Kasi Allen and Kemble Schnell

# DEVELOPING Mathematics Identity

*Strategies are offered to help teachers support the emergence of their*

Don't let the noise of others' opinions drown out your own inner voice.

—*Steve Jobs, Stanford University commencement speech, 2005*

Many middle school students approach math with caution, often trepidation, and generally less-than-complete confidence. Several factors contribute to their views of what math actually is (a system of rules to follow and formulas to apply) as well as who might be good at it (people who can see the path to an answer and calculate quickly). A few tell us they "just aren't math people"—something we know to be false. Students at this age are immersed in forming their identity, including their mathematics identity. At a time when they might be embracing math as a powerful tool for reading their world, young people can instead succumb to fixed mindsets, the perpetuation of math myths, and a compromised relationship with math, thus affecting their school and career trajectory for the rest of their lives. Middle school math teachers have a unique opportunity to steer their students' mathematical development in a more positive direction.

*students' math identities.*

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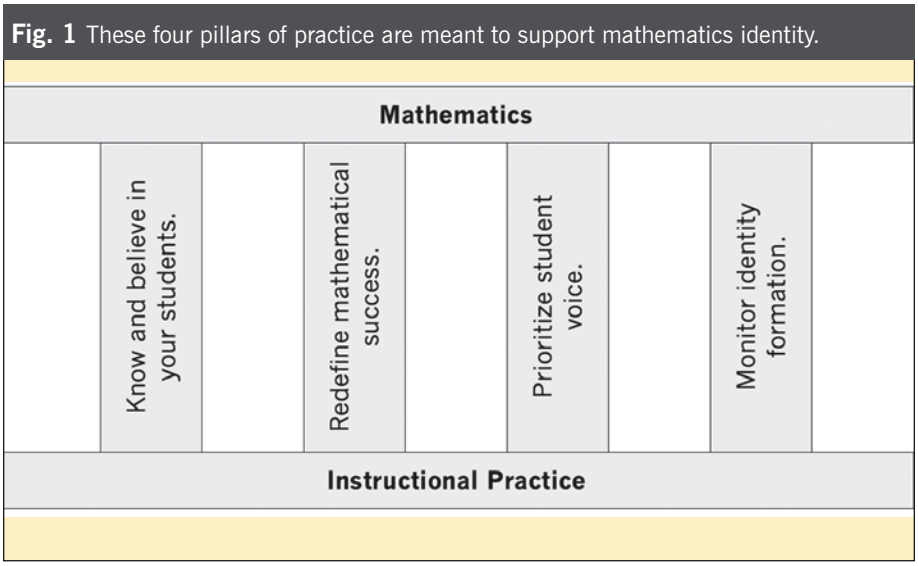
**Fig. 1** These four pillars of practice are meant to support mathematics identity.




## WHAT THE RESEARCH SAYS

We find the concept of "mathematics identity" to be a critical component of framing the knowledge, skills, habits, attitudes, beliefs, and relationships that students need to develop as successful mathematics learners (Aguirre, Mayfield-Ingram, and Martin 2013; Anderson 2007; Boaler 2002; Grootenboer and Zevenbergen 2008). The term *identity* is one used by researchers across many fields. In the most general sense, it refers to how people see themselves and how others perceive them, taking into account personal histories, abilities, character, culture, and so on. Developmental psychologists often refer to the middle school years as a period of "identity formation" as young people discern who it is they want to become. Students in early adolescence simultaneously grapple with multiple identities on the basis of their identification and association with different groups. Factors such as gender, race, class, language, religion, neighborhood, family, and academic history play powerful roles in shaping how students see themselves in the world.

In *The Impact of Identity in K–8 Mathematics Learning and Teaching,* Aguirre and colleagues provide this definition of "mathematics identity":

> The dispositions and deeply held beliefs that students develop about their ability to participate and perform effectively in mathematical contexts and to use mathematics in powerful ways across the contexts of their lives. (Aguirre, Mayfield-Ingram, and Martin 2013, p. 14)

They go on to make a strong case for how students' mathematics identities connect to their other identities. Each identity has the potential to influence the other. For example, a particular female might simultaneously have all these identities: an athlete, a good daughter, a Catholic, a Spanish-speaking immigrant, a strong student, and someone who is slow in math. Instructional choices that teachers make have a significant impact on each student's mathematics identity (Aguirre, Mayfield-Ingram, and Martin 2013). From the learning communities they create in their classrooms to their daily instructional choices, teachers have the power to shape students' mathematics identities and to debunk many of the math myths operating in our culture.

One research-based concept we regularly use in our mathematics classes to support mathematics identity is "mindset" (see Dweck 2006). Dweck has spent decades studying the benefits of having a "growth" mindset rather than a "fixed" mindset in a wide range of contexts, including schools. Mathematics is an academic area that is particularly prone to a "fixed" mindset: Most people think they are either born with or without math ability, something they essentially cannot change. However, when Dweck works with adolescents, she explains to them that their brain is more like a muscle; using it makes it stronger. She tells them,

> When you learn new things, these tiny connections in the brain actually multiply and get stronger. The more that you challenge your mind to learn, the more your brain cells grow. Then, things that you once found very hard, or even impossible—like speaking a foreign language or doing algebra—seem to become easy. The

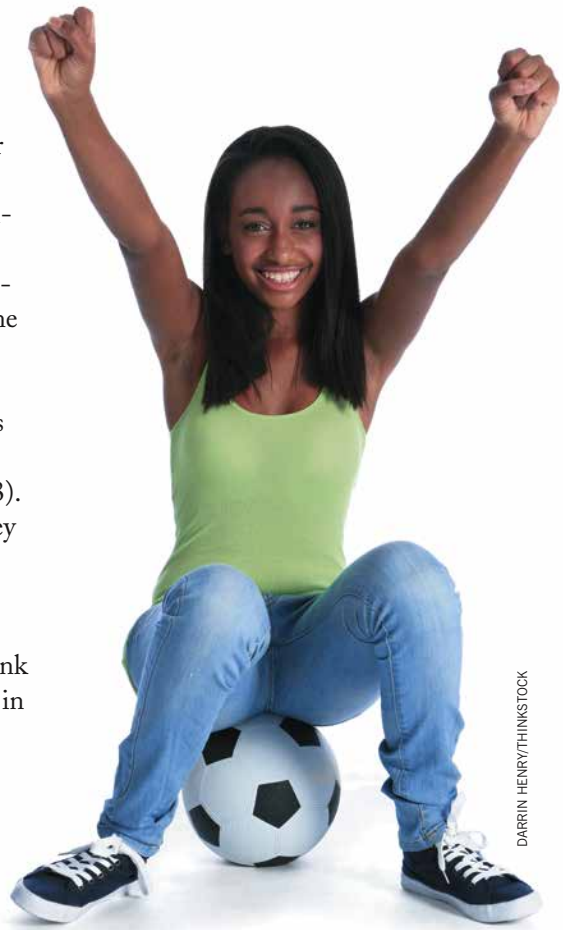


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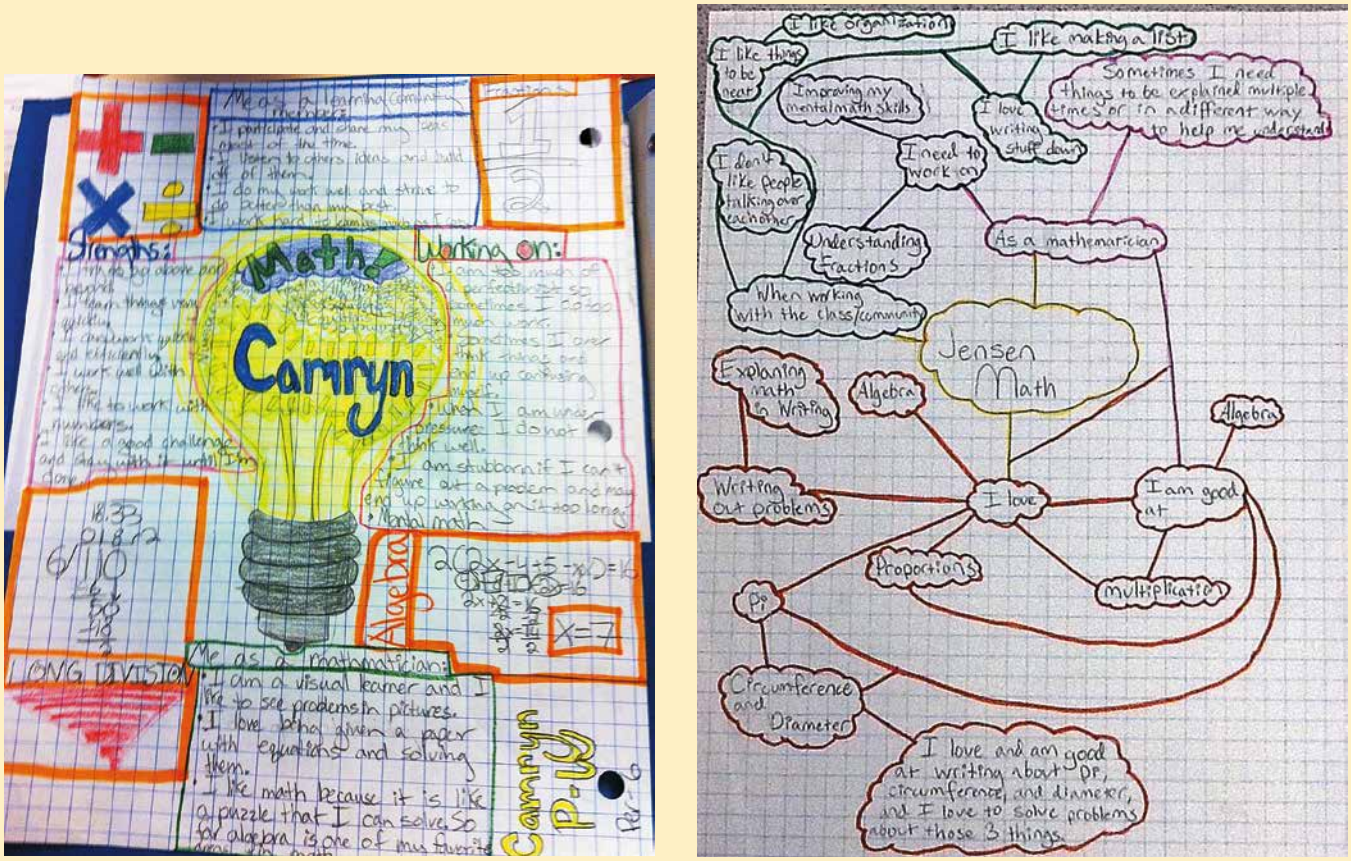
**Fig. 2** Students' "mathographies" allow students to communicate their view of mathematics to their teachers.




(a) (b)

result is a stronger, smarter brain. (Dweck 2006, p. 219)

We strongly encourage taking time to teach students about their mathematics identity and the research that confirms that they can grow their math brains (Willis 2010). Here, we share some strategies for supporting the development of our students' positive and powerful mathematical identities—quite possibly our most important work as math teachers.

## WHAT TEACHERS CAN DO

We have generated four pillars of practice (see **fig. 1**) for investing in mathematics identity, each of which is described below. The ideas are not necessarily new. However, taken together, they provide a strong start for any middle school math teacher who is interested in promoting the development of powerful and positive mathematics identity for all students.

Before discussing the details of the four pillars, we articulate some key elements of our daily teaching that we take as givens. First, students work in groups, meaning that we invest in classroom community all year, make use of roles, and assign group-worthy tasks, with the goals of promoting equity and ensuring that a few students do not dominate interaction. Second, students keep math journals, which they use every day in class; math journals contain a variety of entries including but not limited to warmups, classwork, open-ended reflections, and homework. Third, as teachers, we see ourselves as facilitators of classroom activities and co-learners with our students. Finally, we communicate high expectations for every student to learn mathematics and to contribute to the math learning of others.

## KNOW AND BELIEVE IN YOUR STUDENTS

Teachers who want to build mathematics identity know their students as people, make an effort to understand students' life circumstances, and believe unconditionally in each person's mathematical capacity. This means vigilantly viewing student attributes as assets rather than deficits. We find it especially valuable to have students tell their individual mathematical stories at the outset of each course, reflecting on these documents as the

**Fig. 3** The Tablecloth Protocol's rules are meant to promote a positive classroom environment.

**Tablecloth Protocol**

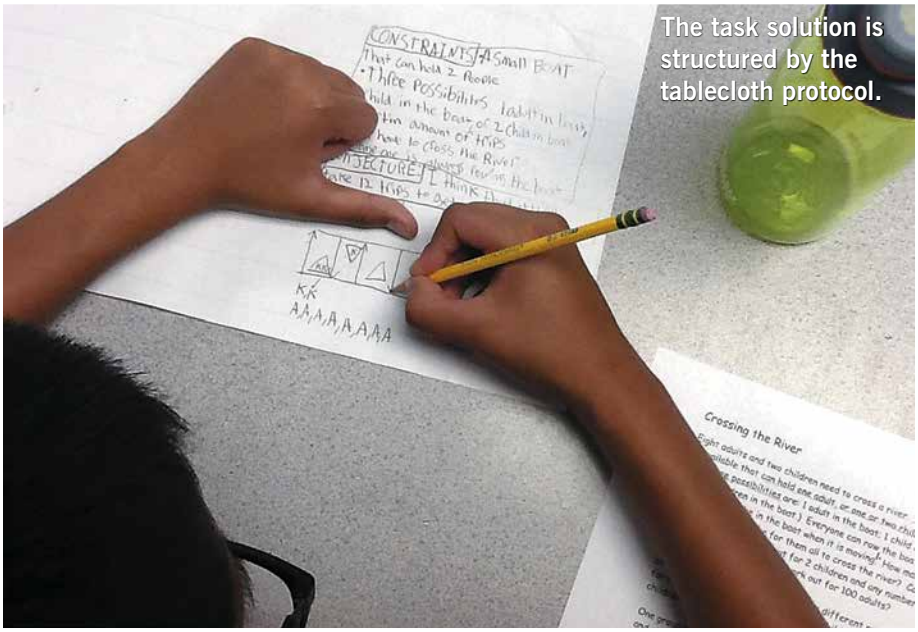
1. Place a large piece of paper (preferable poster size is 20 in. × 25 in.) in the middle of the table group.
2. Give each group of students a task. Without talking to each other, each student takes time to consider, reason about, and begins to solve the problem, writing only on his or her corner of the large piece of paper.
3. Remind students that their solution should involve multiple representations, making use of models, numbers, and words.
4. Post the following sentence starters after about 5 minutes of private think time for all the students to see:

   - I agree/disagree with you because. . . .
   - I appreciate. . . .
   - I noticed. . . .
   - I would add. . . .

5. Ask students to move to another table group and give written mathematical feedback to another student for about 3 minutes.
6. Ask students to return to their work and read the feedback and continue revising their work. If a student does not leave written feedback, have that student return and give verbal feedback to the student.

Offering students a verbal option is important. Mandating a single mode of communication, especially writing, can squash mathematical identity. Teachers could take the work in many directions from here, for example, whole-class discussion, individual reflection, "think-pair-share," or small-group problem solving.

*Source:* Developed by Kemble Schnell




The task solution is structured by the tablecloth protocol.

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year unfolds. Each "mathography," essentially a math autobiography (see **fig. 2**), affords a vehicle for setting the mathematical record straight on the child's terms (often clarifying past grades or identifying challenges) and initiating direct communication between student and teacher.

Students are given these instructions for creating a mathography:

> Create a piece of work on an 8 1/2 × 11 inch piece of paper that represents you as a mathematician. Include your strengths, your challenges, and how you plan to actively contribute to our math community this year. Be creative!

Ideally, individuals share their narratives with one another and revisit them over time. We have students write reflections on their mathography, one midyear and one at year's end. The semester reflection serves as a revision of the initial mathography, encouraging students to evaluate their progress and articulate goals for the months ahead. If feasible, the year-end reflection takes the form of a letter to the child's next math teacher.

## REDEFINE MATHEMATICAL SUCCESS

For students to believe in one another as capable thinkers and problem solvers, they must directly experience the positive contributions each of their peers can make. This requires moving beyond a definition of mathematical success centered on mastering algorithms or quickly generating right answers. As teachers, it means that we must name and make public the skills and talents that each child brings to the work, such as the following:

- Representing an idea in a new way
- Asking an insightful question
- Listening carefully and restating someone's thinking

- Making a systematic list
- Talking about an idea before writing it down
- Using or interpreting a graph
- Breaking a complex task down into smaller ones
- Working with the calculator
- Relating a new problem to a previous problem
- Connecting multiple ideas
- Using symbols to communicate an idea
- Drawing a diagram or picture

Keeping a class list of such appreciated math expertise encourages all to be mindful of what it really takes to do math successfully. The teacher might facilitate a class conversation at the beginning of the year that launches such a list. Then students could add to it during their work. What proves most powerful is when a teacher notices the work of a "low status" student and publically acknowledges that person's contribution. For example, an English language learner who seldom speaks in class might create a visual example or ask a clarifying question that helps the group communicate its idea. The teacher can draw attention to this, boosting the student's math status and simultaneously contributing to positive mathematics identity.

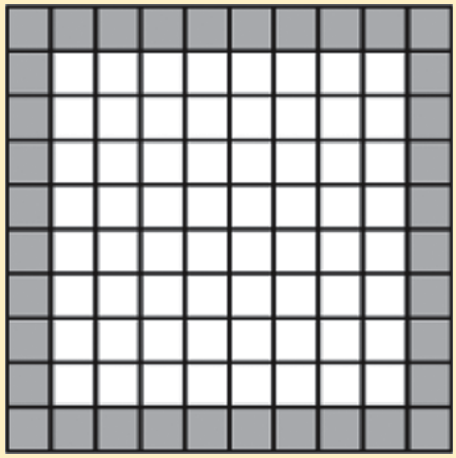
If we commit to honoring the differences in our math classroom, then we will remember that some people need to think, some need to write, and some need to talk as they make sense of a new idea or concept. We will implement classroom routines, like the Tablecloth Protocol (see **fig. 3**), that create space for students who need more time to collect and express their mathematical thoughts.

When selecting tasks for the Tablecloth Protocol, we look for problems with multiple access points that benefit from nonalgorithmic approaches and diverse problem-solving strategies. Such tasks promote communication among students and lend themselves to more opportunities for feedback and revision. One of our favorites is the Border problem (Boaler and Humphreys 2005) (see **fig. 4**). In the Border problem, students use a visual representation to move from concrete calculations to more abstract generalizations using algebra. The central role of the visual display in this problem and the focus on pattern to seed the generalizations invites all learners to share their ideas.

**Fig. 4** The Border problem is an example of a task with multiple access points.

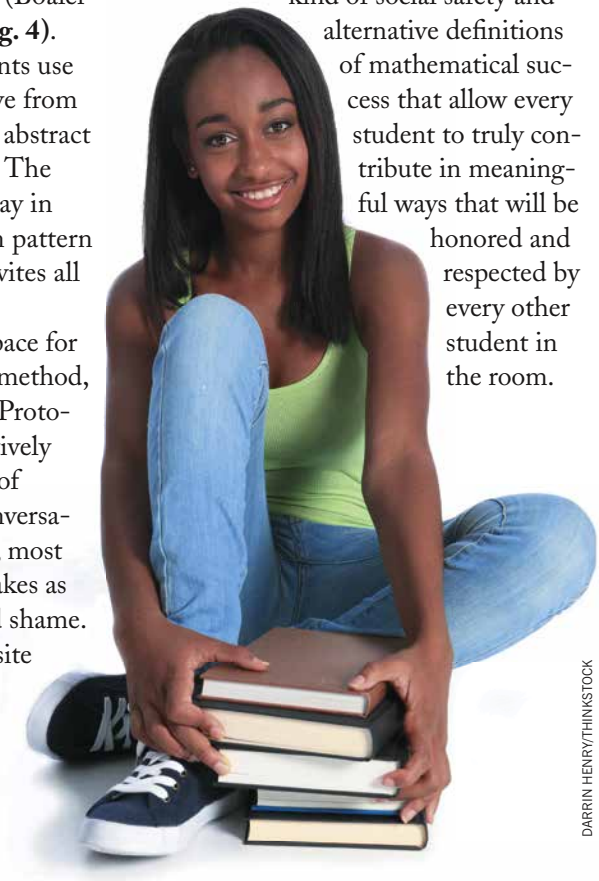
**The Border Problem**

Without using paper or pencil, find the area of the shaded border of the $10 \times 10$ square shown. How could you use your method to find the border of a $100 \times 100$ square? How about a square with an area of $n \times n$?



*Source:* Boaler and Humphreys (2005)

In addition to offering a space for more than one mathematical method, structures like the Tablecloth Protocol also provide a way to positively work with mistakes as points of mathematical interest and conversation. Unless taught otherwise, most students continue to see mistakes as sources of embarrassment and shame. They should be just the opposite because mistakes make our synapses fire and our brains grow, which is not the case with correct answers derived from mindlessly following a procedure. Only in classrooms where errors serve as a cause for inquiry, even celebration, can we cultivate the kind of social safety and alternative definitions of mathematical success that allow every student to truly contribute in meaningful ways that will be honored and respected by every other student in the room.



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## PRIORITIZE STUDENT VOICE

Who is doing the work? This is a question we ask ourselves after teaching or observing any math lesson, especially at the middle school level. We hope the answer is "the students," but too often it is "the teacher." Why is this question so important to us? In our experience, the extent to which students' mathematical voices (both spoken and written) play a role in the math classroom directly influences the mathematics identities they develop. If students spend most of a lesson watching someone else do the math and then duplicate what that person does, then they are unlikely to see how a new idea connects to their prior learning or to generate their own conjectures relevant to the topic at hand. Sometimes, in an effort to make math class a safe place, we reduce the intellectual challenge, depriving students of thinking for themselves, leading to boredom and frustration on everyone's part (Willis 2010).

Nearly 70 years ago, mathematician and mathematics educator Pólya offered advice to math colleagues that holds to this day:

> The teacher should help, but not too much and not too little, so that the students shall have a reasonable share of the work. (Pólya 1945, p. 1)

Similarly, Dan Meyer advises us to generally "be less helpful" (Meyer 2009). The inherent message is that students need to take responsibility for their own learning and the learning of each other. We offer a list of some strategies we use to make this pedagogical shift.

**1. *Limit broadcast questioning.***
Asking questions of the whole class and then calling on one student among the first raised hands is a habit all math teachers need to break because it inevitably privileges the voices of a small group of students. Instead, give students a chance to write or talk to a partner before anyone speaks publically.

**2. *Establish routines that help students develop ideas privately and express them in a small group before presenting publicly.***
Such subtle shifts as having students "think-pair-share" in the midst of a class discussion or using roles in groups rather simply asking students to work together can have a huge impact because they ensure that every child has a way to take part in the collective work.

**3. *Leverage formative assessment and self-assessment.***
Have students do a mid-lesson "fist to five." Every student or one from each group holds up a hand, showing a fist or a number of fingers to indicate the extent to which the student or the group is ready to move on. When using this scale, a fist means "I/we need help" and five fingers means "I/we can help another student or group."

**4. *Have students help set goals and write learning targets.***
When only the teacher sets goals for the class, math can feel like something being "done to students" rather than something they do. Asking students to participate in goal setting can shift the power dynamic and send strong messages about the confidence we have in our students.

Ultimately, our job as teachers is to draw the math out of students. To do so, we must remember that it is in them. We must create safe spaces in our classrooms for students to express ideas about which they remain uncertain, help them experience the power of making conjectures and verifying or refuting them, and validate the process as much as the end product. This will require withholding judgment, maintaining flexibility in terms of how students express their thinking, being patient, and providing as many tools as possible.

## MONITOR IDENTITY FORMATION

If developing each student's "mathematics identity" is important to us, then we must monitor it regularly. Targeted formative assessments embedded in our daily instruction, such as think warmups, index cards, and exit tickets, allow us to gather valuable data about student progress related to mathematics conceptual understanding as well as identity. Teaching students to authentically self-assess plays a critical role. If students can articulate what they know and what they are working on, then we as teachers stand a much better chance of being able to help them. If they can learn to use the language of

"mindset" and "mathematics identity" and recognize that such things are always changing and always ripe for revision, then math will become a different subject for them. For us, journals have served as a primary tool for this piece of the work. They provide a running record of each student's growth, private documentation of their mathematics identity formation, and evidence of conceptual exploration.

## A WORK IN PROGRESS

Identity formation, including mathematics identity, is a lifelong process. This holds true for math teachers as well. As we focus more time and energy on supporting students in the development of their mathematics identity, we benefit from examining our own. In doing so, we should challenge ourselves with questions like the following:

- What is my own mathematics identity?
- How do I see my own mathematics identity reflected in that of my students?
- Do I see any patterns in the mathematics identities of my students based on their other identifications, especially gender, class, and ethnicity?
- What am I still grappling with? Do I fully understand the mathematics myself?
- How can I invest in my own mathematical identity?
- How can I share this with my students?

Many math teachers are initially attracted to math because of its order and perceived objectivity. Right answers feel good. However, teaching math is not about the answers; it is about the journey we take each year with our students. As the guides who chart the course of exploration, we must believe in ourselves as well as in our students. This means viewing our own mistakes as opportunities to learn and grow. We cannot say too strongly how important it is for us to reflect continuously on how our own assumptions, and potentially skewed perceptions of students, result in self-fulfilling prophesies. Our students become the words we use: brilliant, lazy, high, low, fast, slow. Let us not forget that a budding mathematician resides in every one of them.

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