Teaching Mathematics for a Growth Mindset Part 1: Recent Findings on Student Ability

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Introduction

In 2006, a trade book appeared on bookshelves that would ultimately have one of the biggest impacts on education of any research volume ever published. In Mindset: The New Psychology of Success (2006a), Carol Dweck summarized key findings from her research on the nature and impact of different mindsets. The book quickly became a New York Times bestseller, and was translated into more than 20 languages. In it, Dweck summarized her research evidence (from decades of research with different age subjects) showing that when students develop what she has called a "growth mindset," then they believe that intelligence and "smartness" can be learned and that the brain can grow from exercise. The implications of this mindset are profound, especially for students of mathematics. While Dweck's work on mindsets has become a high priority for many schools, I have found that teachers don't know what it means for their mathematics teaching. Some teachers believe that students will develop a growth mindset if they give students the right messages about their potential, but it means a lot more than that.

The Science of the Brain: New Evidence

In mathematics education we have to deal with a very damaging myth that: Mathematics is a gift—some people are naturally good at mathematics and some are not.

This is one of the most damaging ideas in education (Boaler, 2009). It is also a message that is believed strongly in the Western world, but virtually absent in the Eastern countries that are highly successful and top the world in mathematics achievement. It is not surprising that students, teachers, and parents develop the idea that only some people can be good at mathematics; it is a message that is communicated regularly through media and television. My own daughters' Disney TV shows communicate the message that only some people can be good at mathematics at a surprisingly frequent rate to their vulnerable young viewers.

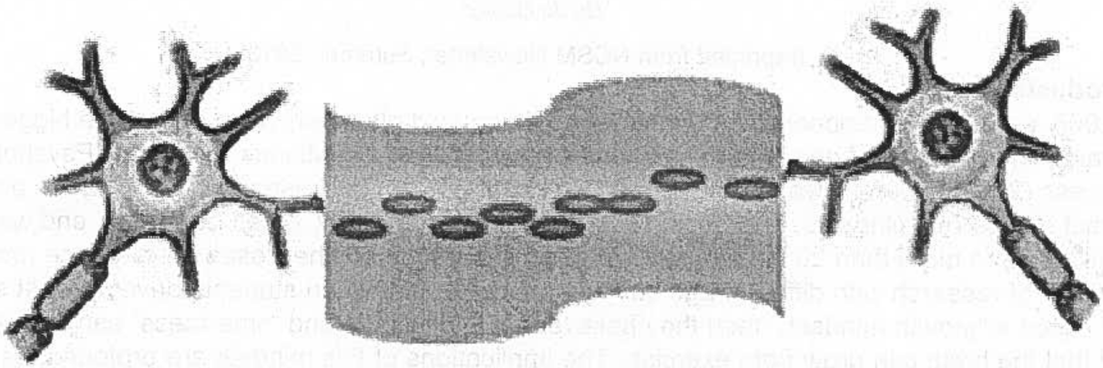
So what is wrong with the idea that you need a certain, fixed ability to do well at mathematics and why is it so enduring? We probably all know of students who come into mathematics classes able to work quickly and more able to grasp ideas than others—is that because they have a gift? For a long time scientists thought the answer to that question was "yes," but in recent years the findings from neuroscience have blown that idea apart. We now know that all students are capable of learning high-level mathematics—and the reason for that is the incredible capacity of the brain to grow in response to experience, and to do so in a short period of time.

Brain Plasticity

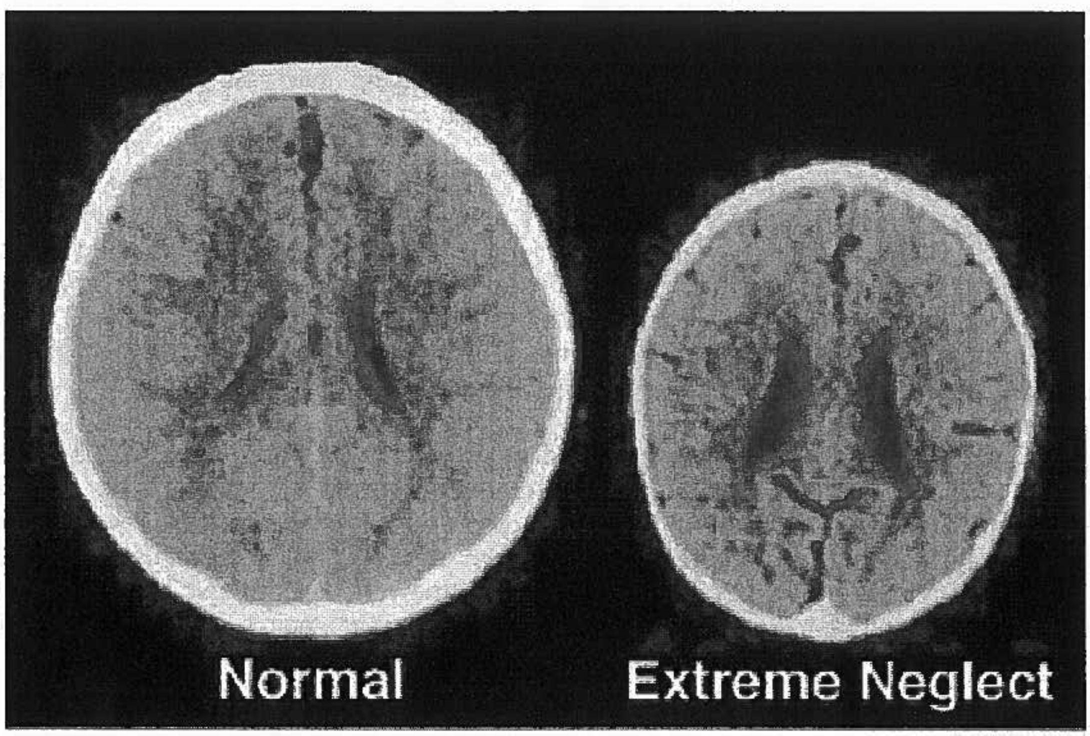
The brain isn't actually made of plastic but "neuroplasticity" refers to the life-long capacity of the brain to change and rewire itself in response to learning and experience. In recent years there have been stunning examples of the brain's ability to create new neurons and connections. When learning happens a synapse fires—an electric current makes new neurons and connections between neurons.

The paths of synapses are like footprints in the sand; they can become firm paths that are substantial and result in concrete learning gains, or they can wash away if they are not followed and made deeper. Synapse production is the way the brain grows. One of the most important mes-

Jo Boaler is invited to keynote the Network Connections on February 13, 2014. See page 55 for her bio and full agenda.



sages I have heard in recent years came from Carol Dweck who stated, every time a student makes a mistake in mathematics they form a new synapse. Mistakes and challenging work are critically important for students and part of teaching, for a growth mindset involves giving students complex work and valuing mistakes that are made. It may make students feel comfortable to keep getting correct answers, but it does nothing for their brain development.



An example of brain plasticity is shown [top, right] in the brains of two three-year-old children, one who was raised with parental love and one who was raised in a home of neglect (Hsu, 2012). These distressing photographs have demonstrated for scientists the huge impact of life experiences on brain growth. London cab drivers provide another example of brain plasticity. To qualify to drive a London "black cab" you have to learn the 25,000 streets and 20,000 landmarks and places of interest within a six-mile radius of Charing Cross in London. Black cab drivers have to pass a test that is simply called "The Knowledge." It takes between two and four years to pass the All-London Knowledge but once you have you have passed it you can drive a black cab anywhere in the greater London area. Researchers have compared the brains of London taxi drivers with London bus drivers who follow predetermined driving routes and found that the cab drivers have a larger hippocampus than bus drivers (Maguire, Woollett, & Spiers, 2006). The region of the hippocampus that is larger is the area that specializes in acquiring and using complex spatial information in order to navigate efficiently.

A third example of brain plasticity comes from a nine-year old girl who had half of her brain—an entire hemisphere— removed. After the operation the left side of her body was paralyzed, but she stunned scientists when she regained all of her functions in a very short space of time—because her brain adapted and remade the connections she had lost (Celizic, 2010).

Brain changes can happen quickly: In one study scientists found that students' brains adapted and grew in response to a four-week intervention (Karni et al., 1998). But these important results that are emerging from neuroscience stand in strong contrast to the messages that prevail in U.S. schools where many administrators and teachers believe that students don't have the "brain power" to work on high level mathematics. In one of the school districts where I work, the high school mathematics teachers argued and wrote in a letter that some students (mainly those who were students of color or from low-income homes) could never learn algebra, and that "brain theory" supported their views. These and other educators believe that some students do not have the brains to work on complex mathematics, but it is working on complex mathematics that enables brain connections to develop. Any student can grasp high-level ideas, but they will not develop the brain connections that allow them to do so if they are put into low-level classes and given low-level work.

Scientists now know that students can develop the wiring to learn any level of mathematics in school, but many teachers believe in natural, fixed, and limited ability levels, and schools in the U.S. are often set up on models of fixed ability thinking. Teachers refer to "high" and "low" ability students, "fast" and "slow" students, as though these are stable characteristics of the students even though such abilities can change in a matter of weeks.

One of the research avenues that has developed from the research on brain plasticity is that of mindset and Carol Dweck has shown the importance of students' beliefs about mindset for their learning trajectories over their lifetimes.

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