

The Power of Mistakes and Struggle

I started teaching workshops on how to teach mathematics for a growth mindset with my graduate students from Stanford (Sarah Kate Selling, Kathy Sun, and Holly Pope) after principals of schools in California told me that their teachers had read Dweck's books and were "totally on board" with the ideas but didn't know what it meant for their mathematics teaching. The first workshop took place on Stanford's campus, in the light and airy Li Ka Shing center. For me, one of the highlights of that first workshop was when Carol Dweck met with the teachers and said something that amazed them: "Every time a student makes a mistake in math, they grow a synapse." There was an audible gasp in the room as teachers realized the significance of this statement. One reason it is so significant is that it speaks to the huge power and value of mistakes, although students everywhere think that when they make a mistake it means that they are not a "math person" or worse, that they are not smart. Many good teachers have told students for years that mistakes are useful and they show that we are learning, but the new evidence on the brain and mistakes says something much more significant.

Psychologist Jason Moser studied the neural mechanisms that operate in people's brains when they make mistakes (Moser et al., 2011). Jason and his group found something fascinating. When we make a mistake, the brain has two potential responses. The first, called an ERN response, is increased electrical activity when the brain experiences conflict between a correct response and an error. Interestingly, this brain activity occurs whether or not the person making the response knows they have made an error. The second response, called a Pe, is a brain signal reflecting conscious attention to mistakes. This happens when there is awareness that an error has been made and conscious attention is paid to the error.

When I have told teachers that mistakes cause your brain to spark and grow, they have said, "Surely this happens only if students correct their mistake and go on to solve the problem." But this is not the case. In fact, Moser's study shows us that we don't even have to be aware we have made a mistake for brain sparks to occur. When teachers ask me how this can be possible, I tell them that the best thinking we have on this now is that the brain sparks and grows when we make a mistake, even if we

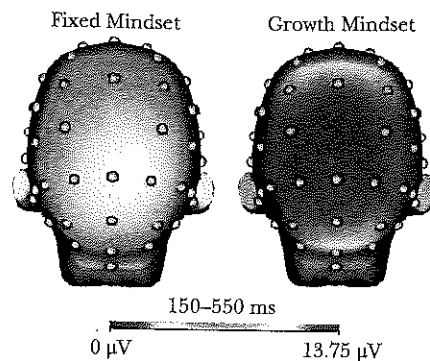


FIGURE 2.1 Brain activity in individuals with a fixed and a growth mindset
Source: Moser et al., 2011.

are not aware of it, because it is a time of struggle; the brain is challenged, and this is the time when the brain grows the most.

In Moser and his colleagues' study, the scientists looked at people's mindsets and compared mindsets with their ERN and Pe responses when they made mistakes on questions. Moser's study produced two important results. First, the researchers found that the students' brains reacted with greater ERN and Pe responses—electrical activity—when they made mistakes than when their answers were correct. Second, they found that the brain activity was greater following mistakes for individuals with a growth mindset than for individuals with a fixed mindset. Figure 2.1 represents brain activity in individuals with a fixed or growth mindset, with the growth mindset brains lighting up to a much greater extent when mistakes were made.

The fact that our brains react with increased activity when we make a mistake is hugely important. I will return to this finding in a moment.

The study also found that individuals with a growth mindset had a greater awareness of errors than individuals with a fixed mindset, so they were more likely to go back and correct errors. This study supported other studies (Mangels, Butterfield, Lamb, Good, & Dweck, 2006) showing that students with a growth mindset show enhanced brain reaction and attention to mistakes. All students responded with a brain spark—a synapse—when they made mistakes, but having a growth mindset meant that the brain was more likely to spark again, showing awareness that a mistake had been made. Whether it is mathematics, teaching, parenting, or other areas of your life, it is really important to believe in yourself, to believe that you can do anything. Those beliefs can change everything.

The recent neurological research on the brain and mistakes is hugely important for us as math teachers and parents, as it tells us that making a mistake is a very good thing. When we make mistakes, our brains spark and grow. Mistakes are not only opportunities for learning, as students consider the mistakes, but also times when our brains grow, even if we don't know we have made a mistake. The power of mistakes is critical information, as children and adults everywhere often feel terrible when they make a mistake in math. They think it means they are not a math person, because they have been brought up in a performance culture (see Boaler, 2014b) in which mis-

classrooms are designed to give students work that they will get correct. Later in the book I will show the sorts of math questions that engage students and enable their brains to grow, along with the teaching and parent messages that need to accompany them.

Countries that top the world in math achievement, such as China, deal with mistakes very differently. I recently watched a math lesson in a second-grade classroom in Shanghai, the area of China where students score at the highest levels in the country and the world. The teacher gave the students deep conceptual problems to work on and then called on them for their answers. As the students happily shared their work, the interpreter leaned over and told me that the teacher was choosing students who had made mistakes. The students were proud to share their mistakes, as mistakes were valued by the teacher. In Chapter Nine I share a short and very interesting extract from one of the lessons in China.

The various research studies on mistakes and the brain not only show us the value of mistakes for everyone; they also show us that students with a growth mindset have greater brain activity related to error recognition than those with a fixed mindset. This is yet another reason why a growth mindset is so important to students as they learn mathematics as well as other subjects.

Moser's study, showing that individuals with a growth mindset have more brain activity when they make a mistake than those with a fixed mindset, tells us something else very important. It tells us that the ideas we hold about ourselves—in particular, whether we believe in ourselves or not—change the workings of our brains. If we believe that we can learn, and that mistakes are valuable, our brains grow to a greater extent when we make a mistake. This result is highly significant, telling us again how important it is that all students believe in themselves—and how important it is for all of us to believe in ourselves, particularly when we approach something challenging.

Mistakes in Life

Studies of successful and unsuccessful business people show something surprising: what separates the more successful people from the less successful people is not the number of their successes but the number of mistakes they make, with the more successful people making *more* mistakes. Starbucks is one of the world's most successful companies, and Howard Schultz, its founder, one of the most successful entrepreneurs of our time. When Schultz started what would later become Starbucks, he modeled the stores on Italian coffee shops. The United States did not have many coffee shops at the time, and Schultz had admired the coffee shops of Italy. He set up the early stores with servers wearing bow ties, which they found uncomfortable, and opera music played loudly as customers drank their coffee. The approach was not well received by American customers, and the team went back to the drawing board, making many more mistakes before eventually producing the Starbucks brand.

Peter Sims, a writer for the *New York Times*, has written widely about the importance of mistakes for creative, entrepreneurial thinking (Sims, 2011). He points out: "Imperfection is a part of any creative process and of life, yet for some reason we live in a culture that has a paralyzing fear of failure, which prevents action and hardens a rigid perfectionism. It's the single most disempow-