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Research Paper

Math Can Be Fun: Pedagogical Improvements in Math Education

Math is a tricky subject, one that is adored by some and abhorred by many. It is arguably the most challenging discipline to teach not only because students' skill sets are so diverse, but also because there seems to be a constant, heavy resistance and backlash from these students. It is evident that the general attitude towards mathematics needs improvement, for it is the foundation for essentially every discipline and career. While we cannot alter people's brain structures to make everyone mathematically "gifted," we can certainly improve our teachers and professors. By focusing on simplicity, clarification, emotion, and creativity, the teachers of our generation can aim to provide students with the most helpful and effective learning environments possible.

People tend to hate math. This is a seemingly radical statement to make, but a truth nonetheless. It is far more likely that a student will grumble rather than smile when a calculus exam is placed on their desk. In fact, the horrors of math classes follow these individuals into adulthood, leading them to still cringe upon a mention of the subject. To prove this to oneself, one can simply approach a random sample of people in, say, a grocery store, and watch the respondents' faces when asked about their feelings toward math. Though every discipline in school is detested by at least *someone*, there is an unbelievably large majority that has very strong negative connotations with mathematics. Ironically, math is *the* single most important discipline in academia (Adams, 2011). No student will conclude their schooling without several courses in mathematics, and it is fundamentally inescapable in the "real world" as well. Not only does every career involve math to some degree, but mere existence in society necessitates a basic knowledge of and competency with numbers. In fact, math is the *only* language shared by all human beings regardless of culture, religion, and gender (Annenberg Learner, 2011). It links us to our past, present, and future in a constantly applicable way that no other discipline can (Adams, 2011). Why, then, do *so many* people hate math? And how do we change this?

The former question must be examined before the latter can be addressed. Though individual differences exist, the vast dislike for mathematics can be boiled down to two general categories: internal and external influences. Internal causes refer to that which is specific to the particular person's perception and aptitude. In terms of cognition, genetics and brain chemistry allow for an initial natural ability to surface at a very young age when math is introduced (Math Forum, 2011). This unconscious ability then yields the child's trajectory of successes or failures, and it becomes evident who is "gifted" and who will struggle. Once a child begins to consciously guide their own behavior, other factors come into play. Confidence affects how a child perceives their abilities, care affects whether they are bothered by their outcomes, and vigor affects how hard they work to thrive. Motivation and dedication can improve the skills and grades of a less "math-smart" child, while a lack of both will only hurt them (Ewen, 2009). These attributes further guide an individual's abilities to succeed, and become increasingly influential as the child ages into adulthood. Ultimately, a student chooses how many more math classes they will take when they decide upon a major and, finally, a career.

An incompatibility with math is not necessarily a bad thing, however. Different sets of skills allow for the wonderful diversity in the world, which is universally valued by society. To think that everyone should be great at math is not only unreasonable, but the attempt to accomplish such an ideal would be a waste of time. It is when people follow their strengths and passions that society is happy, successful, and balanced. The goal, therefore, should not be to aim for universal brilliance, but to improve the attitudes and perceptions surrounding mathematics (Adams, 2011). This brings about a discussion of the external influences on such outlooks, the most powerful of which being the teacher.

When asking a person why they dislike math, the two most common responses are: “Because I am bad at it,” and “Because I had a horrible teacher.” Though it is not rare to hear this second reason concerning any given subject, the teacher excuse is used *far* too frequently with regard to math and thus cannot be ignored. Teachers play incredibly significant roles in our lives, for they have the ability to inspire us to grow, and to help us discover and follow our dreams. In this way they can also leave lasting negative effects that we carry for the rest of our lives (Garcia, 2011). It is difficult for a person to enjoy a class or subject if their teacher is mean, unfair, confusing, or boring. Soon we associate the negative attitudes and feelings we have towards the teacher with the material as well. Now, for the “how?” part of this discussion. There are many areas in which professors could improve their methods and styles of teaching that would in turn enhance their relationships with students. These ideas can be grouped into the following categories: simplicity, clarification, emotion, and creativity.

Mathematician S. Gudder once famously stated, “The essence of math is not to make simple things complicated, but to make complicated things simple” (Math Forum, 2011). The goal for the generalized teaching of elementary and high school mathematics should be to relay the basic and necessary concepts (Math Forum, 2011). Those who are passionate and enthusiastic will seek further education in the matter because they *want* to understand the complexity. Once the class grasps the fundamental forms of each element, teachers can progressively approach more complicated forms and problems.

This solution sounds relatively self-explanatory and intuitive, so why need it be mentioned at all? Interestingly enough, math professors are almost *too* smart (Garcia, 2011). Having received their PhD’s, the endless depth of their knowledge would fry most of our brains. Because they are so advanced, this extent allows them to better understand the main ideas.

However, students are not yet ready to contextualize their learning with such intense intricacy, and they in turn feel very confused when professors imbue their lectures with information attained in graduate school. Though it sounds odd and counter-productive, professors must actually force themselves to disregard everything beyond what they are teaching (Garcia, 2011)). This is an extreme statement and is not meant to be taken literally, but the implications of figuratively doing so are astounding. When one is so far along in math, one forgets what it was like to first learn calculus and basic algebra. A professor needs to put him or herself in the perspective of a fresh mind in order to properly teach math (Garcia, 2011). The concepts must initially be explained as simply as possible to provide a foundation for knowledge that can then be built upon with gradual complexity.

As a calculus tutor, the most common reaction I receive upon explaining a minute detail is, “Well why didn’t he just *say* that?” I am continually astonished at the explanations, definitions, and steps that are never taught. Or, sometimes they are stated once and thereafter omitted. This issue is ancillary to the previous, in that it is for the same reasons that professors fail to clarify concepts effectively. When working out a problem on the board, teachers will frequently skip steps for the purpose of efficiency. Unfortunately, even if the students are following along with acute attention, it is unlikely that they will pick up on the mental short-cuts that have not been properly demonstrated or mentioned. Though it may be a piece of cake to do half of the problem in one’s head, a teacher must be aware that the students do not have this same capacity and certainly do not possess the extensive knowledge background yet (Garcia, 2011). While it is tedious and perhaps boring to the professor, the students will ultimately appreciate the extra time spent on the little nuances that can make a big difference in one’s experience of math.

The aversion to mathematics is so considerable that it not only incites fleeting moments of annoyance and frustration, but runs deep in the lasting emotions one has toward the discipline (Math Forum, 2011). Alternatively, one could argue that feelings and math are incompatible concepts, for the logic and rationality of the field are fundamentally devoid of emotion. This is valid with regard to the actual processes of theorems and solutions, but cannot be said of the mindset one has while *learning* these processes. Regardless of the fact that math cannot love or hate anything, a person can indeed love or hate math. These attitudes can drastically affect how a student receives the information and performs in return. When a professor learns how to attend to their students' emotions, a large piece of the puzzle is found.

What does this mean, and how is it accomplished? First, it is not the intent to imply that teachers be *emotional* people. There is no reason to bring one's personal life into the picture, but rather one must know how to understand people's personalities, attitudes, and needs (Miller, 2000). Most professors are experts in their fields, but never spent an extensive amount of time learning how to teach. The idea is not to merely speak at students, but to work *with* them. Even worse are those who are condescending and judgmental, which creates an environment that is neither enjoyable nor productive. Instead, if teaching is viewed as a connected experience, the goal becomes to help and guide rather than to lecture (Ewen, 2009). If one wants to be liked and respected, one must in turn like and respect. Students must feel that they matter and are appreciated, and this comes about when a teacher knows how to appropriately deal with people.

Professors must also be sensitive to the students' specific attitudes about the material. Though it is good to be passionate about what one is teaching, one must be careful not to be *too* "in love" with everything. Though this may sound silly, students are actually very aware of the emotions with which information is presented. They are intimidated by a professor who views

math only in a positive light, because they are worried that the professor will not be capable of understanding any alternative feelings (Miller, 2000). Most students not only find math endlessly confusing, but also perceive the material to be pointless. One of the most common questions students ask while learning is, “When will I ever need to know this in the future?” For the most part, this qualm is not only reasonable, but correct (Adams, 2011). Most people will never again use limits, infinite series, or integrals after they leave school. Therefore, their “why” question is incredibly valid. Professors need to respond honestly by admitting that some mathematical concepts are seemingly useless. In doing so, they are putting themselves on the side of the students, which allows the opportunity for students to feel that their misgivings are understood (Ewen, 2009). By joking about the apparent absurdity and futility initially, one can gain the approval and respect of one’s students. Once the professor is on the same page as their students, they can slowly build meaning and importance into the concepts. Students will then be more willing to accept and discover that there is a purpose after they have been validated for their irritation. The idea is not to act dismissive about math as a whole, but to respond to the moment-by-moment needs of the students.

$$\frac{dy}{dx} = \lim_{h \rightarrow 0} \frac{f(x+h) - f(x)}{h}$$

Figure 1

This method involves reverse psychology, and is controversial at first glance. I would therefore like to support it with an example of an instance when this

approach worked wonders. A few weeks ago I was tutoring a student in Calculus I, and she was having trouble with a few problems that asked her to use the Definition of a Derivative (see Figure 1) to solve. Her equation was $f(x) = x^3 + x + 4$. She knew how to take the derivative the “normal” way (which means using the individual steps learned for the respective type of equation), but found the definition method to be difficult and pointless. She was very upset

because not only was it hard to solve, but she felt as though she were being tricked by the assignment.

Instead of explaining right away why it was important to understand the definition, I smiled and said, “Yeah, this method is superfluous. After this exam, you will never have to use it again.” Shocked and incredulous, she stared at me, perhaps contemplating whether I was serious. Then she laughed, shook her head, and said, “Well thank you for being honest.” We joked together for a moment about how irritating these problems were, and the transformation I observed in her was astounding. She had gone from stressed, confused, and cynical to relaxed, entertained, and open-minded. I then explained that the Definition of a Derivative is essentially an algorithm for taking the derivative of *any* possible equation. Rather than have a slew of different methods for different equations, it encapsulates the fundamental process behind all of these shortcuts. It is not utilized beyond its introduction because it is not efficient or sensible, but is required in order to provide students with a sense of how math functions beneath the tangible. After clarifying some of the details, she was able to solve the problems with a much better mindset and a heightened understanding. What I did was simply to find a way to genuinely identify with her feelings and validate her attitude until she was ready to accept help. The intent is not to advertise math as unimportant, but to understand where students are coming from in their frustration and to cater to those perceptions (Ewen, 2009). It is easier and more meaningful to get through to students when they feel that they can identify with their teacher.

Although creativity is typically thought to coincide with the arts, it can be extremely applicable to mathematics as well. If one of the goals of teaching is to help students enjoy learning, the best way to achieve this is to instill creativity into the curriculum. As mentioned previously, students are constantly at war with the question of how “this stuff” relates to their

interests. The professor must therefore make math relevant. They must find an aspect in each discipline that connects to the material and illuminate the relationships during lectures. This concept has been referred to as “soft mathematics,” which is the blending of math with other approaches and fields (Devlin, 1997). Some examples are as follows: the dystopian novel *We* by Yevgeny Zamyatin (literature), the golden ratio in paintings (art), patterns of behavior in public (psychology and sociology), financial derivatives (political science), and fractal geometry in nature (environmental science) (Devlin, 1997).

Not only could the professor mention and explain these links, but the students would also benefit from individual and/or group projects. By keeping a journal, writing papers, giving presentations, and completing other hands-on projects, students use creative opportunities to tie ideas together that highlight major disciplines (Devlin, 1997). Any time a person invests oneself in a concept, the memory becomes stronger and will last longer. Group work allows students to share the thinking load and act as planning and strategy models for others. Having students discuss concepts in class and write down their thoughts in a journal or paper enables them to reflect. Professors should consider breaking away from the standard methods for teaching math, because adding assignments that inspire students to use their imagination not only improves their skills but provides a better learning environment in which to thrive (Ewen, 2009). Finally, humans did not invent math, they discovered it. A creative mode of teaching that helps students to *discover* math themselves is the goal.

Ultimately, teachers of mathematics need to properly understand how incomprehensible math can appear at times. They must remember what it was like to first learn these difficult concepts, and must adopt their teaching style to fit this perspective. Math is the most frustrating and debilitating subject in school for many students, a realization that gives way to empathy and

cooperation. Above all else, math professors must be patient. The process of teaching and learning math is a reciprocal team effort, and only when professors understand that they are part of this team can the ideal experience for the student occur.

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