LEARNING TO LOVE MATH

Introduction

> Human history becomes more and more a race between education and catastrophe.
>
> —H. G. Wells

No other school subject pushes emotional buttons the way math does. It usually falls at the bottom of a list of subjects that people like or in which they feel interested or successful. Yet it's increasingly clear that building an education system that provides students with a strong foundation in math is important for both individuals and society.

From a broad perspective, today's world presents us with an increasing volume of information (from online sources, for example) that is not prefiltered for accuracy or evaluated for all potential uses. Under these circumstances, the ability to make sound personal, financial, political, ethical, and social decisions requires mathematical thinking, careful observations, and sound deductions. These skills, in turn, utilize information that the brain validates and interprets using developed reasoning skills.

More specifically, a well-educated workforce is needed to handle increasingly complex technology. It is obvious that the people who employ auto mechanics or plumbers aren't looking for candidates with limited math knowledge to work on their customers' expensive cars or water filtration systems, no matter what technical skills those candidates might have. As the future quickly becomes the present, it is becoming clear that almost all professions (with human employees) will require some degree of mathematical thinking. Quite simply, this is because unpredictable problems inevitably arise for which creative solutions are required. Machines and computers

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Reversing Math Negativity with an Attitude Makeover

> I let that negativity roll off me like water off a duck's back. If it's not positive, I didn't hear it. If you can overcome the negativity, everything becomes easier.
>
> —George Foreman

The first step to success in math is a positive attitude. Yet that's the last thing we can expect from many of our students.

Many students, like their parents before them, come to our classrooms with valid feelings that make them unhappy doing math. A 2005 AP-AOL News poll of 1,000 adults in the United States revealed that 37 percent recalled that they "hated" math in school. In the poll, more than twice as many people said they hated math as said they hated any other subject. (The poll was conducted by Ipsos, an international polling firm, and has a margin-of-sampling error of plus or minus 3 percentage points.)

One would think that once they were out of school, these folks would have found the real-world value of the math they disdained in school. In an evaluation of math literacy of a random sampling of adults in the United States, 71 percent could not calculate miles per gallon on a trip, and 58 percent were unable to calculate a 10 percent tip for a lunch bill. Yet only 15 percent of those polled said they wished that they had learned more about or studied more math in school (Phillips, 2007).

GRAY MATTER

Trial and Error

Much of what we do or say is based on the brain's interpretation of information stored in memory from prior experiences. Most of our decisions are predictions made on an unconscious level, guided by these memories. Memories of decisions are embedded with the pleasure or displeasure that resulted from previous predictions. As previous experiences build, so does the brain's stored network of data; as a result, our response to new input becomes more accurate.

Through curiosity, trial and error, and the dopamine-mediated pleasure from correct responses and the negative feelings from erroneous responses, our brains are better able to interpret the environment. The brain becomes more and more accurate in anticipating (predicting) what action (answer) is correct (will bring pleasure). These predictions send out signals to the parts of the brain that control our actions, words, or answers to questions. The older children get and the more experiences they have, the more their thinking, reflective prefrontal cortex can modulate the emotional (involuntary, reactive) response of the lower brain. Through trial and error, mistakes, and correct choices, the brain builds neural tracks to preserve and repeat the rewarding behavior. For students and others, this means that after making an incorrect prediction (answer), the next time the question comes up, prediction accuracy is better because the faulty information in the circuit has changed.

Research suggests that young children are usually comfortable making mistakes. In children younger than eight, the areas of the brain involved in cognitive control show strong activation following positive feedback, and stress-reactive regions are *not* activated by negative feedback (Crone, Donohue, Honomichl, Wendelken, & Bunge, 2006; Van Duijvenvoorde, Zanolie, Rombouts, Raijmakers, & Crone, 2008). If you are a teacher of younger students, you are the caretaker of their precious creative potential. Challenge builds skills, and without sufficient challenge, their math brains won't grow.

The most important learning activity in math, or any subject, is participation. This naturally leaves one open to making mistakes, but the brain learns by restructuring neural networks that make incorrect predictions. Playing this game lets students participate without the fear of making a mistake, which gradually builds confidence to participate, even if the response is wrong.

STRATEGY: Learn from Mistakes

One of the most effective ways to help reduce students' fear of making mistakes is to model the process of how *you* learn from your mistakes. You can then progress to demonstrating how students can learn from errors you purposely generate, and when students are prepared to reflect on, not react to, mistake negativity, they can be guided to learn from their own mistakes.

Strategies in this category aim to lower the emotional overreaction the brain has to mistake negativity; to help students discover the motivating memories of perseverance, including perseverance through mistakes; to build students' tolerance for mistakes; to reduce excessive anxiety-related errors; and to encourage students to strive for achievable challenge. These strategies, and your modeling, help students understand the value of mistakes.

Start a discussion with a statement or question such as, "Does a guitar player prefer playing songs with chords only after mastering dozens of chords?" Then promote discussion of personal memories of mistakes that led to success and gratification: "Can you describe a time when you kept trying even though you felt like giving up?" "How did you learn to play soccer so well?" "Do you still enjoy the beginner snowboarding runs now that you are advanced, or do they seem boring?"

This discussion will remind your students that once they built up their skills in playing sports, a musical instrument, or video games, it became boring to stay at the same level—*but they made mistakes as they took on challenges to advance.* Gradually, with effort and practice, they made fewer mistakes and enjoyed the pleasure of doing something with greater skill. When they make the connection to math challenges, students come to understand that mistakes are a natural part of new skill development in math just as they are in mastering a new video game or an athletic skill.