"I'm Just Not Good at Math!" Rethinking What You Know About Mathematics

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Abstract: There are many misconceptions regarding mathematics that produce negative student dispositions in a classroom. Such misconceptions are not fact based but are due to an ineffective, fixed mindset where a student limits their abilities based upon low self-efficacy and self-concept. Fixed mindsets fuel negative attitudes toward mathematics and can contribute to math anxiety. Studies have shown that the brain can grow and develop throughout a person's life is partially dependent upon one's mindset and experiences. Mathematics teachers can utilize a growth mindset where students have high self-efficacy and self-concept to promote positive dispositions toward mathematics. In doing this, teachers must model high teacher efficacy themselves and believe in student ability by disregarding false limitations set by prior experiences.

Keywords: misconceptions, self-efficacy, self-concept, mathematical mindset, math anxiety, teacher efficacy

Introduction

Close your eyes, take a deep breath, clear your mind, and think about your experiences with mathematics. Think about the mathematics teachers of your past and choose one teacher that has left their mark deep within your memory. Picture their classroom, the arrangement of the desks, your classmates seated around you, and your teacher diligently working through the lesson of the day. What is the mood and environment like in this classroom? Does your classroom consist of group work and mathematical chatter? Or is it quiet, orderly, and routine with students working independently on today's lesson? Is your teacher motivating and passionate, moving through the room guiding and assisting students? Or apathetic and unstimulating? Reflect on the feelings that wash over you as you submerse yourself in this memory. Are you excited, content, bored, anxious, or nervous? Are you confident in your mathematical abilities? Would you say that all of your classmates are "good" at math? Based upon your experiences, how many students do you think have been positively affected by mathematics?

All elementary students have to take a math class, but it is the experiences that students have in that classroom that can shape their future in mathematics. Adverse student experiences in a classroom may cause negative attitudes and beliefs regarding mathematics. Such experiences can cause negative dispositions that directly affect instruction and learning mathematics in a classroom. These can be negative teacher dispositions through their conceptions or experiences on mathematics or they can be negative student dispositions that minimize motivation and participation. The teacher plays an important role in cultivating a positive learning environment that can improve student experience and mathematical achievement. Every student has the capability to conceptually engage in mathematics with the correct mindset and with knowledgeable teachers who model high teacher efficacy to counteract negative dispositions while increasing academic achievement. How can teachers prevent or rectify negative dispositions of mathematics in a classroom to improve student learning, experience, and perceptions of mathematics? To answer this question, student ability needs to be addressed.

Ability and Misconceptions

Ability and limitations are a common topic of debate when discussing mathematics instruction and learning. There are many misconceptions regarding ability and learning thresholds in mathematics. Such misconceptions lead to negative dispositions and attitudes toward mathematics that directly affect how students view their limitations of mathematical achievement. According to Boaler and Dweck (2016), new studies have proven that the brain can grow and adapt throughout all stages of development in a human's life. They state that "the new evidence from brain research tells us that everyone, with the right teaching and messages, can be successful in math, and everyone can achieve at the highest level in school" (Boaler & Dweck, 2016, p. 4).

Another common misconception regarding mathematics is that some individuals are naturally "good" at math. Many students have uttered the phrase, "I'm just not good at math and do not have a math brain." Boaler and Dweck (2016) believe that "there is no such thing as a 'math brain' or a 'math gift.' No one is born knowing math, and no one is born lacking the ability to learn math" (p. 5). This is vital information for mathematics teachers to consider because it may change how teachers approach instruction regarding low-achievers. All students will not be mathematicians, statisticians, or actuaries, but Boaler and Dweck (2016) argue that all students have the ability to do well in mathematics with the correct mindset and support.

Self-Efficacy and Self-Concept

Dweck (2006) has generated research that shows "the view you adopt for yourself profoundly affects the way you live your life" (p. 6). Here, student self-efficacy and self-concept fuse together predetermining how an individual limits their abilities. Self-efficacy has been

defined as "people's judgments of their capabilities to organize and execute courses of action to attain designated types of performances… Self-efficacy contributes to motivation and determines the goals that individuals set for themselves" (Bandura, 1986, p. 516). Self-efficacy then can have positive or negative motivational influences that are correlated to achievement in a classroom. The way a student views their mathematical ability determines their individual goals for achievement. If a student views their ability as limited they will not strive to succeed and will settle for less than their innate ability.

Shavelson, Hubner, and Stanton (1976) describe how self-concept refers to an "individual's perceptions of the self that are formed through experiences and evaluative feedback received from significant others" (p. 336). According to Bong and Clark (1999), "Self-concept represents an individual's knowledge about him or herself along with emotional reactions toward the cognitively recognized competencies and attributes he or she possess" (p. 336). If a student perceives that they cannot achieve highly in math, they will develop a negative reaction to math which lowers their self-concept. Bong, Cho, Ahn, and Kim (2012) describe how individuals emotionally react to self-evaluation and comparison to others heavily influences self-concept. They also discussed how self-concept differs from self-efficacy by describing self-efficacy as the students' confidence toward successfully performing a task, whereas self-concept describes their positive or negative views of themselves and their competencies. Self-efficacy and self-concept are generalized psychological constructs that mold student self-beliefs regarding their potential and ability.

Mathematical Mindset

Together, self-efficacy and self-concept lay the foundation for a student's idea of their abilities and limitations in any content, including mathematics. This idea of student limitations and attitude towards their perceived abilities forms their mathematical mindset. Dweck (2006) suggested that people have one of two different mindsets, a fixed mindset or a growth mindset. Boaler and Dweck (2016) describe a fixed mindset as "believing that intelligence is a gift that you either have or you don't have" (p. 5). A growth mindset is defined as "the belief that intelligence grows and the more you learn, the smarter you get" (Dweck, 2006, p. 34). Individuals set their own limitations in a fixed mindset where they tend to make excuses for their shortcomings, feel that they have to constantly prove themselves to others, and have a pessimistic perspective of themselves. Individuals with a growth mindset persevere through tough situations and look at every hurdle as an opportunity to learn which, "allows people to thrive during some of the most challenging times in their lives" (Dweck, 2006, p. 7). If a person has a fixed mindset, this does not mean they are forever cemented within this limited state of mind. The mindset of a person can change back and forth between a fixed and growth mindset depending upon their life experiences and surroundings (Blackwell, Trzeniewski, & Dweck, 2007).

To put this into perspective, Boaler and Dweck (2016) discuss differences in brain ability. Everyone is not born with the same brain but the brain can change and grow throughout life based upon an individual's experiences. They looked specifically into a well-known genius and theoretical physicist, Albert Einstein.

> Einstein, probably the most well-known of those thought to be a genius, did not learn to read until he was nine and spoke often about his achievements coming from the number of mistakes he had made and the persistence he had shown. He tried hard, and when he made mistakes he tried harder. He approached work and life with the attitude of someone with a growth mindset. A lot of scientific evidence suggests that the difference between those who succeed and those who don't isn't in the brain they were born with, but their approach to life, the messages they receive about their potential, and the opportunities they have to learn. The very best opportunities come when students believe in themselves. (Boaler & Dweck, 2016, p. 5)

Boaler and Dweck (2016) linked this data to the importance of high student self-efficacy and self-concept in a mathematics classroom. Self-belief is the key to cultivating a growth mindset where students will embrace mathematical challenges through problem solving, reasoning, and critical thinking. Students need to believe in their own abilities and potential regardless of past experiences to achieve success in a mathematics classroom. When students do not have self-belief, they develop a fixed mindset and often math anxiety.

Math Anxiety

Another important issue that teachers need to be aware of is math anxiety which Blazer (2011) defines as "negative emotions that interfere with the solving of math problems" (p. 1). Blazer (2011) revealed, "approximately 93 percent of Americans indicate that they experience some level of math anxiety" (p. 1). Math anxiety can develop at any age and physical symptoms include increased heart rate, clammy hands, upset stomach, and light-headedness. Further, Blazer (2011) research has shown that math anxiety disrupts student performance in a classroom because it reduces the working memory of students and prevents their ability to block out distractions and retain important information. Math anxiety poses is an additional obstacle between the student and their mathematical success. This anxiety also disrupts the accuracy of mathematical assessments because assessments are not able to precisely measure student ability due to their anxiety (Blazer, 2011).

Math anxiety impedes student success because it supports and enables a fixed mindset. Students become so focused on achieving the correct answer that they develop a fear of making mistakes. Boaler and Dweck (2016) reported on studies that found the brains of individuals with a growth mindset reacted differently to mistakes than the brains of individuals with a fixed mindset. The studies found that "the brain activity was greater following mistakes for individuals with a growth mindset than for individuals with a fixed mindset" and "a growth mindset has a greater awareness of errors than individuals with a fixed mindset, so they were more likely to go back and correct errors" (Boaler & Dweck, 2016, p. 12). This means that mistakes provide opportunities for the brain to grow and develop. However, today, our society views mistakes as something negative or even as failure, when really mistakes are essential to achieving success in learning. This data shows how important self-efficacy is for mathematics students when they confront a mistake or error in their work. Students need to have a growth mindset where they face mistakes as an opportunity and a challenge instead of failure.

In some mathematics classrooms, correct answers are celebrated and mistakes are associated with failure. To alleviate math anxiety, Boaler and Dweck (2016) advise teachers to change the message of mistakes and incorrect answers in mathematics. They recommend educating students on the importance of making mistakes because it is an opportunity for the brain to develop and grow. One of their strategies is outlined below:

> Teachers should share with students that they are looking for their favorite mistakes, which should be conceptual mistakes, not numerical errors. Teachers can then share the mistakes with the class and launch a class discussion about where the mistake comes from and why it is a mistake. This is also a good time to reinforce important messages-that when the student made this mistake, it was good, because they were in a stage of cognitive struggle and their brain was sparking and growing. (Boaler & Dweck, 2016, p. 17)

When teachers celebrate student mistakes it removes the negative stigma that is associated with making errors, alleviating math anxiety. This promotes the development of a growth mindset and positive dispositions regarding mathematics. Other strategies of celebrating mistakes involve minimizing testing and grading in a classroom where mistakes are associated with punishment. Boaler and Dweck (2016) also recommends one-on-one interaction between teachers and students where teachers can explain incorrect answers. This technique fosters brain development allowing the brain to grow and learn. By doing so, students will interpret mistakes as opportunities to become more knowledgeable instead of discouragement and failure.

Teacher Efficacy

What do self-efficacy, self-concept, mathematical mindsets, and math anxiety have to do with a mathematics teacher? Mathematics teachers have a responsibility to their students to be aware of the emotional state of their students and differentiate their instruction between those with a fixed mindset and a growth mindset. Mathematics teachers need to be aware that the brain can grow and change based upon the self-concept, self-efficacy, and experiences of each individual student. Teachers need to acknowledge that unless there is an intellectual disability, all students have the capability of obtaining mathematical success in the right classroom environment when they receive the proper support. It is the responsibility of the teacher to provide that support.

Further, mathematics teachers need to believe in their own abilities to instruct, engage, and lead their students. They need to embody teacher efficacy which is defined as "a judgment about capabilities to influence student engagement and learning" (Woolfolk Hoy & Davis, 2006, p. 117). According to Cantrell, Young, and Moore (2003), student learning and mathematical achievement are largely effected by the instructional performance and teaching efficacy of the math instructors. Teachers have the power to influence students to overcome anxiety in math by engaging and encouraging their students in learning. Chang (2015) investigated this idea by examining the effects of teachers' efficacy on student mathematical self-efficacy. The study found that there are significant effects of mathematical teachers' efficacy on student mathematical achievement. Chang (2015) findings "indicate that the more efficacious a mathematics teacher the better her/his students' mathematics self-efficacy, and that, in turn, promotes their mathematical achievement" (p. 1317). Teacher efficacy is important for the development of student self-efficacy and for promoting students' learning achievement. Mastery experiences, verbal persuasion, vicarious experiences, and physiological arousal have an effect on teacher efficacy. Additionally, student self-efficacy was positively affected by teacher's effective teaching performance which was reinforced by teacher efficacy. By improving student self-efficacy and academic achievement, negative mathematical dispositions will improve due to positive teacher efficacy (Chang, 2015).

Conclusion

A teacher's mindset on their approach and attitude toward teaching can make or break a student's experience in a classroom. Teachers are the most influential and useful tool in a classroom that can cultivate positive self-efficacy and self-concept within their students. Observant

and attentive teachers can identify students with negative dispositions and fixed mindsets toward mathematics to broaden the individual limitations for success preconceived by each student.

Teachers need to take a pledge that no matter how low a student's self-concept in math is, to never let them say that they "cannot do math." Research has shown that it is a myth that individuals are innately good or bad at mathematics. Teachers need to acknowledge that all students have the ability to conceptually engage in mathematics with a growth mindset where the brain grows and develops over time. They need to pledge to model high teacher efficacy and enthusiasm to improve student self-efficacy and academic achievement. Students should be able to grow confidence in math without anxiety, uncertainty, or negativity. It should become the mission of math teachers to ensure that their students leave the classroom with a new appreciation for mathematics. All students should have the opportunity to develop a growth mindset where they have cultivated a positive disposition of student self-efficacy, self-concept, and an appreciation for the prodigious world of mathematics.

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