unable to move forward.

I think about these situations a lot as I teach my students. They are well beyond the years of timed multiplication testing, but they do struggle with mathematics. They become discouraged from future learning, but I know that the struggle may actually help

them be successful. When they lose confidence in themselves and their abilities, their mindset, rather than their skills, becomes a blockade to their success. If students learn that their mindset affects the way they learn and achieve they may be able to be more successful.

Personal Experiences as an Educator

As a teacher of ninth-grade math intervention courses and rigorous college preparatory math courses, I see students in my classroom straining each day to learn the material set in front of them. This is even further exacerbated by the effects of a global pandemic. They struggle with basic skills in the classroom like bringing materials, participating in regular discussions appropriately, and behaving in ways that ensure safety for all students. It takes time to help students understand these basic skills, but day-to-day operation of the classroom is not the only reason why students are not successful. Many of them have anxiety about learning mathematics. Some of them have not set foot in a classroom setting for over 18 months. They have forgotten what it means to learn from mistakes while in the classroom, in front of others, instead of the comfort of their own spaces. Maybe they never learned the skills to think about mathematics in this way. Some of my students have moments where they put forth the effort to learn and attempt a problem and then see their efforts not pay off in the way they expect. Discouragement and lower achievement then follow.

Early on in mathematics, students learn simplistic rules to navigate more complex fields of algebra, arithmetic, and geometry. This is not the fault of the students. Educators use rules as a way to teach their students, and in some ways, this way of teaching and learning may be *easier*. My students are able to remember these procedures because, to

them, the *rules* they learned felt like absolutes. Students can cling to consistency and rely on the never-changing systems and methods to get them through problem after problem. However, sometimes these rules only apply to very specific situations. For example, students in my high school classroom are struck with panic and shock when I tell them that they do not actually have to use a specific order of operations to solve a single equation. There are moments when it makes more sense to multiply by a constant before simplifying parentheses. Sometimes an exponent outside of a set of parentheses does not mean that you can move that exponent to every term or variable you see inside of the parentheses. Soon my students learn there are more *exceptions* than there are *rules*.

Sometimes reteaching these concepts to my students can be discouraging. Students may feel like they know less than they did when they walked into my classroom at the beginning of the period. In many ways adding these new layers to their understanding is very beneficial, but when the struggle of new learning comes at the cost of student confidence, there must be another way to ensure that students will be able to move forward with understanding something new, even when they grapple with new concepts.

Rationale

As I continued to experience the frustration of my students, I wondered if a shift in their mindset could help them be more successful in my class. The way I learned mathematics will not suffice for my students. There must be better ways to help students build confidence in mathematics while also allowing them to make mistakes and develop new connections that are beyond procedures and formulas. I firmly believe that all students are capable of learning the standards and skills set before them, but if they do

not believe that they are skillful, it is difficult for them to move forward. Similarly, I see the value in learning about difficult topics in mathematics, so I choose to teach them. However, if my students cannot identify these values, they feel that they cannot learn. It is important to help students recognize the value of learning difficult concepts so that they can advance within mathematics while also learning crucial problem solving that will benefit them beyond the classroom.

Integrating growth mindset presents an opportunity for school and district educators to stretch students' perspectives about learning and find success in mathematics. A shift in student mindset can stem from conversations in a single classroom, but these approaches may be most effective on a larger scale. There is a need for professional development centered around answering the question: *How can teaching high school students about growth mindset affect their attitudes toward mathematics learning and academic achievement?*

By teaching our students to understand the relationship between learning and mindset, we empower them to take on the responsibility of deepening their understanding of the content taught in the classroom. While intentionally exploring a fixed and growth mindset with students in the classroom setting, I could see more confidence in my students as mathematics learners, a willingness from students to take risks to learn difficult material, and a deeper motivation to understand. All of these changes would lead to better achievement outcomes for students, including a mastery-approach to learning (Greene et al., 2004) they lacked before understanding the power of mindset. I created and will present a series of professional development sessions to current math teachers and administrators in my district to explain and explore the need for growth mindset in

teaching and learning mathematics. These sessions focus on understanding growth mindset, implementation of strategies to use growth mindset in teaching and learning mathematics, and reflection on the effectiveness of these strategies in classroom environments.

Summary

My experiences as a student of mathematics and as a mathematics teacher helped me identify approaches to learning that are successful and unsuccessful. I must discover methods of teaching and learning that help students understand mathematics deeply, encourage students to make mistakes and take risks, and grasp that struggle does not indicate failure. Through developing and teaching a growth mindset to students, I will help teachers and educators build student confidence in mathematics with these new means of teaching and learning.

The second chapter will include a literature review exploring the question: *How can teaching high school students about growth mindset affect their attitudes toward mathematics learning and academic achievement?* The research will analyze growth and fixed mindsets, mathematical teaching and learning experiences that build student confidence by reshaping their mindset, and an exploration about teaching and learning mathematics at the high school level. Chapter Three will include a description of the project, a timeline of implementation, and participants involved in its execution. The final chapter will describe my results and conclusions, both personal and professional, about the project's completion.

CHAPTER TWO

Literature Review

Introduction

There are undeniable gaps in achievement in mathematics learning. It is one thing to read about these statistics in official school reports or in the media, but I am a witness to them each day. I know that I have control, to some extent, over the management of the classroom and what content I teach to my students, but I have not tried to change the way my students feel about mathematics and mathematics learning to help them achieve better learning outcomes. In this chapter, I will attempt to answer the question, *How can teaching high school students about growth mindset affect their attitudes toward mathematics learning and academic achievement?* by exploring mindset, student achievement, and secondary teaching and learning strategies.

Mindset

Dweck (2006) defined two types of mindsets, fixed mindset and growth mindset. A fixed mindset is “believing that your qualities are carved in stone” (p. 6). A growth mindset is “the belief that your basic qualities are things you can cultivate through your efforts, your strategies, and help from others" (p. 7). A person’s mindset, whether we realize it or not, alters how they perceive and react to different situations. These first and second sections will provide a broader exploration of growth and fixed mindsets as well as their effect on secondary student learners. More specifically, the second section will explore the origins of student mindset. The final section will discuss how students may be able to change their mindsets to help them be more successful learners (Laurian-Fitzgerald, 2016).

Growth and Fixed Mindset

Development, improvement, and learning are essential parts of a student's education, and they are possible by providing opportunities for challenge. It is in these challenges that students express either a willingness to continue working through the challenge or frustration and defeat. Growth and fixed mindsets as defined above send students on educational paths that affect their futures (Haimovitz & Dweck, 2016). For example, a student with a growth mindset values learning, effort, and mastery whereas a student with a fixed mindset may only seek to sustain their abilities, see little value in effort or struggle, and feel helpless completing difficult tasks (Haimovitz & Dweck, 2016).

A student's mindset does in fact affect their learning. Students with a growth mindset are more successful academically (Blackwell et al., 2007). In an age of education where grades and standardized tests are the measurement of success, we must understand how mindset is responsible for altering these results for students and provide opportunities to increase or improve their achievement outcomes. In a study from the United States in 2019, Yeager et al. found that in a group of students who participated in growth mindset intervention programming, beliefs related to a fixed mindset were reduced and lower-achieving ninth-grade students earned higher grade point averages than students who did not participate in the intervention. These same results are replicated in other countries like Peru (Outes-León et al., 2020), Turkey (Alan et al., 2019), and Norway (Bettinger et al., 2018). Achievement and a growth mindset are positively correlated, so understanding where a student's mindset stems from and how it can be changed is valuable in education.

Origins of Mindset

Early studies about parent and child self-perception have tried to conclude that an adult's mindset predicts that of a child's, including a study from Frome and Eccles (1998). This study used data from a longitudinal survey study completed between 1983 and 1984 of sixth- and seventh-grade students to conclude that "parents' perceptions of their children's ability and effort predict children's self- and task perceptions in math" (Frome & Eccles, 1998, p. 446). In more recent studies of American children and their parents, there was no significant correlation between the parents' and children's intelligence mindsets (Gunderson et al., 2013; Haimovitz & Dweck, 2016). The same can be said about teachers and their students; a teacher's growth mindset does not predict the mindset of his students (Haimovitz & Dweck, 2016). Without these correlations, we must seek other avenues to attempt to change a student's mindset.

Changing Student Mindset

The most important revelation about mindset and student achievement is that these mindsets can be taught. Educationally, classroom teachers and parents have the power to affect student mindset with their behavior, not just their beliefs (Haimovitz & Dweck, 2016). Educators can use their responses to success and failure in the classroom environment to affect student mindset.

Responses to Success

An educator's response to student success, whether focused on intelligence or process, contributes to the student's development of a growth or fixed mindset (Mueller & Dweck, 1998). In six studies analyzed by Mueller and Dweck, they found that praise given to students for intelligence resulted in more negative effects for a student's

motivation for achievement than praise given for effort. For example, in my classroom, if I provide students with feedback that praises their intellect, they may see their intelligence as fixed. This means that any failures or misunderstandings undermine their smartness or abilities. In contrast, a student provided with feedback that focuses on their process remains determined to learn; these students tend to develop a growth mindset (Haimovitz & Dweck, 2016).

Responses to Failure

While success plays an important role in developing a student's mindset, so does failure. A teacher's or parent's response in these situations is just as valuable in developing a growth mindset (Haimovitz & Dweck, 2016). In a study from Haimovitz and Dweck, parents' views on failure as either enhancing or inhibiting learning resulted in parental actions that encouraged different mindsets in their children. Parents that responded to a failing grade with a focus on their child's ability and performance believed that failure hindered an opportunity to achieve, demonstrating a fixed mindset of the student's abilities. On the contrary, parents who believed that failure was a part of the learning process used the opportunity to discuss paths to improvement with their students, like asking for help from their teachers. (Haimovitz & Dweck, 2016). Responses to failure that encourage a process orientation to learning, taking risks, and seeking help from others mirror and support a growth mindset.

Educational Environment and Mindset

Teachers have influence over the students in their classrooms with their words and actions, especially in setting the tone for dynamic or collaborative learning opportunities (Meloth & Deering, 1999). For example, I can control the volume in my classroom by

raising my hand in the air or through verbal cues, like a call and response protocol. However, my personal preferences about volume and learning are insignificant. I work well while listening to music or in a more *active* work space, but this does not mean that my students feel the same way. In the same fashion, a teacher's mindset does not directly affect a student's mindset, but their practices, whether intelligence- or process-focused, does predict their students' mindsets (Haimovitz & Dweck, 2016). A teacher's practices as well as the culture they cultivate in the classroom or school community affects how students will or will not develop a growth mindset.

Educators have a hand in changing student mindset, but these efforts are less about willing students to change their mindset through sharing personal experiences or perspectives. Teachers can support a student's shift to a growth mindset by responding to successes and failures with praise or recognition of process (Haimovitz & Dweck, 2016). They can also encourage a culture of process-oriented learning that leads to a growth mindset to continue to advocate for a mindset that will lead to better achievement.

Student Achievement

All educators wish for their students to achieve, but it is often left up to other individuals, programs, or organizations to identify what exactly that achievement may look like. Moreover, these parameters for achievement may advantage or disadvantage certain students (Elliot, 2015). In the first section, an investigation of definitions of achievement for secondary learners will be provided, including the approaches to reaching goals that affect achievement. The next section will explore issues related to equity in mathematics teaching and learning that stem from current or traditional beliefs in achievement, including how we measure or define achievement as educators (Seo &

Lee, 2021). In later sections, a connection between achievement in mathematics and fixed or growth mindsets will be discussed.

Achievement Goal Theory

In education, achievement goal theory primarily focuses on two types of defined goals for achievement: performance-based and mastery-based goals (Senko & Hulleman, 2013). These goals define the types of perceived achievement for students and educators. Performance goals are set to define student success or failure as it relates to their peers' relative success (Senko & Hulleman, 2013). Standardized scores can be used to assess a student's level of achievement for these types of goals, including national or state tests, and even classroom assessments (Senko & Hulleman, 2013). If students' scores are compared to one another to define their level of success, this is a performance-based measure of achievement. Mastery goals focus on developing skill rather than striving to meet a set standard of success (Senko & Hulleman, 2013). Oftentimes in education we refer to setting mastery goals as learning-oriented as opposed to performance goals which are grade-oriented (Eison, 1982).

Performance and mastery goals can be differentiated by an approach focus or an avoidance focus. With a performance-approach goal, individuals are motivated to outperform others to exhibit superiority in comparison to a performance-avoidance goal where an individual is motivated to avoid negativity or judgments of inferiority (Hoose, n.d.). For instance, in a typical high school classroom, a student with performance-approach goal orientation may seek higher grades to be ranked as the top student in their grade level by grade point average. A student with a

performance-avoidance goal orientation may only want to earn a certain grade to avoid failing a course for fear (Nesbit, 2005).

A mastery-approach goal orientation leads an individual to seek improvements in understanding, skill, and learning. However, a mastery-avoidance goal orientation represents a desire to avoid situations where an individual feels unable to learn (Hoose, n.d.). A student with a mastery-approach goal orientation may be motivated to take a class to learn as much as they can about a topic for their future career. On the other hand, a student with a mastery-avoidance goal orientation may choose easier course work because they are concerned with their inability to learn the material (Nesbit, 2005).

Effects of Achievement Goal Theory in Educational Success

When students and teachers engage in mastery-approach goals, they take part in learning strategies that are typically associated with positive achievement outcomes (Greene et al., 2004). We may see these students contribute to learning by seeking out help, putting forth more effort, learning from mistakes, and taking an interest in the subject or task. In contrast, performance-avoidance goals have the opposite effect for students, generating little persistence, high anxiety, and the use of rote strategies rather than critical thinking typically associated with negative achievement outcomes (Hoose, n.d.).

In between, a performance-approach goal orientation has been positively associated with achievement while also contributing to test anxiety or the use of poor learning strategies (Linnenbrink-Garcia et al., 2008). Performance goals, while they may be successful in reaching some positive achievement outcomes, imply a student is motivated extrinsically rather than intrinsically, as with mastery goals (Svinicki, 2009).

By encouraging a mastery-approach to achievement, educators move students toward a growth mindset, focusing on process rather than ability, to contribute to long-term, positive achievement.

Realities of Achievement Goals in Education

As a high school classroom teacher, I have goals and expectations for my students that relate to learning and achievement. In a perfect world, I would strive to learn my students' current level of understanding of mathematics, then foster an environment that would allow them to develop, through a variety of strategies, a deeper understanding of the content. However, these expectations may be different from the goals of the department, district, or standardized test (Kohn, 2000). For example, the state of Minnesota has set statewide goals for academic achievement, seeking to close the achievement gaps in reading and math at different grade levels (Minnesota Department of Education, n.d.). The results of these goals will be based on students meeting acceptable standards of achievement on statewide assessments, a performance-based goal. Similarly, students will prepare to take the ACT in the spring for admittance to their preferred college or university, setting the expectation that their performance is what is important. These standardized tests were not designed to measure if students were capable of thinking deeply to understand a concept. Instead they were designed to accommodate *superficial* learners, valuing skills in knowing facts or strategic guessing (Kohn, 2000). While research tells us that performance goals may contribute to positive achievement outcomes, their benefit comes at a cost to developing learners (Linnenbrink-Garcia et al., 2008). However, there are unwavering systems in education that perpetuate a need for students to adopt a performance-approach goal orientation to succeed.

Students Affected by These Realities

The opportunity to learn (OTL) "generally refers to inputs and processes within a school context necessary for producing student achievement of intended outcomes" (Elliot & Bartlett, 2016, p. 1). OTLs may include "content coverage, content exposure (i.e., time on task), content emphasis (i.e., emphasis of cognitive processes), and quality of instructional delivery" (Elliot & Bartlett, 2016, p. 3). A study comparing the OTL of the time dedicated by a teacher to deliver content with effective teaching strategies and the achievement growth of students with disabilities (Elliot, 2015) found that any goals related to student performance to mitigate achievement gaps ignore a fundamental understanding of the realities that teachers and students face. There simply is less OTL for students with disabilities leading to fewer opportunities for critical thinking and poor academic growth (Elliot, 2015). With performance-based learning, especially when students are to *catch up* to their peers, goals must be "contextualized by empirical findings that describe the instruction and growth that occurs for students as a function of their exceptionality and background" (Elliot, 2015, p.63). If student learning is approached through mastery rather than performance, it may be better understood how much growth typically occurs in students to set goals that are not unattainable, but rather individualized and realistic (Senko & Hulleman, 2013).

High school students' mathematics achievement may also be affected by their perception of self (Seo & Lee, 2021) and social relationships (Hoose, n.d.). Suppose that a student attempts to have a closer relationship with a peer; they may seek help from a peer leading to better academic performance from the collaboration that typically supports achievement. On the contrary, students may seek out approval from peers with a

desire to impress them with their individual skills and understanding (Hoose, n.d.). By not seeking out help from other students or a teacher, they, in fact, keep themselves from opportunities to learn like collaboration, taking risks, and learning from mistakes.

Individual students' self-perception of ability in certain social situations may also affect their achievement. Stereotype threat is a "situational predicament in which individuals are at risk of affirming negative stereotypes associated with their social positions" (Seo & Lee, 2021, p. 1410). Students in these circumstances tend to underachieve on standardized or diagnostic exams from the fear of validating negative stereotypes brought on by circumstantial or social signals. From several experimental studies reviewed by Seo and Lee, women were negatively affected by stereotype threat in mathematics testing. Black and Latinx participants were also victims of stereotype threat, performing lower on general academic tasks. Academic achievement, especially in mathematics, is so much more than setting a goal and asking students to reach it. There are nuances in the types of goals we set with and for students, their motivation behind reaching these goals, and their personal and social relationships with the goal that affect achievement (Hoose, n.d.; Seo & Lee, 2021).

Inequities in Mathematics Education

Contemporary education allows for windows of measurable disparities in mathematics achievement and expectation of students' achievement based on gender, race, and sexual orientation (D'Ambrosio et al., 2013; Forgasz & Hill, 2013; Gottfried et al., 2015). For example, in a dialogue about racial issues in mathematics education, Martin (D'Ambrosio et al., 2013) implores researchers and educators to "understand black children as black children before you try to make any kind of conjectures or

conclusions about how they are deficient or what they do or don't know" (p. 31-32). Children, especially children of color, are navigating the world of education where it is necessary to create counternarratives to stereotypes that hurt their self-esteem, self-image, and ultimately their achievement (D'Ambrosio et al., 2013). Martin continues:

> How do you teach black children in a school or district setting when the district and the country and the principal are telling black children that they're inferior to white children, because all that your teachers hear about is the racial achievement gap. How do you teach children when they're being assaulted in that way, when their identities are being assaulted and crushed and subjugated and subordinated in that way? (p. 32)

Disparaging and discouraging information about the achievement and opportunities for success of minority students can leave students and educators confused about how to proceed in teaching and learning (D'Ambrosia et al., 2013; Gottfried et al., 2015). Could a growth mindset help offset some of the inequities that plague mathematics education? Can educators improve a student's self-image and achievement in mathematics by introducing strategies that encourage and insist on the development of a growth mindset?

Achievement and Mindset

Achievement is affected by many factors, but is there a relationship between achievement and mindset? Mastery-approach goal setting and growth mindset are very closely related; both systems emphasize development of skills, improving, and putting forth greater effort, all of which have positive outcomes in academic achievement (Bostwick et al., 2020). It is not enough, though, that we recognize this important connection (Bostwick et al., 2020). Educators are also responsible for mitigating

negative outside influences with a growth mindset. If a teacher herself holds a growth mindset and tendency to set growth-related goals for and with students, students may reach high levels of mathematics achievement, as demonstrated by Bostwick et al. . On the other hand, students facing stereotype threat are more likely to experience the threat to their academic performance if their mathematics teacher exhibits a fixed mindset (Seo & Lee, 2021). That is, a teacher's mindset can not only influence a student's performance but challenge disadvantages or other factors that may affect their achievement. With the understanding that educators can influence how a student approaches learning through mindset, there are strategies that classroom teachers can implement to develop an environment for a growth mindset for all students.

Secondary Classroom Teaching and Learning

This section will discuss teaching and learning strategies for the secondary mathematics classroom that will positively impact student mathematics learning and achievement, along with an abridged history of mathematics education in the United States. Some strategies shared will be related to educational best practices that benefit all learners of mathematics, especially those historically underserved (Hollie et al., 2015). A considerable focus in this section will be on strategies that promote growth mindset in a mathematics classroom. These strategies include ways to improve student growth mindset through direct instruction as well as mathematical teaching strategies that develop a student's mindset and perceived mathematical ability (King, 2013). Additionally, strategies that improve educator mindset or readiness to be able to address student mindset through teaching will be examined.

Abridged History of Mathematics Education in the United States

STEM (Science Technology Engineering Mathematics) education in the United States has its roots in the international space race of the 1960s (Bernstein, 2019). This need for other-worldly achievement sparked the competition and stronger interest in mathematical sciences. A few decades later, concern for students' scores on standardized exams indicated a need for a more aggressive emphasis on teaching and learning mathematics and science; thus came the development of the term STEM from the National Science Foundation (Bernstein, 2019).

Even with the pressure to perform well in the sciences on an international stage, STEM education had suffered because of the introduction of the new math movement (Klein, 2003). The new math movement pulled away from basic mathematical skills and pushed for teachers and students to work in theory - set theory, calculus, and non-ten number bases (Klein, 2003). The high-level mathematics education that new math attempted to create was more off-putting than it was encouraging. By the 1980s, mathematics education worsened, leading to low enrollment in math and science programs and reduced expectations for college entrances (Klein, 2003). In 1989, the National Council of Teachers of Mathematics [NCTM] developed general mathematics standards for kindergarten through 12th grade, emphasizing problem solving and the use of technology (NCTM, 2022). Thus began the country's current approach to mathematics learning - a focus on what is being taught rather than the how. No Child Left Behind [NCLB], signed into law by President George W. Bush in 2002, required states to create standardized tests that would measure what students know in reading and mathematics (NCTM, 2022). Then, in 2010, the Common Core standards were developed to prepare

students for college and career, focusing on fewer topics but allowing for more depth within each topic (Nelson, 2014). While each shift in mathematical standards brings more attention and value to STEM in traditional educational settings, low standardized test scores are evidence of the need to alter the ways in which educators deliver this content to students (The Nation's Report Card, 2019).

Best Practices in Mathematics Education

Teachers may struggle to implement any new specific strategies related to mindset in their classrooms without first creating a culture of student engagement and expectation that are fundamental to math learning. The NCTM (2008) has identified six principles essential for high-quality instruction: equity, curriculum, teaching, learning, assessment, and technology (Midgett & Eddins, 2001, p. 40). Equity in mathematics teaching requires high expectations and high support for all students, but these expectations can be set by teachers as they relate to student performance or set by students about their own learning and development (Schindler & Bakker, 2020). Curriculum can be developed by teachers or organizations, but it should remain focused on deepening student understanding (NCTM, 2008). Teaching and learning mathematics requires a thorough knowledge of the content (Tchoshanov et al., 2017) as well as the students in the classroom; effective instruction is responsive to the needs and cultures of students to help them learn best (Hollie et al., 2015). Learning mathematics, as discussed earlier in the chapter, is affected by many factors, but effective mathematics learners are committed to understanding and persevering through difficult tasks (Üredi & Kösece, 2020). Assessment and technology should both support and improve student learning, not hinder or obstruct a student's ability to deepen their understanding of mathematics (NCTM, 2008). With these guiding

principles, teachers may be able to see where teaching a growth mindset is valuable to their students' learning by deepening understanding of mathematics and teaching skills in problem solving.

Improving Student Growth Mindset

Students of mathematics are advantaged in their opportunities for achievement by a growth mindset (Bostwick et al., 2020). To develop this mindset in students, there are a number of strategies that math educators can use including purposeful reflection, discussion of brain plasticity, teaching students how to *fail well* (King, 2009), and implementing low-floor high-ceiling tasks for multiple entry points for students to discuss and collaborate while learning mathematics (Kachwalla, 2021).

Purposeful Reflection. Students with a growth mindset are effective problem solvers, capable of communicating their ideas through clear and respectful discourse with others (Dweck, 2006). Students who are able to respond to prompts or engage in discussions that reflect the varying depths necessary to solve difficult problems are more likely to develop a sense of deeper learning, consistent with a growth mindset. Suh et al. (2011) created a series of reflection prompts for students that allowed them to think critically about the problems they would solve, communicate a specific plan or idea about the problem, and engage in thoughtful discussions with peers. These reflection prompts allowed teachers to glean more information from students about their thought processes before and after attempting learning tasks (Suh et al., 2011). While using these prompts, educators in the study were also clear with students the purpose of each of the questions, to practice clear communication, respectful communication, flexible thinking, or

persistence (Suh et al., 2011). In this respect, there is an active connection between what is being asked of the students and its connection to development of a growth mindset.

Neuroscience and Growth Mindset. At its core, adopting a growth or fixed mindset fundamentally changes your behavior and even the way your brain responds to new information or learning experiences (Blackwell et al., 2007). Scientific research showed that individuals who had a growth mindset and attempted to learn from a mistake had more brain activity than individuals with a fixed mindset (Mangels et al., 2006). In these individuals, there was a stronger inclination to fix mistakes because they were more aware of them, and in turn, created more intense brain activity (Mangels et al., 2006). By teaching students these important findings, especially students at the secondary level capable of understanding more advanced aspects of neuroscience, we allow mathematics learning to take meaning beyond a letter grade or report card. Students may start to make connections between a growth mindset and their performance in athletics or other areas of performance (Dweck, 2009), enhancing its value in the classroom.

Failing Well. Failing well is a term whose roots are in cognitive and behavioral studies (King, 2013), however, it can be used to describe how students react to failure. In mathematics teaching and learning, normalizing failure can have a positive effect on a student's growth mindset. It is typical for students in high school to hide their failures, especially if influenced by social circumstances or performance-based goals, however, it is important for teachers to be able to teach students the value of failure and failing well (Robinson, 2017). Even sharing their own failures, both related and unrelated to mathematics, teachers create a safer environment for students to fail (Robinson, 2017). In my own classroom, I encourage students to point out my mistakes in lessons or

assignments. It allows for an opportunity for me to be vulnerable and to model to my students what mindset I take when I do make mistakes. By teaching students to fail well, we allow them to practice growth mindset and change their patterns of behavior in response to setbacks that can lead to greater achievement.

Low-Floor High-Ceiling Tasks. To encourage students to develop a growth mindset, it is important for them to both find success in mathematics and challenge themselves with tasks. Low-Floor High-Ceiling (LFHC) math tasks ensure that all students "can access the problems but they can be extended to high levels" (Kachwalla, 2021, p. 100). A principle of mathematics teaching is not only learning a set of skills or content, but transferring that knowledge to deeper understanding (NCTM, 2008). With LFHC tasks, students are able to construct an understanding of a problem at their own level, at their own pace. All students, regardless of readiness level or mathematical achievement prior to the task, contribute to the discourse in these types of problems because there is not a singular result that could be deemed correct or incorrect (Kachwalla, 2021). For example, in a geometry class, I could ask students to find the area of a rectangle whose width is 4 meters and length is 9 meters. The only solution students could come up with is 36 square meters. Most students will use the algorithm for *width x length* to determine their answers; they may draw a picture or use another strategy, but the solutions are limited. To broaden the task, I could ask an open-ended question like, *What are the dimensions of a rectangle whose total area is 36 square meters?* In this task, students may be able to come up with multiple solutions and may even be encouraged to try strategies to find a solution not related to a learned algorithm. Using low-floor high-ceiling math tasks in class encourages students to take risks, make mistakes, and

learn from a process of critical thinking rather than a rule, an important aspect of growth mindset (Kachwalla, 2021).

Educator Mindset

While student mindset is important, it is equally important to establish an educator's growth mindset for these strategies to be effective for students. Teachers effective in establishing and maintaining a growth mindset in students use language that mirrors the values of growth mindset (Lee, 2009). These types of educators also continue to learn from professional development opportunities about the benefits of growth mindset and strategies that can be used in their classrooms (Lee, 2009).

Teacher Language and Mindset

Language is a powerful tool used by teachers to establish expectations for learning and behavior, and it is also invaluable in developing a growth mindset in students (Hollie et al., 2015). Responses to student work should focus on effort rather than solution (Lee, 2009). A teacher may ask, *What strategies did you try to solve the problem?* rather than, *What answer did you get?* Communication from teacher to student is more than verbal, too. Feedback on assessments or assignments can play a pivotal role in how students respond to failure. By using wise feedback, a strategy that "embeds high expectations and a genuine belief in the student's ability to meet or exceed those expectations within the context of constructive feedback," (Thayer et al., 2018, p. 276) students will be able to evaluate their work, learn from mistakes, and will be encouraged to continue their understanding. By being intentional in the way that educators use language and feedback to encourage students, they will be able to cultivate a growth mindset in the students in their classrooms (Thayer et al., 2018).

Continual Learning

A criticism of the recent research and excitement surrounding growth mindset in education is the failure to meet the needs of educators in regards to implementation of new strategies in their classrooms (Blad, 2016). The adoption of a growth mindset classroom is balanced upon teachers' knowledge of the subject matter and willingness or ability to carry out effective strategies in their classrooms (Blad, 2016). There is a demand for educators to receive practical education about teaching and using growth mindset in their classrooms, but it is also important to recognize that many educators only have an informal understanding of the cognitive and behavioral science of growth and fixed mindsets (Blad, 2016). In practice, many educators use their own understanding of growth mindset to communicate with their students, but in actuality do very little to promote these same characteristics in their students (Blad, 2016). Any professional development related to growth mindset should not be rushed; it should be informative, comprehensive, practical, and more importantly, reflective, in its approach. Educators should take away learning to develop a growth mindset in themselves and especially in their students.

Summary

Fixed mindset is so ingrained in the culture of traditional mathematics teaching that it can be difficult to envision a classroom that can fully integrate a growth mindset for both teachers and students. However, as identified in the research provided in this chapter, there is a clear positive correlation between students' growth mindset and their achievements (Bostwick et al., 2020). Even the way that students approach problems and engage in mathematical discourse changes is improved by a growth mindset (Suh et al.,

2011). The challenge then, is not understanding the value of a growth mindset, it is teaching this value and way of thinking to students. Through purposeful student engagement and the development of teacher mindset, it is possible to change the way students perceive mathematics and allow them better opportunities to achieve.

In the following chapter, I will introduce my project centered around understanding and teaching growth mindset to secondary mathematics students. The project will describe in more detail the purpose behind and creation of a series of professional development presentations for staff at the secondary level. The information in the professional development curriculum will continue to answer the question: *How can teaching high school students about growth mindset affect their attitudes toward mathematics learning and academic achievement?* Further information of the intended audience, setting, and timeline for implementation of the project will also be discussed.

CHAPTER THREE

Project Description

Introduction

The literature reviewed in Chapter Two solidifies my understanding that students with a growth mindset are more likely to achieve academic success (Bostwick et al., 2020). However, it also creates a need for more learning for educators about how to affect a student's mindset, promoting a growth mindset for learning rather than a fixed mindset. It is not to say that teachers and administrators do not believe in the importance of a growth mindset (Blad, 2016), but these gaps in understanding of how to implement specific strategies to help students necessitates more training for educators. In an effort to address this issue, my project will address my research question: *How can teaching high school students about growth mindset affect their attitudes toward mathematics learning and academic achievement?*

The first section of this chapter will provide a description of my project and its intended goals. Subsequent sections will explain research-based practices that will be essential to providing effective professional learning for the intended audience and a more detailed description of the project's implementation setting and timeline.

Description of the Project

My capstone project is a series of professional development seminars that inform math educators about students' growth mindset, the effects of mindset on student achievement, and strategies that teachers may use to teach about mindset in their classrooms to increase achievement. There are three professional development sessions to

learn about the topics, understand strategies, create a plan for implementation in classrooms, and reflect upon execution of these plans.

Throughout my literature review in Chapter Two, I focus on student learning, but also the adult or educator role in a student's growth mindset and achievement (Bostwick et al., 2020; Mueller & Dweck, 1998). By bridging the research in Chapters Two and Three, I am able to make connections for and with teachers between student mindset, student achievement, and specific strategies teachers may use to cultivate that mindset in their classrooms. Included in the research in this chapter will be information about adult learner theories (Jackson, 2009) and best practices in professional development (Felder et al., 2011) to create an effective professional development capstone project.

Adult Learner Theory

Classroom educators can be experts on how children develop and learn, but they themselves are also students in professional development learning seminars. From personal experience, the collective extent of knowledge, experience, and expertise rises in a room of educators when discussing education. However, there are research theories about adult learning that explain how knowledge and understanding is developed in adult learners. This can affect how educators interpret new learning and are able to apply it to their practices. Merriam et al. (2007) outline five learning theories or "orientations" to learning held by adult learners: behaviorist, humanist, cognitivist, social cognitivist, and constructivist. In these theories, respectively, learning is affected by the environment in which a person learns, how people are motivated to grow as learners, the meaning behind educational experiences, a learner's relationship and response to those teaching them, or a combination of individual interpretation of new learning with social interactions

(Jackson, 2009). While designing a professional development seminar that meets the needs of all of these approaches may be unrealistic, it is important to create opportunities for my audience to be able to make sense of new learning in the context of their classrooms (Cox, 2015).

Knowles et al. (2011) use the constructivist approach to adult learning to describe six characteristics of adult learners that impact how they may approach learning. Cox (2015) summarizes these characteristics as:

- They need to know.
- Adults are self-directed.
- Adults have an abundance of prior life and work experience.
- Adults learn when they are ready and when they have a need to learn.
- Adults are life-centered in the orientation to learning.
- Adults can respond to external motivators, but for the most part they are internally motivated. (pp. 29-30)

In the professional development sessions, I use these characteristics to create opportunities for learning for my participants that adds to their experience and expertise rather than taking away from or detracting from the opportunity to learn and apply new knowledge.

Goals of the Professional Learning Sessions

The first session is dedicated to identifying the need for an instructional shift in teaching and learning in our classrooms as it relates to mindset. This session will include opportunities for reflections from staff about their mindsets and perceived mindsets of their students. Questions for reflection may include:

- How does your mindset affect how you approach certain tasks in your personal life?
- How does your mindset affect how you approach teaching and learning mathematics?
- How might your students' mindsets affect their mathematics learning?
- How do you discuss mindset in your classroom teaching?

This session includes definitions of fixed and growth mindsets (Dweck, 2006), the neuroscience behind growth mindset, and examples of its effect on student learning and achievement (Blackwell et al., 2007) to establish a need for more learning (Cox, 2015) and continued reflection.

The second of these sessions is dedicated to sharing with participants teaching and learning strategies in secondary mathematics education that can improve student mindset. These theories and practices include teaching the value of failing well (King, 2013; Robinson, 2017), the use of low-floor high-ceiling tasks to help all students see success (Kachwalla, 2021), the language teachers use to relay a growth mindset to students (Lee, 2009), and the importance of purposeful reflection for students about their learning (Suh et al., 2011). As a part of this session, teachers devise a plan of implementation for some or all of these strategies in their classrooms. They will be able to work with colleagues that teach the same grade level or course to discuss approaches for teaching and reframing student mindset in the coming weeks.

Shorter, more frequent professional development sessions will take place to ask participants to reflect with colleagues about the progress they see in their own and their students' mindsets. These conversations may include discussions of these questions:

- What strategies have you tried to implement in your classroom to improve student mindset?
- What might you change in the next week or month to improve student mindset?
- Review an upcoming assessment or learning activity. How might you incorporate intentional reflection into this learning experience?
- How have you or might you include other stakeholders in your journey to improve student mindset?

The last of the longer professional learning sessions is dedicated to celebrating successes, reflecting on challenges in implementing learned strategies, and looking forward to new ideas for the coming school year to encourage a growth mindset. This session includes an overview of the first two sessions, but will be largely discussion-based to share and hear the scope of learning that took place over the school year to identify how *teaching high school students about growth mindset affects their attitudes toward mathematics learning and academic achievement.*

Setting and Audience

The professional learning sessions will take place in a school district in a suburb of Minneapolis that enrolls about 3,000 students. The primary participants will be approximately 20 math teachers and content coaches of grades 5-12 from the district's middle school, high school, and alternative learning center. Other participants may include curriculum coordinators and administrators from all schools. These individuals will take part in the professional development sessions throughout the year.

It is important to note the student population these educators serve. In the district, almost 12% of students are English Language Learners, about 14% of students receive

special education services, close to 60% of students are eligible for free or reduced lunch prices, and 1% of students are homeless or unhoused. While these are factors that classroom educators cannot control, they do play an important role in how teachers may approach learning and new strategies with their students (Elliot, 2015; Hollie et al., 2015; Seo & Lee, 2021).

Timeline

The first of the professional development sessions will take place before the start of the school year, during a week of training and professional development for all teachers. The first training will be an hour long. There will be two other longer professional development sessions throughout the year on designated non-student contact days, one in November and one in February. These sessions will be 2 hours long and 1 hour long, respectively. Shorter meetings throughout the year will take place before or after school, lasting about 30 minutes, to reflect on the goals of the previous session. While more time dedicated to this new learning in a larger group would be appropriate, once-monthly meetings in subject groups and grade-level teams will allow for adequate reflection with colleagues among participants.

Summary

In Chapter Three, I reviewed the information gathered from research in Chapter Two about growth mindset, student achievement, and teaching strategies for secondary learners as they relate to the professional development sessions created for this capstone. It is the purpose of the project described in this chapter to effectively relay an understanding of fixed and growth mindset to math educators so that they may also teach these critical understandings to students to answer the question: *How can teaching high*

school students about growth mindset affect their attitudes toward mathematics learning and academic achievement? Educators attending these professional development sessions will learn strategies to engage students in a growth mindset in a secondary mathematics classroom and have the opportunity to plan and reflect with colleagues about the implementation and success of these strategies.

I also researched the critical components related to adult learning and effective professional development for educators. The intended audience, timeline, and structure of the professional development for my project was also discussed.

In Chapter Four, I discuss significant learning from my research, implications for my project, and limitations for this capstone. I also draw conclusions related to student mindset and achievement that stem from the implementation of my capstone, including celebrations and challenges.

CHAPTER FOUR

Conclusion

Introduction

The purpose of this capstone project was to explore the question: *How can teaching high school students about growth mindset affect their attitudes toward mathematics learning and academic achievement?* As a high school mathematics teacher, I am called to help students reach their fullest potential as learners of mathematics. However, negative attitudes towards mathematics, whether they be intrinsic or extrinsic, impact how students feel about and in turn achieve in my classroom.

In the first chapter, I shared how my experiences as a math student brought out frustrations that diminished my confidence, but I learned strategies that helped me persist enough to find success. I also reflected on my conversations and observations of my own students whose mindset can set them back; they are discouraged because they see failure as an end to learning instead of as a way forward to new ideas. I wondered if teaching with a growth mindset to my students could affect their beliefs about mathematics learning and their achievement. I felt that the best way to ensure that all students would benefit from the development of a growth mindset, is through their trusted teachers. This is the reason I sought to create a series of professional development sessions for mathematics teachers, instructional coaches, and administrators to learn about growth mindset, its implications for learning, and strategies for educators to encourage a growth mindset in their students.

In this chapter, I will share significant research and major learnings from writing this paper and creating my project, limitations of the project in its current form,

implications for future iterations of this project, and the benefits of sharing this project with other professionals.

Significant Research and Major Learnings

As I began looking for research to understand growth mindset in education, I thought there would be ample literature about how teaching growth mindset affects the learning and success of students academically. I found quite a few studies that concluded that growth mindset and student achievement are positively correlated (Alan et al., 2019; Bettinger et al., 2018; Outes-León et al., 2020; Yeager et al., 2019). This helped me solidify my understanding that a growth mindset could be beneficial to student achievement. However, simply knowing that a growth mindset can benefit my students was not enough to develop my project. There must be a connection between knowing that a growth mindset is valuable and creating that value in our classrooms.

It was important to me to understand how a student's mindset related to learning is developed and changed, specifically if educators would have the power to help students change their mindset. From Haimovitz and Dweck (2016), I concluded that the least effective avenue for helping students develop a growth mindset would be through understanding the mindset of their parents or educators. The mindset of students is not predicated on the mindset of these adults, but educators can teach students to help them develop a growth mindset and reach success.

I focused my attention on aspects of teaching and learning that affect a students mindset. I found some of the most compelling literature in this area related to the definitions of success for young learners. I had heard of standards-based grading, but achievement goal theory opened my eyes to how educators can set standards and goals

for learning that are well-intentioned but may actually contribute to a fixed mindset (Nesbit, 2005; Senko & Hulleman, 2013). If educators can create environments that emphasize and encourage a mastery-approach to learning, they may be successful in establishing a growth mindset in their students.

This learning for me was strengthened by Elliot (2015) and D'Ambrosio et al. (2013) who suggested that a focus on performance goals only further exacerbates the perception that underperforming students, typically those in minority demographics, are unable to achieve. Educational outcomes that anchor themselves on performance goals create narratives that groups of students are destined to need intervention or remediation when, in fact, there are other factors that contribute to lower performance on standardized assessments. More specifically, a student's self-image and perceived ability in certain circumstances related to stereotype threat or continued expectations of underperformance is at fault for reduced achievement (D'Ambrosia et al., 2013; Hoose n.d.; Seo & Lee, 2021).

The first half of my literature review helped me understand that mindset is important to student learning, but I needed to find research that would help me connect this learning to actual classroom practices. The most meaningful literature for the basis of my project came from practical applications for teaching students to *fail well* (King, 2009) and to be open to learning mathematics with reflection and performance tasks that allowed multiple entry points for students (Kachwalla, 2021; Suh et al., 2011).

These teaching and learning strategies are what drove the development of my final project. I thought about what I would want my participants to know and be able to do as a result of completing the professional development sessions. If the goal is to

increase student achievement through a growth mindset, how can the educators in my district accomplish that in their classrooms? What do they have the power to control and change to make a positive impact on student learning and achievement?

From researching best practices for professional learning, I knew that I needed to create a space where participants would be able to make sense of new learning in the context of their own classrooms (Cox, 2015). This is why the opportunity to reflect on their current practices was so vital to the success of the project. From these sessions, participants will take away new learning and understanding, but they will also be able to use their experiences to apply what they have learned (Cox, 2015; Knowles et al., 2011). In this way, the organization of the project and professional development sessions models the development of a growth mindset; participants will be focused on improvement and learning rather than meeting arbitrary performance goals.

The literature review grounded me in research to create a project that would build upon the expertise of my colleagues, not take away from it. It also helped me learn the connection between academic research and practical application; this marriage is critical to move forward with evidence-based best practices that help students achieve and answered the question: *How can teaching high school students about growth mindset affect their attitudes toward mathematics learning and academic achievement?*

Limitations of the Project

Developing a student's growth mindset through classroom teaching and learning is possible; it is also beneficial to their achievement in mathematics. However, classroom educators are limited by their time and resources to do so. While this project aims to create a space for reflection and planning of one performance task to encourage growth

mindset, a single assignment for students will not create the necessary culture of learning to develop a growth mindset. In its current form, the series of professional development sessions are effective in helping educators learn how to teach with a growth mindset through a variety of strategies, but it does not allow for the building or redevelopment of a year-long curriculum that may need significant overhaul to accomplish these goals.

There are also a number of strategies and professional programs that could encourage a growth mindset in mathematics that were not mentioned in the project. While this was intentional to build upon the established work of the participants and avoid adding another required teaching tool, some participants may find programs that offer guided lessons to be beneficial.

Similarly, the project is designed for secondary mathematics teachers, instructional coaches, and administrators, but these individuals are not the only teachers of mathematics. Support staff or elementary educators may also be interested in learning about these strategies to help their students be more successful in mathematics learning.

Lastly, the literature review and project touch on the science and research behind the fixed and growth mindset. However, limited time is dedicated to explaining these details to participants in the project presentation. For some participant groups, it may be necessary to share more scientific research and numerical data to establish the need for these types of teaching strategies in classrooms.

Future Projects

This project provides an opportunity for educators to learn about growth and fixed mindsets, understand the effect of a growth mindset on mathematics learning, establish a culture in their classroom that encourages a growth mindset, and develop classroom

resources that will help them do so. However, it may be important for future projects to collect data on the level of success that these strategies have on student learning. It may be possible to collect data on particular strategies, like purposeful reflection or low-floor high-ceiling tasks, and how they lead to improved student achievement. It would also follow that research on the actual development of students' growth mindset may give insights to their achievement. A pre- and post-assessment of a student's mindset, much like the one given to the participants in the project, could be used as a measurement tool of student mindset.

Other projects may aim to research the relationship between growth mindset and stakeholders other than classroom teachers and administrators. This may take the form of a series of community learning and listening sessions for support staff, community experts, or parents and guardians.

Benefits to the Profession

With this project, I will be able to use my role as a mathematics teacher and mathematics instructional coach to impart knowledge and expertise onto already established professionals that does not diminish the work they already do in their classrooms, but enhances it. It has the potential to be adapted for all subject area educators, for support staff like paraeducators or community coordinators, and for learners in all grade levels.

The project and its intended audience, classroom teachers and administrators, validates the need for cohesive learning outcomes that can be supported by all levels of leadership. In order for any school initiative to be successful, there must be full support from these stakeholders to initiate and follow through with effective implementation.

Summary

In this chapter I summarized and explained in more detail essential components of research from my literature review. I reflected on how this literature informed my understanding of growth mindset and student learning and the development of my capstone project. I discussed the limitations of the project and ideas for future projects related to my research topics. I also shared how the series of professional development sessions as they are designed will benefit participants and the teaching profession.

At the core of my role as an educator is student success. I have learned that if I can share what I have learned from research with my colleagues to create opportunities for more students to achieve, then I will have been successful in creating this project.

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