DORDT UNIVERSITY

Dordt Digital Collections

Faculty Work Comprehensive List

2022

# Pedagogies that Foster a Growth Mindset Towards Mathematics

Valorie L. Zonnefeld

Follow this and additional works at: https://digitalcollections.dordt.edu/faculty_work

 Part of the Science and Mathematics Education Commons

# Pedagogies that Foster a Growth Mindset Towards Mathematics


## Abstract

Research demonstrates that a student's mindset plays an important role in achievement and that mindsets are domain specific. Carol Dweck claimed that mathematics needs a mindset makeover and has shown that teachers can foster a growth mindset through their pedagogical choices. This paper shares how one university trains preservice teachers in mathematics pedagogies that are key to fostering a growth mindset. These practices include educating students on brain function, equitable access, metacognition strategies, feedback practices, the importance of productive struggle, and learning from mistakes.



## Keywords

pedagogy, growth, mindsets, research, students, academic achievement

## Disciplines

Science and Mathematics Education

## Comments

Paper presented at the International Conference *Building on the Past to Prepare for the Future* held from August 8-13, 2022, in King's College, Cambridge, UK.

# Pedagogies that Foster a Growth Mindset Towards Mathematics

Valorie L. Zonnefeld, valorie.zonnefeld@dordt.edu
Dordt University

**Abstract**

Research demonstrates that a student's mindset plays an important role in achievement and that mindsets are domain specific. Carol Dweck claimed that mathematics needs a mindset makeover and has shown that teachers can foster a growth mindset through their pedagogical choices. This paper shares how one university trains preservice teachers in mathematics pedagogies that are key to fostering a growth mindset. These practices include educating students on brain function, equitable access, metacognition strategies, feedback practices, the importance of productive struggle, and learning from mistakes.

## Introduction

Mindset refers to an individual's belief about their intelligence and its potential to develop. Students with growth mindsets believe that they can grow their intelligence (Dweck, 2006). This stands in contrast to individuals who hold fixed mindsets; these students believe that intelligence is fixed and cannot be improved. These, often unconscious, beliefs make a big difference in the behaviors that help students succeed. Students who believe they can improve their intelligence are more persistent when faced with setbacks and apply more productive learning strategies (Dweck & Leggett, 1988). Rattan and colleagues (2015) see attention to mindsets and growth mindset interventions as an under-utilized method to improve student achievement.

Mindsets are domain specific, with students who hold a fixed mindset toward math ability at a "significant disadvantage compared to students who believe that their abilities can be developed"(C. S. Dweck, 2008, p. 1). Mathematics has the distinction of being a subject with the highest levels of individuals with fixed mindsets. Dweck stated that "math was the subject most in need of a mindset makeover" (Boaler, 2016). Fortunately, mindsets can change, and teachers can use practices that foster growth mindsets.

This paper examines how Dordt University, a small university in the United States, intentionally trains pre-service teachers in mathematics pedagogies that foster a growth mindset, answering the call from Rattan and colleagues (2012) to develop training materials for teachers and administrators. Students learn about growth mindsets throughout their mathematics content courses and in their mathematics pedagogy course. The remainder of this paper will outline the key practices that preservice teachers need to foster a growth

Zonnefeld, Valorie L. (2022). Pedagogies that Foster a Growth Mindset Towards Mathematics, in Morska, Janina & Rogerson, Alan (Eds) *Building on the Past to Prepare for the Future, Proceedings of the 16th International Conference of The Mathematics Education for the Future Project,* King's College, Cambridge, Aug 8-13, 2022 (pp. xxx-xxx). Münster: WTM. htpps://doi.org/10.37626/ GAxxxxxxxxxxxxx.x.xx.

mindset in their mathematics classes which includes educating students on brain function, equitable access to challenging mathematics, metacognition strategies, feedback practices, the importance of productive struggle, and learning from mistakes.

**Educating about Brain Function**

Learning about the physiology of the brain helps preservice teachers and their future students understand that a growth mindset is not just a motivational gimmick, but the result of recent developments in scientific research that uncovered the biological changes that occur during learning. Mindset Kit from The Project for Education Research that Scales (n.d.) is an example of a resource that helps teachers and students understand the physiological changes that occur when a student learns. This understanding, coupled with guidance on effective learning strategies, empowers students who previously did not believe they could achieve (Donohoe et al., 2012).

**Equitable Access**

Teachers who believe in the malleability of the brain give equitable access to high-quality learning experiences for all students. They believe that all students can grow their math ability and, as such, deserve the opportunity to learn through challenges in a supportive environment. Teachers must be aware of negative stereotypes and be cautious of being influenced by negative stereotypes of who can succeed in mathematics.

Equitable access also includes encouraging all students to take advanced coursework in mathematics. The common structure of tracking students by ability in middle school and high school should be flexible to allow students to advance into more difficult material since students who “are given access to high-level content…. achieve at higher levels”(Boaler, 2016, p. 111). All students deserve access to high quality mathematics opportunities. This includes offering support for students who want to transition to a more challenging path.

**Metacognition Strategies**

Metacognition is the thinking that a student does about his or her own thinking. This occurs when students plan, monitor, and reflect on their learning process. When faced with a challenge, students with fixed mindsets are more likely to abandon effective strategies, repeat ineffective strategies, and make denigrating statements about their intelligence. They are also less likely to devise new strategies (Zonnefeld, 2015). Wang and colleagues (2021) argue that metacognition should be taught alongside growth mindset training, providing evidence that metacognition is a necessary skill to maximize a growth mindset as metacognition gives students the skills to act on growth mindset beliefs. Training students to implement metacognitive strategies not only helps them work more productively on mathematics, but also helps them monitor their mindset throughout a challenge. This is beneficial academically

and emotionally since these strategies give students a greater sense of control in the learning process.

**Feedback Practices**

The feedback teachers give to their students can also promote a fixed or growth mindset. Teachers with fixed mindsets are more likely to offer comfort statements such as, “Not everybody is good at math” or “Math is hard” with good intentions. Unfortunately, this communicates that it is acceptable to be bad at math and fails to convey that the student can improve their ability (Rattan et al., 2012). Teachers who teach with a growth mindset are honest with students about their abilities and help them close any gaps in understanding (Dweck, 2006).

Person-directed praise is another feedback practice that promotes a fixed mindset. Teachers should be careful to offer praise on the process, but not about the person (Kamins & Dweck, 1999). For example, instead of praising the person such as “You are so smart” or “You have a math brain,” praise the process, i.e. “You worked so hard on that” or “I appreciated how clearly you demonstrated your work.” Praising the student communicates that they will be measured as a person by their successes. The dark side of this is that it also communicates to the student that they will be measured by their failures. This puts students in a fixed mindset in which they need to prove their intelligence, resulting in challenge avoidance since failure would confirm that they “don’t have a math brain.”

**Productive Struggle**

Struggling with concepts is a natural part of learning mathematics. The National Council of Teachers of Mathematics (2014) identified supporting productive struggle as one of the seven effective mathematics teaching practices. This calls on teachers to provide challenging tasks in a supportive environment. Allsopp and colleagues caution teachers to not protect struggling learners from productive struggle, but to “find ways to engage them in this important aspect of learning mathematics and support them to find success” (2018, p. 231). Supporting students while they struggle communicates to them that the teacher believes students are capable and can master the material. Productive struggle is more constructive when “the learning goal is clear, the level of challenge is neither too high nor too low, and students feel safe in taking risks and in not being successful (Allsopp et al., 2018, p. 232). It is important to name when a student has worked hard through a problem or concept successfully to help them be aware of how their perseverance in productive struggle was successful. An important skill to successfully engage in productive struggle is the ability to employ metacognitive strategies (Wang et al., 2021).

**Learning from Mistakes**

Mistakes occur frequently when engaged in productive struggle. Unfortunately, students with fixed mindsets tend to measure themselves from their failures. In comparison, students with growth mindsets see failure as an opportunity to grow. Boaler urges teachers to “offer mathematics as a learning subject, not a

performance subject" (2014, p. 1). Students need to know that everyone makes mistakes and teachers should model appropriate responses when they make the inevitable mistakes. Students learn the most when they view mistakes as opportunities to enhance their understanding (Briceño, 2016).

It is important that teachers normalize mistakes as a valuable part of the learning experience and take advantage of these opportunities to clarify misconceptions (Allsopp et al., 2018; Urbina-Lilback, 2016). Consider the response to mistakes when a child learns to walk. Babies fall repeatedly as they learn to walk. Parents do not see these falls as failure or an indicator that their child will not walk, but as a natural part of learning to walk. A similar normalization of mistakes is necessary in mathematics as students master concepts and skills.

Pedagogical practices that normalize the value of making mistakes include using "open-ended tasks that include space for learning…struggle and growth" (Boaler, 2014, p. 2). Safe spaces to make mistakes and learn from them are vital to mastering mathematics. Assessment practices are also an important part of creating a classroom culture that values mistakes in the learning process. Homework is often the first time a student is attempting a new skill and mistakes should be expected. The assessment of these early attempts should not penalize mistakes too heavily. In this situation, feedback is important, but should not be graded too harshly or weighted too heavily in the overall grade, if graded at all.

## Summary

Training preservice mathematics teachers continues to evolve as new research uncovers more effective teaching pedagogies. In recent decades, research on the malleability of the brain and the importance of a growth mindset for student achievement in mathematics requires teachers to adjust their teaching practices; and consequently, that universities adjust preservice mathematics teacher training (Zhang et al., 2017; Zonnefeld, 2015). In response, Dordt University has trained its preservice teachers in pedagogies that foster a growth mindset. These practices include educating students on brain function and the malleability of the brain, providing equitable access to challenging mathematics, metacognition strategies, feedback practices, and the importance of productive struggle and learning from mistakes. There is considerable room for growth as research continues to inform best practices and mathematics teachers strive to provide the best learning environment for each of their students to achieve at high levels.

## Funding Acknowledgement

It should be noted that this paper is supported by a US $1.2 million grant from the National Science Foundation [DUE-1660632]. The goal of the grant is to increase the number of highly qualified STEM teachers.

## References

Allsopp, D., Lovin, L. H., & van Ingen, S. (2018). *Teaching mathematics meaningfully: Solutions for reaching struggling learners* (2nd ed.). Brookes Publishing.

Boaler, J. (2014, September 10). *The mathematics of hope: Moving from performance to learning in mathematics classrooms*. YouCubed. https://www.youcubed.org/wp-content/uploads/2017/03/The-Mathematics-of-Hope-5.pdf

Boaler, J. (2016). *Mathematical mindsets: Unleashing students' potential through creative math, inspiring messages and innovative teaching*. Jossey-Bass.

Briceño, E. (2016). Aftermath: Embrace mistakes. *Math Horizons*, *23*(4), 34. https://doi.org/10.4169/mathhorizons.23.4.34

Donohoe, C., Topping, K., & Hannah, E. (2012). The impact of an online intervention (Brainology) on the mindset and resiliency of secondary school pupils: A preliminary mixed methods study. *Educational Psychology*, *32*(5), 641–655. https://doi.org/10.1080/01443410.2012.675646

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

Dweck, C. (2008). *Mindsets and math/science achievement*. Carnegie Corp. of New York–Institute for Advanced Study Commission on Math.& Sci. Education. http://www.growthmindsetmaths.com/uploads/2/3/7/7/23776169/mindset_and_math_science_achievement_-_nov_2013.pdf

Dweck, C. S., & Leggett, E. L. (1988). A social-cognitive approach to motivation and personality. *Psychological Bulletin*, 256–273.

Kamins, M. L., & Dweck, C. S. (1999). Person versus process praise and criticism: Implications for contingent self-worth and coping. *Developmental Psychology*, *35*(3), 835–847. https://doi.org/10.1037/0012-1649.35.3.835

National Council of Teachers of Mathematics. (2014). *Principles to actions: Ensuring mathematical success for all*. National Council of Teachers of Mathematics.

Rattan, A., Good, C., & Dweck, C. S. (2012). "It's ok — not everyone can be good at math": Instructors with an entity theory comfort (and demotivate) students. *Journal of Experimental Social Psychology*, *48*(3), 731–737. https://doi.org/10.1016/j.jesp.2011.12.012

Rattan, A., Savani, K., Chugh, D., & Dweck, C. S. (2015). Leveraging mindsets to promote academic achievement: Policy recommendations. *Perspectives on Psychological Science*, *10*(6), 721–726. https://doi.org/10.1177/1745691615599383

The Project for Education Research that Scales. (n.d.). *Teaching a growth mindset* [Educational]. MindsetKit. Retrieved October 30, 2021, from https://www.mindsetkit.org/topics/teaching-growth-mindset/explain-the-neuroscience

Urbina-Lilback, R. N. (2016). Snapshots of equitable teaching in a highly diverse classroom. *The Mathematics Teacher*, *110*(2), 126–132. https://doi.org/10.5951/mathteacher.110.2.0126

Wang, M.-T., Zepeda, C. D., Qin, X., Del Toro, J., & Binning, K. R. (2021). More than growth mindset: Individual and interactive links among socioeconomically disadvantaged adolescents' ability mindsets, metacognitive skills, and math engagement. *Child Development*, *92*(5), e957–e976. https://doi.org/10.1111/cdev.13560

Zhang, J., Kuusisto, E., & Tirri, K. (2017). How teachers' & students' mindsets in learning have been studied: Research findings on mindset & academic achievement.*Psychology*,*08*(09),1363–77.https://doi.org/10.4236/psych.2017.89089

Zonnefeld, V. L. (2015). Mindsets, attitudes, and achievement in undergraduate statistics courses. *Dissertation*, 216.