## What Your Colleagues Are Saying . . .

"This book helps us with one of the most important goals of all—supporting students to develop positive math identities. It does so with a range of amazing strategies (all based on neuroscience), personal reflections, and compelling stories. A must-read for anyone who wants to support their students', or their own, positive math identity."

**Jo Boaler**
Nomellini–Olivier Professor of Mathematics Education, Stanford University
Stanford, CA

"Math identities are formed and reinforced every day in our math classrooms. Liesl McConchie explains the brain science behind this fact in a way that is both clear and engaging. In so doing, she teaches us how to create positive experiences for our students and, in turn, how to shape their math identities. This book is a must read for any math teacher who takes seriously the emotional well-being of their students."

**Peter Liljedahl**
Professor of Math Education, Simon Fraser University
Author, *Building Thinking Classrooms*
Vancouver, British Columbia, Canada

"In clear, easy-to-read prose and with everyday examples, Liesl McConchie helps us understand the connection between cognitive neuroscience, affective science and teaching. We can and should impact students' math identity for the better."

**Pam Harris**
Founder and CEO, Math Is Figure-Out-Able
Author, *Developing Mathematical Reasoning*
Kyle, TX

"A provocative and enlightening read! By skillfully weaving together equity, brain research, and compelling stories, the author clearly demonstrates why this work is essential. This book offers a powerful, research-backed argument for understanding how students' math identities are shaped—or undermined. A must-read for anyone dedicated to creating meaningful, high-quality math experiences that empower every learner."

**Pamela Seda**
CEO, Seda Educational Consulting, LLC
President, Benjamin Banneker Association
Stockbridge, GA

"McConchie has integrated research on identity development in math with the neuroscience of identity. Her approach will support teachers to build classrooms that help students develop the self-efficacy necessary to succeed in mathematics. I recommend this book to anyone seeking actionable steps to take in the classroom to build student confidence in mathematics."

**Rachel Lambert**
Associate Professor, University of California Santa Barbara
Author, *Rethinking Disability and Mathematics*
Santa Barbara, CA

"This book is EVERYTHING! It is THE ultimate brain-based guide to math identity. Easy to read, packed with powerful tips, and guaranteed to level up your teaching game—every teacher NEEDS this book! I could not be more obsessed."

**Vanessa "The Math Guru" Vakharia**
Owner, The Math Guru
Author, *Math Therapy*™
Toronto, Ontario, Canada

"A rare book by a true math professional. The content is fresh, friendly, and backed by science. Liesl McConchie reveals more than just how a math identity is formed, but also how you can shape the identity that students need to succeed. The insights are great, but the real value is jumping into the book and taking action, with dozens of format-easy, practical tools that can be used the very next day. Yes, you can quit struggling and become a math champion. Raise the bar; then start raising your students' proficiency in math every day!"

**Eric Jensen**
Author, *Teaching With the Brain in Mind, Brain-Based Learning*, and *Teaching With Poverty in Mind*
Maunaloa, HI

"McConchie's new book, *Building a Positive Math Identity: A Brain-Science Approach*, offers a transformative lens on how cognition, emotion, and identity intersect to shape our students' mathematical agency. Grounded in brain science, this book is essential for all educators as we commit to creating equitable and empowering learning environments."

**Brendan Scribner**
Math Consultant, Scrib Mather, LLC
Junction, VT

"As I read this book, memories came flooding back about moments that shaped my math identity. This work masterfully takes us through key ideas about how our brains operate to link together in a meaningful way math identity, emotions, thinking and cognition, belonging, and culture. Amid the deep dives into the science, McConchie provides straightforward, meaningful recommendations for classroom practice that will support the development of more confident math learners."

**Michael D. Steele**
Mathematics Education Professor, Ball State University
Board of Directors, NCTM
Muncie, IN

"If you are seeking to understand how children's brains work in the learning of mathematics, this is an essential resource. The book will expand your knowledge of the brain and provide you with practical tips to ensure that children in your environment are academically successful."

**Kristopher Childs**
K Childs Solutions
Winter Garden, FL

"What a gift it is to take something so impactful and complex and make it accessible for so many. This book will open the doors to equitable mathematics for those starting and allow for building upon knowledge for those who have been in the game for a while."

**Crystal Watson**
Principal, Cincinnati Public Schools
Cincinnati, OH

"McConchie's expertise in the brain science of learning and math identity is approachable and impactful. She breaks down the science into strategies that can immediately be employed in classrooms to positively affect students' view of themselves as math capable."

**Heidi Sabnani**
Consultant, Sabnani Educational Consulting
Stoughton, MA

"This book is a game-changer for educators committed to creating inclusive and engaging math classrooms. Liesl brilliantly connects brain science and practical teaching strategies, showing us how to help every student see themselves as a competent math learner. This book is a must-read for anyone who believes that math classrooms should be spaces of curiosity, joy, and deep understanding."

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Chief Content Officer, Flynn Education
Olympia, WA

"I am so happy Liesl wrote a book on building a positive math identity. Teaching math is so much more than teaching math topics; as math teachers, we need to think about how we are building a positive math identity for each and every student. Liesl does an outstanding job sharing how we can do this."

**Howie Hua**
Fresno State Math Lecturer
Fresno, CA

"Liesl McConchie is *the* source for learning how brains learn best. If you want to feel inspired, excited, and empowered to teach, *Building a Positive Math Identity* is your resource. A perfect blend of in-depth research and actionable strategies, this book will help any teacher cultivate more confidence and competence in our students (and ourselves)."

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Author, *Burnout Cure: Learning to Love Teaching Again*
Kalamazoo, MI

"Every math teacher should read this book to gain knowledge of how our students' brains function in the context of learning mathematics! Liesl also shares practical strategies to understand and nurture our students' relationships with mathematics. Her book is both powerful and practical. Students will feel seen, heard, and supported if we apply what we learn from *Building a Positive Math Identity: A Brain-Science Approach*."

**Amanda Jansen**
Professor, University of Delaware
Author of *Rough Draft Math: Revising to Learn*
Newark, DE

# BUILDING A POSITIVE MATH IDENTITY

**Dedication**

*To everyone who has ever been told, "You are just not a math person!"*

*I wrote this book in hopes that you will see that they were wrong!*

# BUILDING A POSITIVE MATH IDENTITY

## A BRAIN-SCIENCE APPROACH

LIESL McCONCHIE

CORWIN Mathematics

CORWIN

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# CONTENTS

**Note From the Publisher:** The author has provided video and web content throughout the book that is available to you through QR (quick response) codes. To read a QR code, you must have a smartphone or tablet with a camera. We recommend that you download a QR code reader app that is made specifically for your phone or tablet brand.

Videos may also be accessed at the URLs provided under each QR code.

# PREFACE

My most vivid memory of Nico was watching his little 6-year-old body jump up and down in unbounded elation. The only thing more joyful to witness than his impressive vertical jump was the sound of his squeals filling the air. What was prompting this unrestrained excitement? Subtraction, of course!

We had started at 50. (Technically, I had suggested we start at 20, but Nico begged to start at 50. I'm a sucker for a student begging for a challenge.) Each roll of our 12-sided dice dictated how many we were going to subtract. A roll of 2 meant we were going to subtract 2 from 50. Nico jumped up to the whiteboard and wrote 50 – 2 = 48. The goal was to continue until we got to zero.

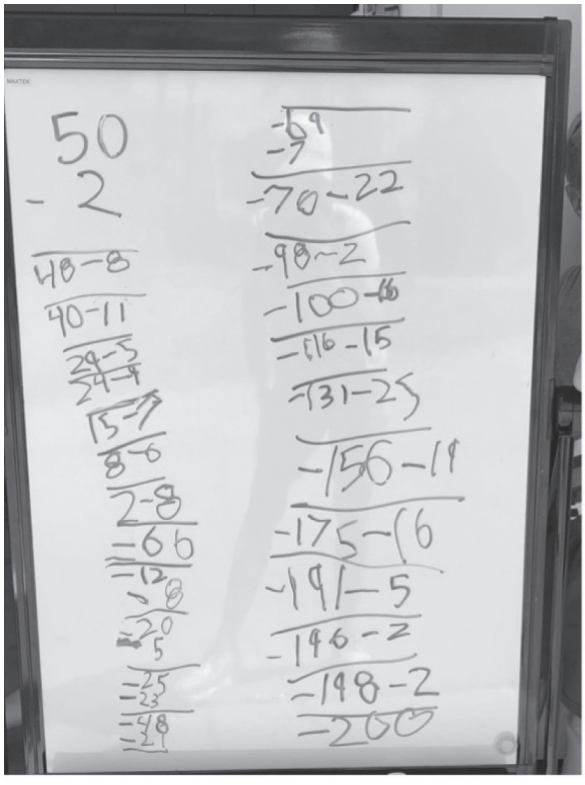
As we got closer and closer to zero, with each roll and subtraction, Nico's excitement seemed to grow. I didn't realize it at the time, but Nico had plans to extend his thinking beyond zero. He didn't know what would happen, but the height of his jumps and decibels of his squeals indicated he was eager to find out.

Nico, and his group mates, had subtracted all the way down to 2. Their next roll was an 8. And that, my friends, is when Nico's squeal broke the sound barrier!

What ensued was the most magical manifestations of mathematical enchantment. Those kids talked, debated, discussed, argued, drew, and ultimately decided that 2 minus 8 was -6. I mistakenly thought that once I confirmed their thinking, we'd celebrate and get ready for dismissal.

Nico had different plans. As if he were pumping up his team at halftime of the Super Bowl, Nico's little 6-year-old body let out a guttural, "Let's keep going!"

And so they did, all the way to –200.




The school day was long over. Nico's mom had been standing by, waiting to take him home. She was able to witness the last few minutes of him living his best math life.

You might be caught up in the idea of kindergartners subtracting deep into negative numbers. Surely, that is impressive. Yet, what I'd like to focus on is Nico's relationship with math. It was built on curiosity, anticipation, joy, and confidence.

As you'll see as we unpack the science of identity formation, Nico saw himself in that mathematic space in a way that allowed that moment to happen. Experiences that had previously happened to him, around him, within him, and what he saw possible in his future contributed to this core memory.

As someone who has spent more than 25 years studying how the brain learns, and the conditions needed for the brain to be at its best, I couldn't help but envision all those positive neurotransmitters and hormones pulsing through his 6-year-old brain. Something magical was happening in there, and a few of us were lucky enough to be witness to it. In fact, a lot of amazing things were happening. Too many for us to explore here. All of it translates to impact Nico's relationship with math.

I spent the first two decades of my career in education primarily working at the middle and high school level. By the time they came to my class, many of my students had a negative relationship with math. They feared it, felt anxious around it, or didn't believe it was something they could ever be good at. So much so, that their relationship with math became part of their identity. Their math identity.

The year I had the honor to teach Nico was my first year teaching early elementary. It reminded me that every child, at some point in their life, had a positive math identity. The way they saw themselves in the context of math was positive and supportive of rich mathematical thinking. It might have been the first time they counted to 10 or proudly announced that 2 + 3 = 5.

I share this as a reminder that whatever the current status of your students' relationship with math, it hasn't always been that way. And, consequently, it doesn't have to always be that way.

(Ask any middle school teacher—they'll tell you that a student's relationship status can change multiple times in a single day.)

In fact, I've watched this happen with Nico. As Nico finished up second grade, his vertical jump is even more impressive, as evidenced by his ability to do a back tuck. But his math joy has been replaced by math anxiety. His squeals have been replaced by tears. And his jumping up and down has been replaced by falling onto the couch in despair.

*Your math identity is how you see yourself in relation to math. In that sense, it truly is a relationship.*

How did this happen? Neuroplasticity. Things changed. His relationship with math changed. The way he sees himself within the context of math has changed. (And, yes—timed math tests were involved. We'll get to that in a later chapter.) His identity within math spaces has changed.

Your math identity is how you see yourself in relation to math. In that sense, it truly is a relationship.

The hopeful news is this is not the end of Nico's story. He has an amazing mom advocating for him and supporting him. I am confident Nico's relationship with math will improve. And the same can happen for your students.

Having a positive math identity doesn't always look like Nico—jumping up and down and squealing. Sometimes it is quieter and more private. I remember a student with selective mutism (a rare form of anxiety that presents itself as being mute in selective situations). For them, it was the smile that crept onto their face—lips pursed together, as if they were trying to keep it to themselves. They didn't need to speak a word for me to know the message being spoken internally: "Math—you and me, we're in a good place."

## The Complexities of Relationships and Identities

Relationships are complex. How is that for the understatement of the millennium?

- Our relationships with other people are complex.
- Our relationship with the planet is complex.
- Our relationship with power, greed, love, and empathy are complex.
- All of them. Including a student's relationship with math.

It's tempting to read a story like Nico's and think a student's math identity is purely determined by their competence and confidence with math. It might look like that on the surface. But as you're about to learn, it is far more complex than that.

Throughout this book, we will accomplish two things:

1. Discover the four main variables of one's math identity and how one's relationship with math impacts learning
2. Gain dozens of brain-based classroom strategies and activities you can use with your students to help them form a more positive math identity

In Chapter 1, we will dive into the human brain and discover where our identities are formed. This will provide the framework for the four main variables that form our math identity—past experiences, future vision of self with math, sociocultural influences, and personal efficacy. We'll reinforce the dynamic nature of our identities (think back to neuroplasticity) to give us the boost of hope needed to do this important work.

In Chapter 2, we'll unpack the relationship between emotions and cognition. Remember, our math identity is how we see ourselves in relation to math. The emotions attached to that relationship have strong connections to cognition—or our math learning. This chapter will give credibility to the need for addressing our math identity. Having a positive math identity improves math learning.

Starting in Chapter 3, we'll begin a four-chapter exploration of each of the four variables that form our math identity. We'll start by understanding how our past experiences with math contribute to our math identity. The good, the bad, and the traumatic—we'll discuss them all.

In Chapter 4, we'll look to the future. Although it hasn't happened yet, a student's vision of their future strongly impacts their current math identity. A lot of it comes down to feeling a sense of belonging in math spaces, which is highly influenced by representation. We'll uncover how marginalization impacts the brain, beyond the devastating impacts on the heart.

In Chapter 5, we'll turn our eyes outward to all the sociocultural forces and messages seeping into our math identities. These messages come from many sources—family, media, and even inside our classrooms. You might be tempted to dismiss these (sometimes) subtle messages. I'll walk you through how to take them on and why it matters.

In Chapter 6, we'll explore the last of the four variables that form our math identity—personal efficacy. Building confidence and competence within math certainly influences how students see themselves in math spaces. I'll guide you through how to help students manage math anxiety and any other unhelpful feeling in math.

Our identities are constantly changing based on a variety of factors. We must give attention to all of these factors if we are to help students form a positive math identity. Too much emphasis on one variable will lead to further oppression of those most marginalized in math spaces.

With each of these variables I'll be spotlighting one activity (and outlining many others) that you can do with your students to reveal and heal different aspects of their math identity.

**LIESL'S WEBSITE**
qrs.ly/amgi5t3
You can find more activities at *https://lieslmcconchie.com/mathwithmeinmind*

To read a QR code, you must have a smartphone or tablet with a camera. We recommend that you download a QR code reader app that is made specifically for your phone or tablet brand.

Each of the first seven chapters conclude with a ready-to-use activity built around a main principle in that chapter. You will find instructions on how to introduce the activity, supplies needed, and a scripted outline of discussion points. Samples of student work are also shared to enhance our exploration of how these topics impact students' math identity.

In the final section of the book, we will turn inward and examine your own math identity as an educator and why that matters—for you and for your students. In Chapter 7, we'll discover how aspects of our math identity as educators can be contagious to our students. I'll share strategies to confront your own math gremlins and biases you bring to class.

In Chapter 8, we'll begin a very nuanced conversation about certain common practices in math classes and the impact they have on a student's math identity. Get ready for your blood pressure to rise a bit as we dissect practices like timed math tests, ability grouping, and more. By focusing on the intentions behind these practices, we can identify healthier tools to reach the same outcome without damaging a student's math identity.

We'll wrap it all up in Chapter 9 with a discussion on how to move forward with this work of fostering a positive math identity in the students we work with. As you read this book, my hope is you will see more clearly the inseparable role of emotion and cognition. From that foundation, any effort to support a student's emotional relationship with math cannot be accurately viewed as something "extra" being added to your plate. It is the plate upon which learning is served.

## Finding the Joy

When you look back at the most joyful moments of mathematical learning you have witnessed in your career, what was the source of that joy? What was it that made you feel proud of the work you do every day with students? I doubt it had to do with right answers, although it might have been accompanied by right answers.

If you're like me, I'd guess the true source of your pride and joy lies underneath the right answers—in the relationship your student is forming with math.

The true joy in teaching math comes from witnessing students see themselves as capable math learners, unrestrained from the failures of their past. It's watching them look inward, not outward, to define who is good at math and what it means to be good at math. The thrill of teaching math comes from watching their math identity take shape and leading them to deep, meaningful learning.

That's when barriers become balconies with beautiful views of what is possible in their future.

## A Note to Leaders

In our current era of education consumed by testing and scores, you play a critical role in supporting your colleagues and staff to prioritize their students' math identity. Some may be looking to you for permission and encouragement to invest in the whole child. They know that another worksheet or new computer program will not solve the challenges their students face of not seeing themselves as being a "math person." We cannot solve emotional problems with a purely cognitive approach.

Others in your sphere of influence may need your leadership in helping to see the connection between emotions and cognition. They may be stuck in thinking that the results of high-quality teaching are best described as the acquisition of more math facts. They may benefit from an updated professional learning session outlining the latest research on the role of emotions and learning.

## A Note About Identity

When we talk about math identity in this book, we are talking about how a student sees themselves in relation to math. That is quite different from what we generally refer to as identity.

To put it simply, we are not referring to the identity you *bring to* math spaces. We are talking about your identity that exists *within* math spaces.

The former is formed by race, ethnicity, family, language, culture, spiritual beliefs, and much more. Many wonderful scholars and educators are doing important work in helping math spaces be welcoming to all identities. I support this work, but it is not my area of expertise.

The latter is formed as a result of your relationship with math. Experiences you bring with you from the past, experiences happening around you, experiences happening within you, and even experiences in your future (that haven't happened yet). It is the interplay of these four variables that form one's math identity.

## Let's Talk About Language

In this book, I have made deliberate choices about language to better reflect the complexity and diversity of the individual and community identities discussed. As we continue to learn and grow in our use of language, I have done my best to use language reflective of the current standard of respect and inclusivity.

For instance, I capitalize "Black" to honor its significance as a racial identity deeply rooted in shared history, culture, and experience, while I lowercase "white" to reflect the absence of a singular, cohesive cultural identity in the same way. I use both "Hispanic" and "Latine" interchangeably, acknowledging the diversity of these identities while recognizing that "Latine" offers a more inclusive term that embraces nonbinary individuals. When citing research done by other scholars, I use the terms they included in their studies to honor their work and for accuracy in citing their research.

I use the term "marginalized" or "minoritized" population instead of "minority population." This phrasing more accurately communicates the use of systems and structures to harm certain

communities, rather than (falsely) reflecting a small quantity of the population. I also use the terms "historically and contemporaneously marginalized" to acknowledge that this marginalization is not just a pattern from the past but is actively happening in our current day.

Additionally, I chose to use "caregiver" in place of "parent" throughout, as this term more accurately reflects the range of individuals responsible for nurturing and supporting children. Furthermore, I use "their" as a singular pronoun to promote inclusivity and respect for individual gender identities. These language choices are intentional, aimed at fostering a more precise, respectful, and inclusive dialogue about identity, power, and the ongoing struggles for equity and justice.

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My husband, James, for always saying "sure, go for it!" when I tell him about my next big work project.

My kids—Dane, Porter, and Ryder—for showing me every day what is possible for all people—a beautiful relationship with math.

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# ABOUT THE AUTHOR

**Liesl McConchie** is an international expert on how the brain learns and coauthor of Corwin's best-selling book *Brain-Based Learning* with Dr. Eric Jensen. She has been published in multiple education journals, including ASCD's *Educational Leadership* journal and *NCTM's Mathematics Teacher*. With over 25 years of experience in education, Liesl bridges her knowledge of how the brain best learns with her experience of teaching math to create tangible strategies to support teachers and schools across the globe. She has a rich background in education that includes creating new schools, leading whole-school reforms, delivering workshops to educators, and speaking at conferences. Liesl brings the highest quality of research, professionalism, and engagement to all her contributions to the field of education.

# PART I

## HOW EMOTION AND COGNITION COLLIDE TO INFORM MATH IDENTITY

# WHAT IS MATH IDENTITY

CHAPTER 1

## EARLY ASPIRATIONS

I spent my childhood playing school on the chalkboard my mother painted on my bedroom wall. All five of my siblings, and the neighborhood kids, sat on the matted green carpet (that's since been removed) in my room as I taught them the love of my life: math. I gave them worksheets to complete. I graded them and recorded their scores in my homemade grade book. Someday, I was going to be a math teacher. Not just any math teacher—an exceptional math teacher.

I never wavered from that goal. I studied each of my K–12 teachers carefully to discover tools to be an effective (or not-so-effective) teacher. Growing up in a tracked education system, I was surrounded by other students who had been identified as excelling in math. In college, I was immersed in a program with other people with similar aspirations of becoming a math teacher.

I'm embarrassed to admit that it wasn't until I first started teaching high school at the wise old age of 21 that I encountered students

who didn't share the same interest or success with math as I had. When a student would say, "I'm just not a math person" or "math just isn't my thing," I didn't know what that meant. I didn't know being a math person—or not—was a thing. In short, I didn't understand that students' experiences and beliefs about math were part of their identity. ●

**In this chapter, we'll explore . . .**

- **A definition of math identity**
- **Where identity formation happens in the brain**
- **Four elements that form your math identity**
- **Why math identity matters**
- **A trip to Mathland**

## Math Identity

How many times have you heard someone say, "I'm just not a math person!"? What does that really mean? The message behind those words extends far beyond whether they know their multiplication facts or can find the roots of a quadratic. It's more a statement about whether the person can see themselves in a positive light within mathematical spaces. In short, it's a statement about their math identity.

We will define math identity as how you see yourself in relation to math.

**Math identity: how you see yourself in relation to math.**

When someone claims to not be a math person, it's possible they are trying to say, "When I see math, I don't see me. When I see me, I don't see math. Me and math—we don't coexist."

That kind of messaging communicates they don't have a math identity. That is simply not possible. We all have a relationship with math. It just might be an unpleasant relationship to reflect on.

I believe the person claiming, "I am not a math person!" is actually communicating their discomfort with the picture they hold of themselves and math. Perhaps they see their relationship with math as being full of pain, anxiety, failure, and shame. It would make sense then, as a coping mechanism, to want to distance yourself from those feelings by not allowing yourself to mentally exist in the same space as math. Hence, "I am a not a math person." This framing allows the person's identity to not have residence in the same mental space as math.

This mental distancing can foster avoidance, and that ultimately leads to poor learning outcomes in math (Choe et al., 2019).

A healthier approach could be getting curious about our relationship with math so we can move toward healing and fostering a more positive math identity. That requires a belief that our math identity can change.

*Math identities are dynamically constructed and constantly being adjusted as we engage in mathematics inside and outside classrooms.*

Some people assume identities are fixed, or genetically predetermined. For example, you might have heard someone say, "My parents weren't 'math people' so I'm not a math person either." This assumption about math identity is false.

Math identities are dynamically constructed and constantly being adjusted as we engage in mathematics inside and outside classrooms. They are continuously evolving based on our environment, social cues, and developmental phase of life (Bishop, 2012).

To understand how math identities are formed, let's dive briefly into a region of the brain most associated with identity formation.

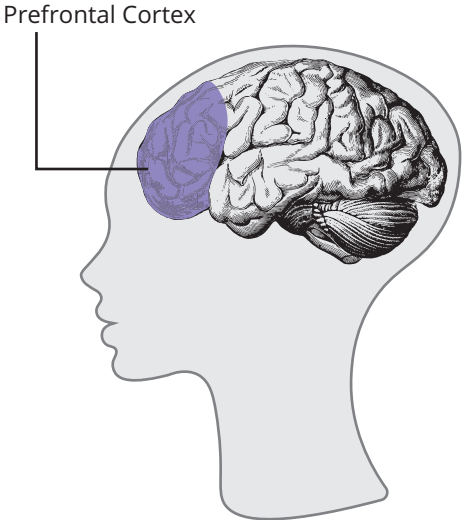
## Math Identity and the Brain

Directly behind our forehead is a region of the brain called the prefrontal cortex (PFC; see Figure 1.1). This part of our brain is a key player in the game of learning. Often referred to as the executive control room, the prefrontal cortex is responsible for much of our higher-order thinking skills such as planning, analyzing, and reflecting (Miller & Cohen, 2001).

Part of that reflecting is centered around you—you reflecting on you. It's happening all the time, even when you aren't aware. Subregions of the prefrontal cortex are constantly scanning and processing various sources of input to help you see yourself clearly in certain contexts. At the karaoke bar, you're reflecting on your perceived singing ability,

**Figure 1.1**

## Prefrontal Cortex—The Hub of Self-Referencing and Identity Formation



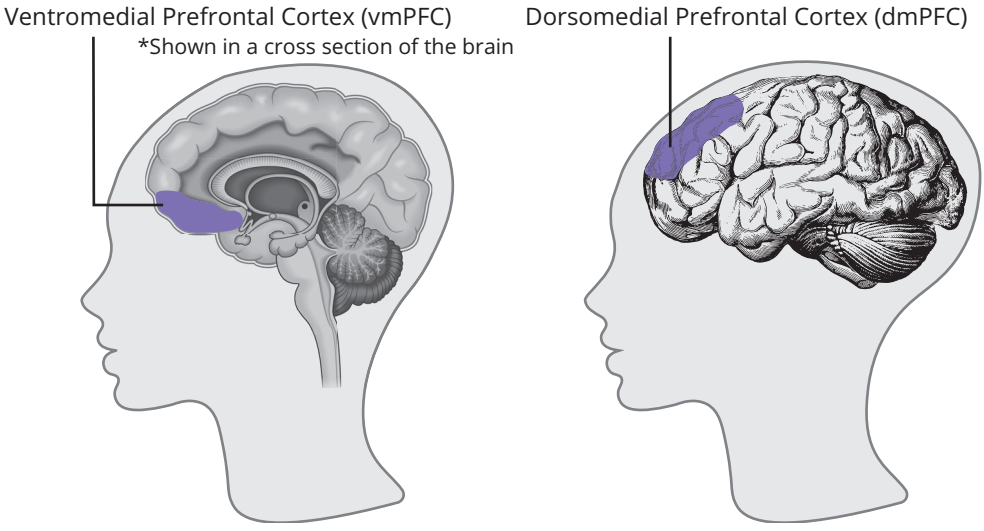

compared to those around you. You're reflecting on your past singing experiences and whether you have singing aspirations in your future. The same level of reflecting is happening for every student in a math classroom (and other subjects for that matter). They are reflecting on their perceived math ability, compared to those around them. They are reflecting on their past math experiences and whether they have aspirations that involve math in their future. All of this is part of the function of the prefrontal cortex. This self-referencing forms your identity within those contexts (Meyer & Lieberman, 2018).

Zooming in a little closer (Figure 1.2), we can see the prefrontal cortex is partitioned into several subcortical regions, each with a unique function. Two of these smaller regions are highly involved in our self-referencing—me thinking about me—and our identity formation.

I'm going to keep this discussion on brain science simple and focused on only what's useful to educators—but I'll be the first to admit it's far more complex.

**Figure 1.2**

## Ventromedial Prefrontal Cortex (vmPFC) and Dorsomedial Prefrontal Cortex (dmPFC)




Here's what you need to understand: Math identities are complex and dynamic. Creating a healthy math identity takes more than feel-good experiences with math (although those certainly help). And, because one's math identity is constantly evolving, it takes more than one positive experience to maintain a positive math identity. The following deep dive into the brain lays the groundwork for the model we will be unpacking throughout this book. It is the science that supports a comprehensive approach to how we help build a positive math identity with the students in our classrooms. And it all starts in the brain.

The two subcortical regions of the brain most associated with identity formation are the ventromedial prefrontal cortex (vmPFC) and the dorsomedial prefrontal cortex (dmPFC). Both are located in the middle region (medial) of the prefrontal cortex with the dmPFC sitting above the vmPFC.

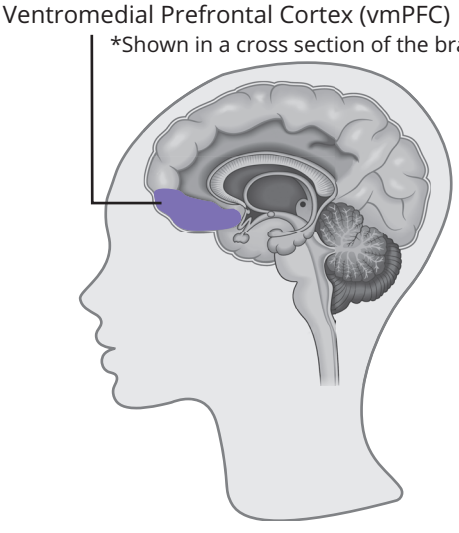
## POSITIONING US IN MENTAL TIME

The vmPFC (Figure 1.3) positions a person in mental time (Stendardi et al., 2021). If you could hear your vmPFC talk, you might hear it reflecting on questions similar to these:

- Do I see myself as young or old?
- Where do I exist along the spectrum of time?
- When I reflect back on my earlier years of life, how have those experiences shaped who I am now?
- Who am I now, compared to who I was then?

**Figure 1.3**

### Ventromedial Prefrontal Cortex (vmPFC)




But this is not a one-directional reflection. The vmPFC also reflects on your future. Your vmPFC might ask questions like these about the future:

- Where do I see myself in 5 years, 10 years, 20 years?
- Who will I be then?

- What will retirement look like for me?
- What kind of grandparent will I be?

(I imagine this region of the brain is spinning in dizzy circles through every recent Marvel movie about space–time continuums!)

So how does the work of the vmPFC translate to what is happening with our students' math identity? The vmPFC forms your sense of self in relation to math along the continuum of time. All of your past experiences with math, combined with your ability to see yourself in math spaces in the future, contribute to your math identity.

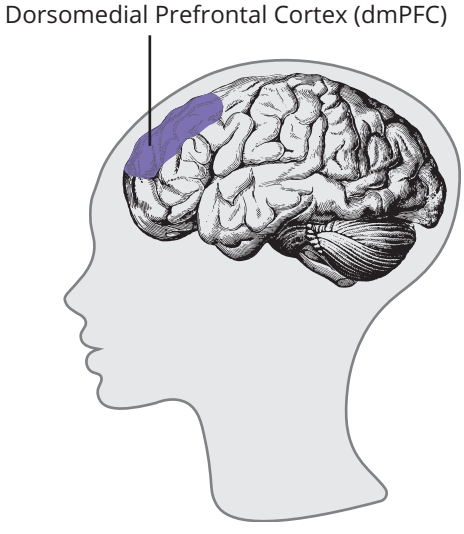
*Identity is bidirectional in relation to* time. *A student's* past experiences *with math combine with a* vision for their future *with math to create their math identity.*

## DISTINGUISHING SELF FROM OTHERS

Reflecting on time is one part of the equation. The other half—distinguishing self from others—lies in the other portion of the prefrontal cortex, above the vmPFC in the dmPFC.

**Figure 1.4**

### Dorsomedial Prefrontal Cortex (dmPFC)




The dmPFC distinguishes self from others (Lieberman et al., 2019) (Figure 1.4). If your dmPFC could talk, you might hear it reflecting on questions such as:

- How am I similar to you?
- How are we different?
- What makes you, you?
- And how is that unique from me?
- When I see you all, do I fit in that picture, or not?
- How are you all influencing how I see me?

Within the context of math identity, this portion of the brain compares how you see yourself (or not) with how others see you in math.

*Identities are formed within the context of social structures that have a tremendous influence on how we see ourselves.*

Identities are personal, so it is easy to see how many people assume it is the individual who is responsible for how their identity within math is formed. However, identities are formed within the context of social structures that have a tremendous influence on how we see ourselves. This is especially true with math identities because of the very clear, and loud, messages we receive from sociocultural influences about *what* math is and *who* math is for. These messages can come from our families, friends, media, and even us as teachers.

So now we've answered the question of who is responsible for how a student's math identity is formed. The short answer is all of us, not just the individual.

*Identity is bidirectional in relation to source. The sociocultural influences combine with our personal efficacy to create our math identity.*

## Four-Part Model of Math Identity

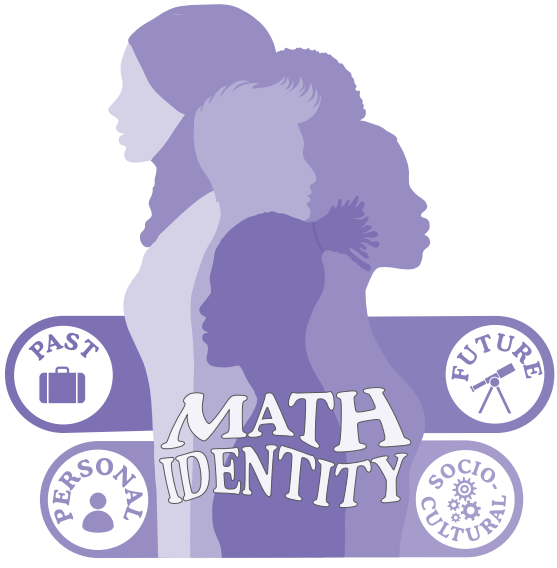
There are four parts to our model of math identity (Figure 1.5).

1. **Past**
2. **Future**
3. **Sociocultural**
4. **Personal**

You'll quickly see how this aligns with what we just talked about—how the brain forms our identity.

**Figure 1.5**

## The Four Variables That Form Your Math Identity




Math identities are formed through the intersection of students' past experiences, future vision of self with math, sociocultural influences, and personal efficacy.

### PAST

Students walk into your classroom with a lifetime of baggage from their previous experiences with math. Some of the experiences have helped them develop a positive relationship with math. Other experiences may have left them feeling fearful or hopeless around math.

So what do we do with a student's past in math? There are many reasons why a teacher might want to ignore students' past experiences with math:

- There's no time.
- We feel powerlessness to do anything about it.
- We are afraid to open Pandora's box of past math trauma.

Ignoring your students' past experiences with math doesn't make them go away, of course. And this certainly doesn't erase the impact those experiences have on your students' current ability to thrive in mathematical spaces.

To open pathways for students to learn at their best in our classrooms we have to clear the weeds that have been growing for years. Invite students into an open and continuous dialogue with you about their past experiences with math. Whatever has happened in their past with math, your role is to honor those experiences as real and meaningful to them. From that foundation of acknowledgment and empathy, you can help students unpack the impact those experiences have had on their relationship with math. From there, you can begin the healing process. I'll show you how to do all of that.

## LEARNING IN ACTION

### Three Ways to Learn About Students' Past in Less Than 30 Seconds

At the bottom of an assignment or quiz, invite students to write one of the following:

1. What they liked about how their favorite teacher taught math—no names needed, just a quick insight into a strategy or mindset that worked for them
2. One thing about their history with math that will help you be a better teacher for them
3. About their favorite topic in math—what it is and why they enjoy it

### FUTURE

Students must be able to look to their future and see themselves in math spaces. This doesn't mean every student has to pursue a math-centered field. It means that when they look forward, there

are no locked doors for them based on who they are. It means that all students can see themselves (or folks like themselves) thriving in math spaces.

This ultimately comes down to developing a sense of belonging in math spaces, guided by visible representation. When your students look at people working in industries they're interested in, do they see people who would prompt them to say, "Hey, they're like me!"? If they can't see them, it is difficult for them to see themselves there, too!

Remember, the vmPFC positions our identity in relation to time. It processes our past experiences with math along with any visions we hold for our future with math.

You might be thinking, "How can I shift how students see their future? That sounds like some wild magic!" In Chapter 4, I'll share several strategies you can implement right away to help students see a future where they can see themselves wherever they want to be.

# LEARNING IN ACTION

## Guest Speakers That "Speak" to Your Students

Invite professionals of diverse cultures and backgrounds to visit with your class to talk about how they use math in their work. Aim for representatives from professions of high interest to your students who are struggling to form a positive math identity—musicians, gamers, social media influencers, athletes, and so on. Even a 15-minute virtual visit can be a life-changing experience for a student.

### SOCIOCULTURAL

There are sociocultural forces whispering (or shouting) messages about *who* is good at math and *what* it means to be good at math. Everywhere we look there are movies and commercials giving math a bad name or reinforcing stereotypes of who is good at math. And it's not limited to the media. Some of these messages we picked up from our family of origin and even within our classrooms.

Taking on this "system" can feel daunting or even impossible. Luckily, as educators, we can help students pull pack the curtain behind these messages and sling some tiny stones at this Goliath.

It begins by guiding students to label the intended message from these sociocultural forces—what are they trying to convey to you? Perhaps a well-meaning parent is hoping to protect their child from feeling poorly about their math skills by saying, "Oh, I wasn't good at math either!" Or maybe an advertisement is aiming to sell more by tapping into people's fear of math. From there, you can help them unpack that message to see who that message serves, before guiding them to a healthier message about what math is and who is good at math.

# LEARNING IN ACTION

## Math Media Message

Make a regular time in your classroom where students can share a "Math Media Message" they saw, heard, or experienced out in the world. It could be a clip from their favorite YouTuber making a positive math reference or an ad they saw on Instagram that paints math as being hard or boring. Lead this movement by collecting media messages that can be shared in 1–2 minutes.

*We can't expect students to "pull themselves up by the boot straps" in a society that sometimes seems determined to make boots that only fit a small subset of people.*

Before moving on to an overview of the fourth variable in math identity (personal efficacy), I want to stress how important it is to understand the significance of the first three variables: past experiences, future vision of self with math, and sociocultural influences. Ignoring these three variables that contribute to a learner's math identity is nothing short of victim blaming. This is a dangerous pattern we have seen play out many times in our society—from gender equality to racial justice. These topics, including math identity, are complex. We can't expect students to "pull themselves up by the boot straps" in a society that sometimes seems determined to make boots that only fit a small subset of people.

As educators we need to push back on the narrative that if students just had enough "grit" or a strong enough growth mindset then they would have a positive math identity.

## PERSONAL

The final variable in our equation focuses on students' personal efficacy with math. Self-efficacy is often defined as an individual's belief in their ability to master a particular task or skill (Bandura, 1989). It involves both confidence and competence. Later on, we'll delve deeper into how confidence and competence are independent, yet highly connected constructs.

But for now, let's acknowledge that it's normal to feel frustration or failure when engaging with math—or anything complex with which we are not familiar. That is part of the human experience. When frustration and failure become our dominant experiences, they impact our identity, and we need tools to navigate our way out of them.

Students need strategies for the moments when they question their efficacy within math spaces. This is the essence of social emotional learning (SEL)—being able to recognize your current state of being (self-awareness) and having tools to manage or shift your state (self-management).

# LEARNING IN ACTION

### Simple Tools to Boost Efficacy

Encourage students to listen to their body and brain. If they are feeling frustrated, anxious, or ruminating on negative self-talk, teach them tools to take back control of their body and brain:

- Take a deep breath.
- Say "yes, I can!" while tapping your foot three times on the ground.
- Step away from the math problem and take a walk around the room.

Mathematically speaking, it is the sum of these four factors (past experiences, future vision of self in math, sociocultural influences, and personal efficacy) that form how we see ourselves in math spaces. They are the main variables that form our math identity.


## Why Does Math Identity Matter?

Does a student's math identity make a difference in their ability to learn? And if so, how much?

These are important questions to ask and to answer. Teachers should be critical of how they invest their time and efforts with students. If a particular strategy, construct, or principle of learning doesn't show a meaningful impact on student learning, then a teacher's time and effort may be better invested on a different intervention. Teachers that embrace every idea that seems to be a "good idea" are setting themselves on the fast track toward burnout. So as we embark on this learning adventure together to explore how math identities are formed, and how teachers can influence them, let's be sure that pursuing math identity is worth our time.

Think about this:

- Does it matter to a student's learning if a student believes any of the following:
  - *I am not a math person!*
  - *Math just isn't my thing.*
  - *I hate math.*

In other words, can a student have a poor math identity and learn math in deep and meaningful ways just as well as another student with a positive math identity?

*Note: I didn't say, "Can a student have a poor relationship with math and still do well in math class?" That is a completely different question. That is very possible. Many students have found ways to play the game of school, through a variety of strategies—mimicry, meaningless memorization, cheating—to help them achieve their

goals of grades, status, and so on. I was one of those students. But we are talking about meaningful math learning, not just getting a good grade in a math class.

Here's a sample of what researchers have to say in answer to the question of does math identity impact student performance. Note that the term *self-concept* is often used in the research field to describe what we describe as math identity.

- Math identity in Grade 11 predicted math achievement in Grade 12 (Bohrnstedt et al., 2020).
- As student self-efficacy increases, so do student grades (Simpkins et al., 2006).
- There is a strong correlation between seventh-grade students' self-concept of their ability to do mathematics and their achievement (Bachman, 1970).
- Student self-concept is a strong predictor of achievement for a diverse population of tenth-grade students (Else-Quest et al., 2013).
- The lower the self-concept, the less math problems students answered correctly (Gresky et al., 2005).

There is some discussion in the research arena around who's the chicken and who's the egg in the relationship between math identity and student achievement. There seems to be evidence for both. Having a positive math identity leads to better student achievement in mathematics. Conversely, there is evidence to suggest student achievement in math leads to a better math identity. Both seem plausible to a classroom teacher who can see the interconnected and spiraling nature of these two forces. The takeaway for teachers is that a student's math identity plays a significant role in student learning and achievement and is worthy of our attention.

It is important to note that math achievement and performance—what many of us teachers would call grades—is not the only outcome worthy of our attention. There are many other outcomes that result from a positive math identity that are perhaps of greater importance: pursuit of math-related fields of study, interest and pursuit of STEM careers, decreased math anxiety, and more. We will discuss many of

these further as we explore the relationship between math identity and the four variables that contribute to its formation.

When we look at the four major factors that contribute to a learner's math identity we can clearly see the significant role math identity plays in the learning process:

- A student's **past experience** with math has a direct impact on the brain's ability to learn math.
- A student's **future sense of belonging and representation** has a direct impact on the brain's ability to learn math.
- **Sociocultural influences** (parental views, teacher bias, societal messaging, etc.) have a direct impact on the brain's ability to learn math.
- A student's **personal efficacy** (confidence and competence) within math has a direct impact on the brain's ability to learn math.

From this foundational understanding of where math identities are formed in the brain, and the impact math identities have on student achievement, we can turn our focus to intentional interventions to support the healthy development (or healing) of our math identity.

One of the first steps in helping students build a positive math identity is to understand how they currently see themselves in relation to math.

In an ideal world, you'd have hours to spend with each student to build a level of trust needed for them to share countless stories of their experiences with math. You'd listen to their dreams of their future and how those are influenced by how they see themselves with math. One by one, they'd tell you about what their family says about math, what they see in the media, and how their former teachers' practices led them to where they are today. They'd map out their levels of confidence with math and how it relates to their competence. If only you had the time!

But let's be realistic: You probably *don't* have that time. Instead, what follows is a simple art activity that can help you see how your students see themselves in relation to math using an exercise that takes less than 10 minutes. You'll likely be astonished by how much you can learn from this one activity.

# ACTIVITY

## A Trip to Mathland

Consider our definition of math identity: how we see ourselves in relation to math.

Now let's find out how your students see themselves in relation to math. Literally.

If there was a place called Mathland, and they were in that place, what would that look like to them? Art therapy is a commonly used tool to reveal underlying emotions relating to an experience (Moula, 2020), and this is at the heart of this exercise.

Putting their relationship with math into words can be challenging for many students. This is especially true for younger students and those who haven't been encouraged to reflect and vocalize their relationships with ideas. That is why Mathland can be such a powerful vehicle for many students to convey how they see themselves in relation to math.

Inviting students to draw their conception of Mathland has value for both the student and the teacher. The student is given time and space to reflect on how they see themselves in relation to math and capture that visually. This helps them clarify and validate their emotional experience with math.

The teacher is able to get a glimpse into how the student sees themselves in relation to math. This picture can accelerate a teacher's understanding of a student's current perception of math and how they exist within math spaces. It is not meant to be an all-defining image of their math identity but rather a snapshot and starting point for further exploration and conversation.

Here's how I introduce the activity to students:

### Set Up

*Imagine a world that is ruled by math. We'll call it Mathland. It might be a new planet, an undiscovered island, or some hidden civilization. It can look like whatever you want. When you picture that place, what images come to mind? Are there living creatures there? What are they doing? What are you doing there? What does the landscape look like? What is happening there?*

*Some of you might create a nature scene. Others might create a picture of a city or classroom. Some artwork might look more realistic. Others might be very abstract. All types of art are valued here.*

*The only thing everyone's artwork will have in common is the title (or at least one word of the title). Today, you're going to draw what comes to mind when you envision a place called Mathland—a land ruled by math.*

**Activity**
A Trip to Mathland

*Based on what you think about math, and how you feel about math, what would this place look like? There doesn't even have to be anything "mathy" in your picture. Just a representation of how you think and feel a place consumed by math would be like.*

*This is your chance to express, through a picture, how you see yourself in math.*

## Discussion

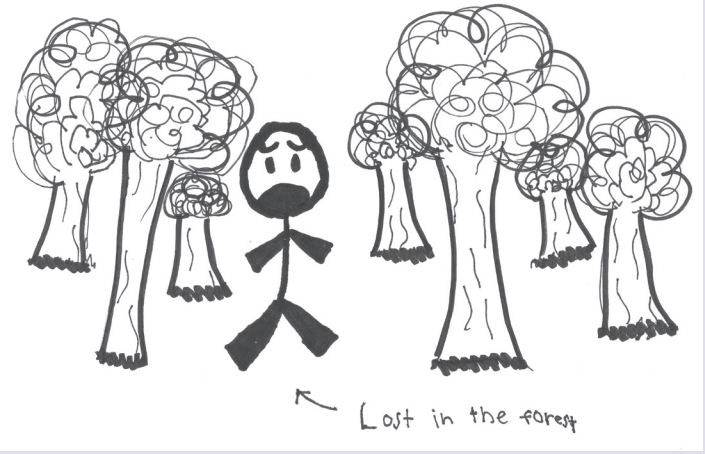
It is astonishing how much students can convey through a simple drawing. Let's take a look at a few. As we do so, think about the following:

- What stands out to you?
- What questions might you want to ask the students who drew these pictures?
- How do you think their belief, as demonstrated about themselves and Mathland, impacts their ability to learn and do math?
- Be on the lookout for elements of their art that depict certain emotional states: joy, confidence, anxiety, or despair.

In Figure 1.6, a middle school student drew themselves "lost in the forest" of Mathland. The expression on their face captures their despair, sadness, and loneliness in Mathland.

**Figure 1.6**

### Lost in the Forest



Luckily, not all students see themselves alone, lost in Mathland. For the sixth grader who drew the picture in Figure 1.7, Mathland seems to be a beautiful place with flowers, hearts, and sunshine. My interpretation of their art also leads me to believe they see Mathland as ruled by order and symmetry. The use of multiple exclamation marks gives the sense that math is exciting for this student.

**Figure 1.7**

## Ruled by Order and Symmetry


The depiction in Figure 1.8 of Mathland gives interesting insights into what might be missing for this student. Their interpretation of Mathland, from a distance, doesn't seem too daunting. There's some grass, a lovely fruit-bearing tree, and a flock of birds soaring through the sky. Even the pool (bowl of water?) appears welcoming . . . from a distance.

On closer look you can see the pool is filled with numbers—lots of numbers. The caption up top gives greater meaning to the picture: "How I see math is just a bunch of numbers squished together. #confusing …"

The way I interpret this picture of Mathland is that the student struggles to make meaning, or sense, of the numbers they work with in math. There are so many numbers all floating around in this soup of math they they've lost any sensemaking they once had with math.

**Figure 1.8**

## A Bunch of Numbers Squished Together


The Mathland image shown in Figure 1.9 breaks my heart.

**Figure 1.9**

## Sentence: School for 50 Million Years


**Activity**
A Trip to Mathland

There are so many features of this picture we could point out and discuss. Here are a few that really stood out to me, communicating how this student feels about math. You might notice the large figure on the left sentencing the student to "s.c.h.o.o.l. for 50 million years until he learns his lesson!" What is the crime committed, you might wonder? The figure in the middle gives us the answer. "Commander—we have found a kid not studying." The child's plea, "Pls spare me" isn't enough for them not to be dragged by a robot to this stormy torture-esque facility called school as they cry out to their parents, "Help me!"

It is a vivid drawing that paints an even more vivid picture of how this student sees themselves in relation to math. One might interpret this depiction of Mathland to mean this student sees math as a form of torture. Moreover, math is only something that exists inside schools—there is no math out in the real world. Additionally, this student seems to believe math is something that exists in isolation—in the absence of family and friends.

Again, ask yourself this question: If this is how a student views Mathland, how will that perception impact how they show up and learn math?

I invite you to consider having your students draw their depiction of Mathland. Give them time and space to reflect on how they see themselves in a world ruled by math. These pictures will likely not go on the wall because they are so personal. But they could be the launch pad for further conversation during a one-on-one conference. You might invite older students to write a few sentences about their artwork and the meaning behind their representation of Mathland. As you listen (and look) to what students share, you'll have a clearer understanding of how they see themselves in relation to math, giving a clearer understanding of their math identity.

Trusted with those insights, you'll be ready to repair, reinforce, or rewire elements of their math identity to allow for greater math learning in your classroom and beyond.

**Activity**
A Trip to Mathland

## WHERE WE'VE BEEN; WHERE WE'RE GOING

In this chapter, we've learned a lot about the prefrontal cortex of the brain and its role in identity formation. The prefrontal cortex has a very unique relationship with another region of the brain—the amygdala. Some might call it a toxic relationship. Understanding the tension in their relationship is key to recognizing the importance of a positive math identity. We'll turn to the relationship between emotions and cognition in the next chapter.

## Reflection Questions

1. Can you think of examples of how our math identity is influenced by the four variables introduced in this chapter (past experiences, future vision of self with math, sociocultural influences, and personal efficacy)?
2. Can you identify any other variables influencing how your students see themselves in math spaces?
3. What would *your* picture of Mathland look like if you drew it when you were the age of the learners you work with now? How does your vision of Mathland look now?
4. How might you modify the Mathland activity to work best for the learners you work with?

## NOTES

## Action Steps

I vividly remember my experiences of attending conferences or reading education books early in my teaching career. I would come back to my classroom so fired up, eager to implement *everything* in my classroom the next day. (Sound familiar?) My students knew this about me, too. I'd be gone for a day or two at a conference, and when I came back, those teenagers would jokingly groan, "What new thing are we going to do now?"

I could see the expression on their face anytime I started a sentence with, "So, I've been reading this book . . . " Their faces usually showed a combination of curiosity and a bit of hesitation. I'd roll into a couple-minute rant about something new I learned—to share my excitement and hopefully get some buy-in to try something new. And then I'd try something new.

Sometimes it would be a huge success.

Sometimes it was an epic failure.

Sometimes the new idea had a short lifespan.

Sometimes it would lead to an entirely new teaching habit that would last until this day.

My learning curve was steep and often a wild and bumpy ride. I'm grateful to my students (and the relationship we established) for joining me on that early roller-coaster ride.

In my defense, I love learning. And I love getting better at implementing both the science and art of teaching. I wanted to be the best teacher I could be. And, since you are reading this book, I assume you want the same, too.

Over the years I have learned to pace myself. I've also learned more about the science of change—how to effectively implement new ideas and establish new habits. As we begin this learning journey together, I want to share a few insights into how you can best implement all you will learn in this book. SPOILER: It's not trying to do it all tomorrow!

At the end of every chapter, you will find a page titled Action Steps. It will act as your companion guide to implementing the strategies and principles outlined in that chapter. The page will be organized into three sections: Simple Steps, Bigger Leaps, and Lasting Change.

### Simple Steps

One of the biggest deterrents to behavioral change is feeling overwhelmed by the task at hand. The thought of cutting our sugar

consumption, or reading a whole book, or learning a new language—it all feels so daunting, so we just never start. You may have moments of similar feelings when reading this book.

There is wisdom in all the adages about eating an elephant one bite at a time or climbing a mountain one step at a time. The same holds true for our relationship with math—math identities are created, healed, and reinforced one step at a time.

The key to getting off the couch and doing your first workout is the same key to engaging in this work: Start with simple steps. Instead of committing to a 5-mile run on your first workout in over a decade, make a plan to walk around the block for the first week. "But that's not gonna do much for my health!" some might say. Well, it's better than sitting on the couch! And now you've got a routine to build on. The following week you can jog around the block and then add another block.

In the Simple Steps section, I will outline a few key ways to "get off the couch." The goal is to do *something*. Doing something simple is more powerful than most people realize. Every success, big or small, counts as a win for the brain. Dopamine—the neurotransmitter most associated with motivation—is released and gives us the boost of motivation needed to keep going. (You'll be learning more about the power of dopamine in Chapter 6.)

The Simple Steps may seem small in effort or time, but they will lay the groundwork for fundamental change in your approach to teaching math with the brain (and heart) in mind. You will be invited to notice, wonder, and think. As you engage in these Simple Steps, you will notice a shift in your mindset about your students, math, and their abilities. Your awareness of emotions and cognition will broaden. These Simple Steps will fuel your desire to take some Bigger Leaps.

## Bigger Leaps

With a bit of motivational dopamine surging through your brain, you'll be ready to lace up your teaching shoes and take a bigger leap.

Oftentimes when people want to make a change, they will try something new, quickly realize that activity is not for them, and stop trying. For example, someone wanting to increase their physical activity may buy a new pair of running shoes, hit the pavement, only to remember how much they hate running. To them, it is boring, lonely, and unenjoyable. Instead of going back to the couch, we'd hope this person would pause and reflect on what kind of exercise is right for them. Maybe a group dance class is a better fit or a stationary bike

positioned in front of their TV. What kind of exercise you do is less important than getting some exercise.

The same is true for the work we do in our classrooms.

Each teacher is unique.

Each student is unique.

Each grade level is unique.

So, there is no "one right way" to teach.

This is why I am wary of any pedagogical approach that advertises a prescriptive, or algorithmic, methodology to teaching.

There are evidence-based *principles* of effective teaching and learning. And there are specific *strategies* we can use in our classroom. Understanding the difference between *principles* and *strategies* is the key to teacher autonomy and student-centered instruction.

Throughout this book I will be unpacking various *principles* of teaching and learning related to math identity. Those are scientific truths, based on the latest research available. An example of a *principle* is students in a motivated state give more effort and learn better. There is robust evidence to validate that principle. I hope we can agree that motivation is a key principle to effective teaching and learning. The question that follows is, How do we increase student motivation? In other words, what specific *strategies* do we use to support student motivation?

Let me start by saying, not all strategies are created equal. Some are harmful. In the case of motivation, the use of bribes, rewards, or threats can be argued as "effective" but often come with harmful side effects. Some strategies work better for different age groups, personalities, and cultures. Consider the classic line-leader in the youngest grades. Those little five-year-olds will claw their way to the front of that line. Teenagers could care less. Having a line-leader is an age-dependent strategy.

Even still, some strategies can feel really awkward or unnatural from the teacher's perspective. Not every teacher feels themselves teaching the ratios of special right triangles while standing on a desk like Robin Williams in *Dead Poets Society* or rapping the quadratic formula. That's OK. Let me say that again—That's OK! Our job is to find the strategies that work for us *and* our students, that provide teacher autonomy and are student-centered. If celebrating your class's learning with a 60-second line dance doesn't feel right to you, or prompts massive eye-rolls from your students . . . that's fine. But, and here is the big *but*, that doesn't excuse us from finding another strategy that aligns with the principle of emotionally punctuating (aka, celebrating) our efforts toward learning.

Throughout this book you'll see the "Learning in Action" sections. They offer a few specific strategies that align with the principles discussed previously. They are not meant to be the "must do" strategies. Instead, they are intended to help you generate ideas that may work for you and your students.

The same principle holds true for the Bigger Leap section at the end of each chapter.

In the Bigger Leap section at the end of each chapter, you may see an invitation to try something for a week and see how it goes. You'll be invited to reflect on that experiment, and maybe even ask your students for their feedback as well. You will see an invitation to carve out 15 minutes per month to do a math identity-focused activity. The purpose of these Bigger Leaps is for you to take a bigger step in your teaching, to broaden your efforts to include an awareness of your students' emotional relationship with math. It may feel like a bit of an experiment—be prepared for a few bumps in the road as you find the strategies that work for you. Adjust, modify, try again as you stay focused on the overarching principle you are aiming to implement.

## Lasting Change

Our ultimate goal is for these new ideas and practices to become natural parts of our teaching practice; in other words, for them to become habits. Habits are behaviors we do automatically, usually in response to a cue. After you brush your teeth, you habitually reach for the floss. As you sip your morning beverage of choice, you reach for your phone and go through a habitual sequence of app checking. When the bell rings for class to start, you likely jump into a sequence of habitual routines with your students. Some research indicates up to 40 percent of our daily behaviors are habits (Wood et al., 2007). Thus, how effective we are as educators is highly related to our habits.

Do you ever feel like your brain is overwhelmed by too many decisions to make every day as an educator? That sense of cognitive load (aka, an overwhelmed working memory system in your brain) can be reduced by establishing habits (Haith & Krakauer, 2018). Establishing habits in our teaching practice is a useful endeavor, for several reasons. Healthy habits can improve our efficiency by automating a desired behavior. This frees up more mental space to focus on all the other important things happening around you.

Habits can also help us compound the benefits of repeatedly doing good things. Yes, going for one post-dinner walk is great for your health. Making it a daily habit will compound those benefits and potentially

alter your genetics to pass those benefits on to your children (Fernandes et al., 2017). Introducing students to one mathematician that reflects their culture is great. Making it a regular habit of highlighting diverse mathematicians can fundamentally shift their view of who is good at math.

How exactly does the brain form a habit? How does it know what to do, and when? And how can we use this knowledge to develop better habits in our classrooms for better efficiency, more repetition of good choices, and compounding those benefits?

There is a small area of the basal ganglia called the stratium that plays a significant role in a behavior transitioning from a deliberate goal-oriented choice to an automated habit. Let's take emptying the dishwasher as an example. When you first get a new dishwasher, you make a deliberate choice as to what order you will empty the dishes—top rack first, then bottom rack, and finish with the silverware. The neurons in your stratium have stable activity as you learn this new behavior.

Through repetition, however, it becomes a habit and you empty the dishwasher in the same order every time without thought. Your brain activity looks different then. Certain neurons in your stratium fire at rapid speeds at both the beginning and the end of a habit "chunk." It senses you are flipping a switch on a sequence called empty the dishwasher. Certain stratium neurons get overly excited (literally) as you initiate a habit sequence. Those neurons then essentially go quiet until the peak happens again at the end of the habit sequence, marking the completion of the habit (Martiros et al., 2018).

Having a basic understanding of the neurobiology of habit formation is important because it teaches us the need for a cue in developing a habit. Without a cue, you are likely to forget about the new behavior you wish to habituate and stick with your usual routines. From a brain perspective, the cue plays a vital role in triggering the brain that it's time for _____ (insert new habit). A cue can be an alarm on your phone, screen saver image, Post-it note, or any physical object that cues you to engage in your habit.

The cue gets you started, but you need something else to ensure you keep at it—dopamine, the reward transmitter. The key to new habit formation is for the reward to be *so* desirable that you'll be begging to do the behavior that will get you that reward. For some, the satisfaction of an empty dishwasher is enough to get them running to the dishwasher the moment the wash cycle ends. The dopamine released at the sight of an empty dishwasher is enough to trigger you into action.

What if you get no satisfaction from an empty dishwasher? Well, that might explain the stack of dirty dishes on your counter! For you, a

different, more desirable reward is needed to keep you out of the dog house. Maybe you decide you get to watch an episode of your favorite show *after* the dishwasher is empty.

The formula to successful habit formation is simple: Cue—Action—Reward.

The key is to neurologically connect the cue to the reward. The brain craves the reward and will thus be driven back to the action that gave the reward.

At the end of each chapter, I will suggest a few new habits you could build into your teaching practices. It's up to you to know what cue will work for you and what reward will keep you coming back for more. Start with *lots* of rewards for a week or two, then adjust your system to feed you intermittent rewards. Once you have habituated the new behavior, you will notice you no longer need the reward. Congratulations! You can then embark on establishing your next new habit.

## A Final Thought About Habits

There are three common ways to design a new habit, with varying levels of motivational drive attached to them:

- Some habits are outcome-driven (i.e., I want to lose 10 lbs.).
- Some habits are process-driven (I will go to the gym 5 days a week).
- Some habits are identity-driven (I am a healthy person).

When an action feels in alignment with your identity, even a difficult task feels more meaningful and important (Oyserman & Destin, 2010). Therefore, identity-driven habits carry more motivation weight because they carry more personal relevance.

Tapping into greater levels of personal relevance connects to one of your core biological drivers: your identity. Notice the difference in these three related goals:

- I *am* a present parent (identity-driven).
- I *put* my phone in another room during family time (process-driven).
- I *want* stronger relationships with my kids (outcome-driven).

The key takeaway is this: Design goals and habits that match the identity you hope to create.

Repeat after me: I *am* a teacher who values my students' emotional relationship with math.

Let's get started!