

# **Improving Students' Attitudes and Beliefs About Mathematics**

## **A literature summary of research-based practices and strategies**

RELNW 5.2.W02.2

Prepared September 28, 2017; Revised December 5, 2017

*This literature summary was prepared under Contract ED-IES-17-C-0009 by Regional Educational Laboratory Northwest, administered by Education Northwest. The content does not necessarily reflect the views or policies of IES or the U.S. Department of Education, nor does mention of trade names, commercial products, or organizations imply endorsement by the U.S. Government.*

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REL Northwest has partnered with Washington STEM (WA STEM), a nonprofit that works to increase access, interest, and success in science, technology, engineering, and math (STEM) for all students in Washington state. Together, REL Northwest and WA STEM are working to build Washington math educators' capacity to improve student attitudes and beliefs about math. One of WA STEM's key initiatives is early math, and the organization prioritizes improving math engagement and achievement in the early grades.

In support of WA STEM's early math initiative and based on educators' concerns that students' negative math attitudes and beliefs ultimately hinder equitable access and success in STEM, REL Northwest conducted a literature search for practices and interventions that have been found to promote math attitudes and beliefs. This search identified evidence-based practices and interventions for four math attitudes: growth mindset, sense of belonging, math anxiety, and self-efficacy. The purpose of this literature summary is to provide educators with an overview of the research on these topics and some practices that support them.

As a companion to this document, REL Northwest has developed a set of materials instructional coaches can use to train upper elementary math teachers in classroom practices and interventions that promote positive math attitudes and beliefs. In addition, REL Northwest has produced an animated video on strategies for combating math anxiety.

## Why are mathematics skills important?

Early math skills are crucial to children's learning and success in school (Claessens & Engel, 2013). Early math skills predict later math performance, as well as academic success in other domains (Duncan et al., 2007). Unfortunately, many children enter school without the requisite math skills, and gaps persist in children's early math abilities—for instance, between children from different socioeconomic backgrounds (Denton & West, 2002).

## What are mathematics attitudes, and why are they important?

"Math attitudes" can refer to many aspects of students' self-perceptions, beliefs, and mindsets related to math. Research suggests that math attitudes and math skills have a reciprocal relationship—positive attitudes about math promote math achievement, which in turn fosters even more positive attitudes down the road (Ma, 1997). Why might this be the case? One reason may be that students who have negative math attitudes tend to avoid math (Hembree, 1990). The result of less math practice is likely to be worse math achievement, which in turn means even more negative math attitudes.

## What can lead to negative mathematics attitudes?

Several factors may negatively influence math attitudes. One is stereotypes about who is good at math and how math skills develop. Widely held cultural stereotypes suggest that a certain kind of person (i.e., white and Asian males) is good at math (Nosek, Banaji, & Greenwald, 2002). These stereotypes can also suggest that people who are good at math are innately talented or

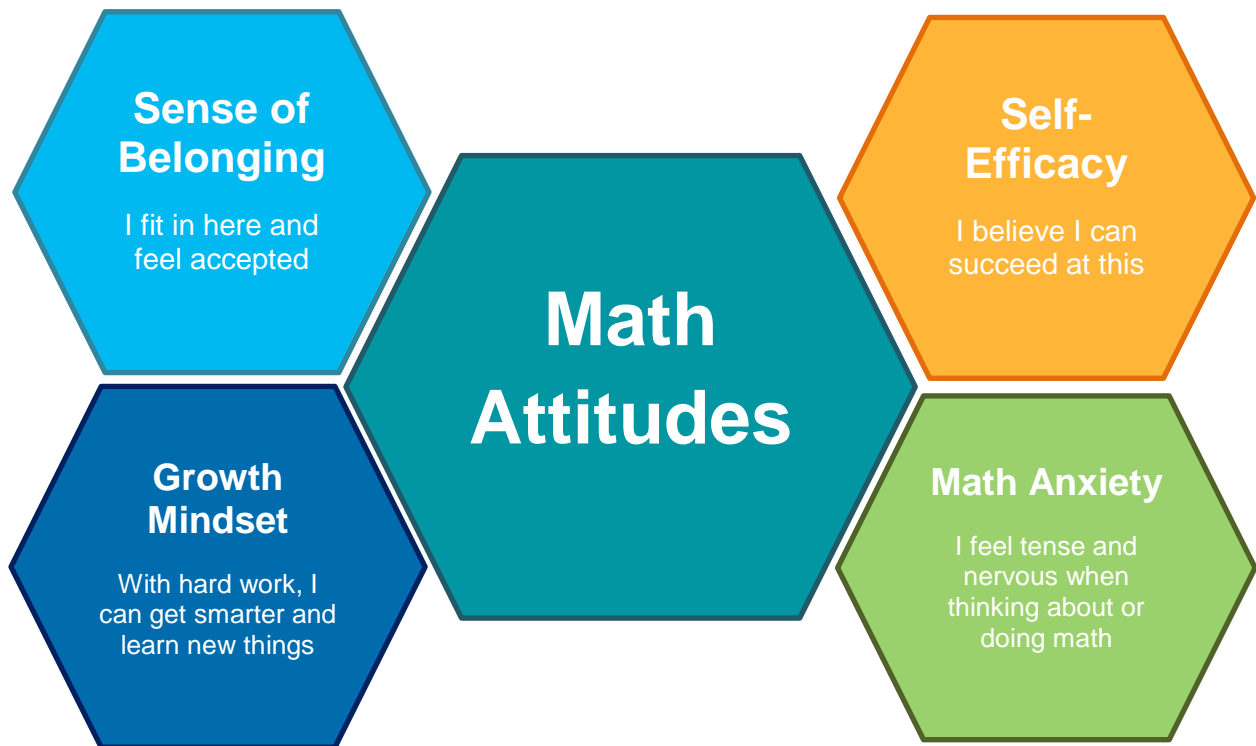
gifted (i.e., a “math whiz”) as opposed to possessing skills they cultivated with hard work and effort (Leslie, Cimpian, Meyer, & Freeland, 2015). Together, these stereotypes can set students up to have negative attitudes about math, particularly when they don’t fit the stereotypes.

In addition, children’s math attitudes can be influenced by those of the adults they interact with who may (unintentionally) pass down negativity toward math. For instance, research shows that children whose parents have math anxiety are more likely to experience math anxiety (Maloney, Ramirez, Gunderson, Levine, & Beilock, 2015). Teachers’ attitudes also matter. Girls—but not boys—whose math teacher has high math anxiety are more likely to develop math anxiety and perform worse in math (Beilock, Gunderson, Ramirez, & Levine, 2010).

### What can teachers do to help bolster students’ mathematics attitudes?

Fortunately, evidence suggests that teachers can use various instructional techniques and interventions to help foster positive math attitudes in students. Next, we provide an overview of four math attitudes (figure 1) and review some evidence-based strategies teachers can use to improve their students’ math attitudes.

Figure 1. Key attitudes and beliefs about math



## Growth mindset

### What is it?

Students can hold different mindsets, or beliefs about the nature of their intellectual abilities (Dweck, 2006). On one end of the spectrum is the belief that intellectual abilities can be cultivated and increased with deliberate effort and hard work (a growth mindset). On the other end is the belief that aptitude is innate and unchangeable (a fixed mindset). It is important to note that mindsets can be domain specific (Murphy & Dweck, 2016); a student may have a fixed mindset about math but a growth mindset about their musical abilities, for instance.

### Why is it important?

Students who have a growth mindset tend to perform better (Blackwell, Trzesniewski, & Dweck, 2007). In addition, students' mindsets influence their reactions to setbacks, with growth mindsets fostering greater resilience (Yeager et al., 2016). Students with a growth mindset view challenges as opportunities to grow, whereas students with a fixed mindset often interpret challenges as evidence that they are "dumb" and react by giving up (Yeager & Dweck, 2012).

### How can educators cultivate a growth mindset in mathematics?

Teaching students that the brain can grow like a muscle and/or reading and reflecting on simple neuroscience articles about brain growth can directly cultivate growth mindset (Blackwell et al., 2007). Given that mindsets can be domain specific, it is important to tailor messages to stress that students can grow their math abilities specifically.

In addition, educators who have a growth mindset themselves are more likely to engage with students in ways that cultivate growth mindset. For instance, research shows that praising students for their ability can promote a fixed mindset, but praising them for their effort or use of strategies can promote a growth mindset and foster resilience (Mueller & Dweck, 1998). Along those lines, educators should offer process praise (e.g., "You really studied for that quiz, and your improvement shows it!") instead of person praise (e.g., "Wow, you're a natural!"). Because struggles can be negatively interpreted as a sign of lack of ability, it's important to normalize this experience (Smith, Lewis, Hawthorne, & Hodges, 2013). Students also need to hear that encountering challenges is a normal part of learning math and that math is hard for everyone.

Educators interested in applying growth mindset principles in the classroom must be aware of how things can go wrong. Fostering a growth mindset isn't only about encouraging more effort. In fact, telling students they "just need to work harder" without also supporting their efforts with new methods and different approaches can be harmful because it perpetuates a failure narrative (e.g., "You failed because you didn't try hard enough."). It's also important to avoid harmful ways of comforting students. Although they are often well-intentioned, teachers who communicate messages to struggling students along the lines of "It's OK, you tried your best—math just isn't your thing" may comfort students in the short term but reinforce a fixed mindset and inadvertently demotivate students in the long term (Rattan, Good, & Dweck, 2012).

## Sense of belonging

### What is it?

Students with a strong sense of belonging feel as if they are welcomed, valued, and legitimate members in academic settings (Goodenow, 1993). Importantly, sense of belonging can be shaped by students' feelings of connection with peers ("I fit in here socially") and the domain itself ("I fit in here intellectually").

### Why is it important?

Research has shown that sense of belonging is a powerful predictor of students' outcomes, including performance, well-being, and motivation (Juvonen, 2006). When students don't experience a strong sense of belonging (i.e., they feel rejected, excluded, or even just uncertain about their fit), it seems to take up precious cognitive resources—which leads to disengagement and keeps students from performing to their potential (Walton & Cohen, 2007). Worrying about belonging is especially pernicious because it can set students up to interpret setbacks and challenges more pessimistically (e.g., a poor quiz grade is taken as definitive proof that they don't have what it takes to "fit in" with math). Students of color and female students are stereotyped as having inferior math abilities (Steele, 1997), which can leave them especially vulnerable to experiencing a low sense of belonging in math (Good, Rattan, & Dweck, 2012).

### How can educators cultivate a sense of belonging in mathematics?

One strategy for increasing sense of belonging is to make doing and learning math more social. Research has shown that children prefer working on collaborative group tasks and are also more motivated, persist longer, and even learn more when they work with others (Master & Walton, 2013). This can be achieved through various strategies, including "jigsaw classroom," in which students learn different content and then rotate within the space to share their knowledge with classmates (Slavin, 2011). This gives each student "expert status," and every participant becomes integral to the success of the group.

Another strategy for increasing sense of belonging involves normalizing concerns about belonging to make it clear that everyone worries about whether they fit in and that these feelings get better with time (Walton & Cohen, 2007). Research has shown that this intervention can improve academic performance, as well as general well-being (Walton & Cohen, 2011). This seems to be in part because shoring up belonging leads to greater resilience in the face of challenges (Dweck, Walton, & Cohen, 2011).

Because students may also worry about their sense of belonging in math specifically, it is important to emphasize that everyone struggles with math in some form or another and that it's normal to worry whether they belong in math. One way to do this is to share stories that emphasize the struggles of famous scientists and mathematicians; research has shown that doing so boosts students' performance and sense of connection with academics, particularly for low-performing students (Lin-Siegler, Ahn, Chen, Fang, & Luna-Lucero, 2016).

## Math anxiety

### What is it?

Math anxiety involves tension, apprehension, and fear of situations involving math (Ashcraft, 2002). It is more than just apathy for math or perceiving math to be difficult—it is an acutely negative emotional response triggered by situations that involve math, whether it be in the classroom (e.g., participating in math drills) or in everyday activities (e.g., determining whether \$5 is enough to buy a sandwich, an apple, and a drink at lunch).

### Why is it important?

Math anxiety is associated with worse math achievement (Ma & Xu, 2004), even in young children (Cargnelutti, Tomasetto, & Passolunghi, 2017). This link is partly explained by the fact that math anxiety eats up working memory (Ashcraft & Kirk, 2001), which is what allows an individual to hold multiple concepts in mind at once and is thus critical to solving math problems. And because students with math anxiety avoid situations involving math, they learn less math—which effectively shuts down many (often lucrative) career paths (Ashcraft, 2002).

### How can educators alleviate math anxiety?

As noted above, adults can pass down math anxiety to children (Beilock & Willingham, 2014). Thus, teachers must be aware of their own math anxiety and how they might be communicating it to students. A critical starting point is to avoid expressing math negativity and talking disparagingly about one's own math skills. Educators can boost their confidence via professional development that increases their preparation to teach math (Kutaka et al., 2017).

Practicing mindfulness in the classroom may also help combat math anxiety. Mindfulness techniques, such as guided breathing exercises, can help students cope with stress and anxiety (van de Weijer-Bergsma, Langenberg, Brandsma, Oort, & Bögels, 2014). Mindfulness exercises can be beneficial for students—and teachers—at any time (Meiklejohn et al., 2012), and they can help boost achievement when teachers use them before stressful performance situations. Studies have shown that students who practice mindfulness before a math test report lower math anxiety and perform better (Brunyé et al., 2013; Shobe, Brewin, & Carmack, 2005).

Certain situations are more likely to evoke math anxiety than others. For example, math anxiety and math performance are more tightly linked when students must perform math under time pressure (Faust, Ashcraft, & Fleck, 1996). Situations with the potential for negative evaluation from teachers or peers may also trigger anxiety (Meece, Wigfield, & Eccles, 1990). Thus, classroom practices that involve timed and/or public performance situations should be avoided. Further, cultivating growth mindsets in the classroom may help alleviate math anxiety by creating a culture that celebrates mistakes as learning opportunities. Similarly, acknowledging that math anxiety is common can normalize the experience. It may also help prevent students from thinking that their anxiety means they are “just not cut out for math.”

## Self-efficacy

### What is it?

Self-efficacy is the mindset that allows a person to say, “I can succeed at this.” Self-efficacy is related to—but more specific than—self-esteem because it refers to one’s belief in the ability to succeed in specific domains or accomplish a given task (Bandura, 1977).

### Why is it important?

Self-efficacy is an essential component of academic motivation and learning (Zimmerman, 2000). Research underscores the importance of self-efficacy in promoting interest and persistence, increased engagement and adaptive responses to challenges, and better academic performance (Pajares, 1996). Students also tend to seek situations in which they feel confident in their abilities and avoid those in which they do not (Bandura, 1986). Thus, students with higher math self-efficacy are likely to participate more, try harder, and persist longer in math classes, even when they encounter setbacks and challenges.

### How can educators cultivate math self-efficacy?

One of the strongest contributors to students’ math self-efficacy is their own past performance (Bandura, 1986). In other words, students who were successful at math in the past will expect to be successful at math in the future. Thus, teachers should use scaffolding to support students’ progress on meaningful and reasonably challenging math tasks to improve the likelihood that they will succeed (Anghileri, 2006). Encouraging students to break large goals into smaller, attainable ones and providing opportunities for them to track and see the progress they make toward those goals can promote success (Schunk, 1990).

Vicarious experiences are an additional but less influential source of self-efficacy (Bandura, 1986). Vicarious experiences build self-efficacy when students observe others—particularly peers deemed similar to themselves—succeed in a similar situation (Schunk, 1989). Teachers can cultivate successful vicarious experiences by inviting students to participate in class demonstrations and model skills being taught. The evaluative stress that class demonstrations can place on students may be diminished when growth mindset messages are reinforced and mistakes are embraced as learning opportunities (Yeager & Dweck, 2012).

Students’ self-efficacy can also be influenced by verbal persuasion from important figures (Bandura, 1986). Thus, teachers should use their feedback to highlight students’ capacity to succeed in math and their growth. Specific rather than general compliments are important to draw students’ attention to their successes, as well as their progress (Siegle & McCoach, 2007). Along those lines, educators should not offer insincere or undeserved praise; they should provide task-specific feedback that helps students uncover the critical factors behind their success.



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