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Three Activities for Growing New Mindsets in Mathematics

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Mathematics education has seen an increase in discussion around growth mindset and learning mathematics. Jo Boaler's work in studying open and closed mathematics in England (Boaler 1998), along with recent publications around growth mindset in mathematics (e.g. Boaler 2015), highlight the potential benefits of rethinking who can do mathematics and what learning it may look like. She argues that encouraging the view of mathematics as problem solving, where students learn from mistakes and grow their mathematical abilities, can help students learn mathematics as a flexible and connected set of ideas. This stands in contrast to believing that a person's ability to learn mathematics is fixed and cannot be taught. However, encouraging a positive and open learning environment that fosters productive mathematics learning can be challenging.

As an instructor of elementary Pre-Service Teachers (PSTs), I was curious to see if growth mindset ideas could be used to support learning in my mathematics content class. I wanted to know if introducing the idea of a growth mindset to PSTs would support them in reconceptualizing mathematics as problem solving. I soon found that many students identified as having more of a fixed mindset while learning mathematics than a growth mindset. When they described their relationship to mathematics as rocky, filled with anxiety, love/hate, and more, I became interested in knowing what fostering a growth mindset towards mathematics would take and what activities would help educators attend to growth mindsets in the mathematics classroom.

In this article, I describe three activities I use to support a growth mindset in students through mathematical problem solving. Although these activities were designed for elementary PSTs at the university level, instructors can adapt them for elementary, middle, or high school classrooms.

Watch a Video on Growth Mindset

One activity that PSTs often do at the start of the semester is to learn about growth mindsets. I ask students to watch a 10-minute video by Eduardo Briceño (**tedxmanhattanbeach.com/past-events/october-2012-conference-journey-to-purpose/presenters/eduardo-briceno/)** and post a short, thoughtful reflection on our online classroom forum.

The purpose of this activity is to have students describe and contrast the characteristics of growth and fixed mindsets in order to become familiar with growth mindset. A person has a growth mindset about mathematics when he/she believes that mathematics can be taught through hard work and persistence. A person has a fixed mindset when he/she believes that mathematics is a fixed, innate ability that cannot be taught.

A student summarized this short video by saying:

> It is important to instill the belief that there is no shame in failure. Though things may be difficult at one point, it does not mean that it will always be that way. You must keep working at something in order to develop that ability.

By watching this video, students learn about the meaning of growth vs. fixed mindsets, the language that may support or hinder each perspective, and the relevance of the idea applied to contexts such as learning how to play chess. This video invites students to push their own thinking about mindsets in a mathematics class. Another student noted that being aware of her fixed mindset would "better help me succeed in this class by making a conscious effort to refute that mindset's voice." One of my students reflected while learning about growth mindset that, "Mistakes are a natural process and there is no shame in fixing your mistakes because that is how you learn." This reflection is important because the idea of growth mindset supports students in trying a different way to problem solve when their initial way does not work.

Watching a video about growth mindsets is a worthwhile assignment at the beginning of the course so that students and instructors alike can develop a common language and vision for success in the classroom.

Draw a Picture of your Relationship with Mathematics

Another activity I use with PSTs in the beginning of a mathematics content course is to have them draw a picture of their relationship with mathematics. The purpose of this activity is to give the instructor a sense of the students' disposition towards mathematics, which is one of the National Research Council's five strands of mathematical proficiency (NRC 2001). Do students find mathematics to be useful? What kinds of emotions do they feel when they do mathematics? Do they like some fields more than others (e.g., geometry versus algebra)? How do they conceive of mathematics—is it a static set of symbols and inscriptions, is it embodied in a creature, or is it a story told over time? Does the picture exhibit a productive view of mathematics? Knowing more about students' mathematical backgrounds can provide useful information when instructors plan activities and interactions for students.

The instructor can periodically ask students to reflect on how they are relating to mathematics as part of their learning process. To complete this activity, students once again draw their relationship with mathematics at the end of the course and reflect on what they drew and why. This can serve as an alternative way to assess students' dispositions over time, another strand of mathematical proficiency (NRC 2001).

One student who did not describe herself as a "math person" originally drew a stick figure with the thought bubbles saying, "Wow, I really didn't get this," "I hate math, why is it so hard?" "I give up," and "I guess I'm really not a math person." After the class, she drew the same stick figure but with the thought bubbles saying, "Alright, so I got this wrong, why?" "How can I change my thinking?" "Let's try something different," and "Let's keep going." She reflected on her change in confidence to engage in mathematics:

> When I first started this class, I was insistent that I was not a math person. Numbers of any kind gave me a knot in my stomach. And while I may not be doing cartwheels for math, I am able to take a step back and reevaluate myself. I am now able to look at things in different ways in order to find what works best for me. I am more confident in my ability, which is not something I've ever been able to say about math. Ever.

Another student described a shift in her relationship with mathematics as moving away from computing with formulas to including understanding of why they work. Initially, she drew symbols and formulas such as $l \cdot w \cdot h = v$, $y = mx + b$, and the Pythagorean theorem. After the semester, she drew an arrow that said "transformation" with a picture of her brain and the words *light bulb, understanding, why, theories, how*, and *real life equations*. She reflected:

> Previously, I was good at memorizing formulas and answering math questions by simply using equations that I had put to memory. Now, I do more than just that. I can understand the theories behind this, and why it is important to understand the reasoning behind these mathematical equations and formulas.

A third student first created a drawing that showed an emotional downward trend in high school. Then, for her final picture, she drew a picture of herself as a teacher teaching students with multiple tools (***Figure 1***).

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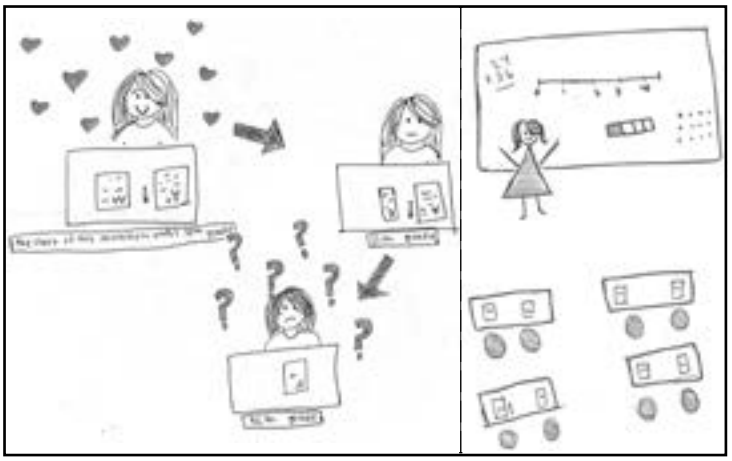

Figure 1

In this activity, students reflect on their relationship to mathematics and, in particular, on how they may have grown over the semester. It serves to focus students on their relationship to the process of learning mathematics and consequently developing a growth mindset towards mathematics. Oftentimes mathematics content can be taught with little to no room for reflection on how the learner learns mathematics. An emphasis on the process of learning rather than just the product of what was learned allows instructors to focus on growth mindset ideas.

Engage in Number Talks

The final activity to support a growth mindset in the mathematics classroom involves engaging students in number talks. Number talks are routines that provide opportunities to develop number sense and fluency with operations on whole and rational numbers (Parrish 2010). While I use them with college students approximately once a week for a fifteen-week course that meets twice a week, number talks may be used more frequently with elementary, middle school, and high school students.

The purpose of routinely engaging in this activity can vary. I use them to demonstrate to students that there are multiple ways to problem solve and to support students in communicating their mathematical thinking to others. By focusing on one task and eliciting several different ways to solve it, students can see mathematics as having many valid solutions. This supports a growth mindset because it gives students tools (such as the distributive property, breaking a number into its factors, or using the commutative property) to deepen their understanding of mathematics.

To help students learn about number talks, I ask them to watch a short video (Boaler 2014) that defines and demonstrates a number talk with college students (**www.youtube.com/watch?v=yXNG6GKFhQM**). I then ask them to respond to the following questions: What stood out to you? What was interesting? How might this affect your participation in this mathematics class?

One example of a number talk in the video asks students to find several different ways to solve 5 x 18. After several moments for individual think time, the instructor then invites students to share with the class how they thought about the problem, while transcribing their work on the board. The following strategies might appear, with supporting vocabulary in parentheses that underlie the method:

- ✔ 5 x 18 is the same as 5 x 10 + 5 x 8, which is 50 + 40 (*distributive property of multiplication over addition, or 5(10 + 8)*).
- ✔ 18 x 5 is almost the same as 20 x 5, which is twenty groups of 5, rather than eighteen groups of 5. Since 20 x 5 is two groups of five more than we want, we can do 100 – (2 x 5), to get 90 (*distributive property of multiplication over subtraction, or 5(20 – 2)*).
- ✔ 5 x 18 is the same as 5 x (2 x 9), which is like 10 x 9 (*breaking a number into its factors*).
- ✔ If 10 x 18 is 180, then half of that, or 5 x 18, is half of 180, which is 90 (*doubling then halving*).

These number talks can be purposefully selected to either support the daily learning goal or a different over arching learning goal, such as developing number sense, deepening proportional reasoning, working fluidly with decimals, percents and fractions, or unpacking mathematical properties (for example, the distributive and commutative properties).

At the end of the semester, students reflect on the biggest take-away they have from the course. A frequently described theme involves having learned multiple ways to solve a problem. Here are some responses from PSTs:

> One thing I will take away from this course is that there are multiple ways to solve a problem. I have multiple tools to use and I can use them to find which way is easier for me. I believe this is my nugget because as a child, I was very close-minded with solving problems. I solved in a way that would get me the right answer. I used the same steps my teacher would use. I did not realize or know that there were multiple ways I could solve it. This makes math a whole lot less challenging and scary.
>
> I was surprised to learn that sometimes my trusty algorithm is not always the fastest way to solve something. In some cases, I am able to do things in my head and I don't have to waste a few minutes doing the algorithm. This sticks with me because I have always wondered how people are able to do math in their head, and now I see how.
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> I think that [my biggest takeaway would be] challenging myself to think outside the way I was taught. For example, I always stacked my numbers in multiplication problems. I now find different methods to solve the same multiplication problem very helpful. I am definitely still learning how to be open to new ways of thinking.
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> A nugget that I will take away is that there are different ways to solve a math problem, and not just one way. This is my nugget because I was taught all my life I had to solve a problem one way only, when there are tons of other approaches or ways to look at a problem. When I become a teacher I want to establish to my students that they have other ways to solve a problem, not just one way.

These PST reflections help to demonstrate the potential benefits of instructors routinely facilitating number talks for supporting growth mindsets in the mathematics classroom.

Conclusion

Teaching mathematics with an orientation towards supporting a growth mindset involves rethinking activities and interactions in the classroom. It means engaging in positive discussions around problem solving, supporting students with rich activities, and creating and sustaining useful mathematical norms such as, "students can learn from mistakes." As one elementary PST concluded about rethinking mathematics at the end of her semester, "If things aren't looking right, change your perspective."

The three activities presented here—listening to and reflecting on a video about growth vs. fixed mindsets, drawing a picture of your relationship with mathematics, and engaging in routine number talks—can be used to help shift students' thinking of mathematics as an innate ability that involves correct numerical solutions to the belief that learning mathematics as problem solving and problem posing can be done through hard work and persistence. This shift can have an important impact on students as they make meaningful connections in mathematics, both for K–12 students and college students alike.

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