

No Royal Road

Extensive practice is the key to being good at mathematics.

By Brian Butterworth

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There are two opposed ideas about mathematical ability. Nature: it is some kind of biological gift, like the gift for music, perhaps. And nurture: it is all due to hard work and educational opportunities.

I will argue that all human beings are born with special circuits in their brains for categorizing the world in terms of numerosities. In other words, at birth we are all equal in our potential to be mathematicians.

Surely, you will be thinking, there was some essential and innate difference between the children in your class at school who seemed to find maths really easy and those who always found it a struggle.

I would not deny that there may have been differences in their capacity for concentrated work or in what things they found interesting. My claim is that there was no difference in their innate capacity specifically for maths. What made the difference was the amount of practising they did.

In a fascinating review of the whole field of expertise, the US-German team of Anders Ericsson, Ralf Krampe, and Clemens Tesch-Römer found a ten-year rule: “The highest levels of performance and achievement appear to require at least around 10 years of *intense* prior preparation [my italics].” This is true of swimming, musical composition, chess, and mathematics.

They argue that the key is deliberate practice, which is usually solitary. It is indeed laborious, and to be effective, it needs intense concentration. Their conclusion is a simple one: more deliberate practice leads to better performance. There is no other significant factor.

The best violin students, for example, practised *alone* over 24 hours a week.

In the movie *Good Will Hunting* our hero, played by Matt Damon, is a young man working as a janitor at MIT, the most prestigious scientific university in the world. As Will mops, the maths professor sets his class an end-of-term test. Whoever can solve it will prove himself or herself to be the most outstanding mathematician in a class of already outstanding students.

After everyone has left, Will Hunting leaves his mop to write the solution on the blackboard. Next day, the professor, astonished, asks the solver to step forward, but of course none does. Eventually, he discovers that it was Will, who turns out to be a mathematical prodigy.

Instead of studying to become a professional mathematician, however, Will prefers to go out drinking and getting into scrapes with his friends from the neighbourhood.

One of the things that makes *Good Will Hunting* so implausible is that Will does not seem to have spent much time acquiring the vast amount of learning that is required to do modern math. Imagine, if you can, asking Archimedes, the greatest mathematician of antiquity, to factor the equation $2a^2 + 2ab - 4b^2 = 0$.

Archimedes would have less chance than an averagely-educated 14-year-old, since he would not know what the strange symbols 0, 2, 3 and 4 mean because they weren't invented until seven centuries after his murder; nor '+' and '-', German inventions of the 15th century; not to mention '=', which was invented in the 16th century. He would also have had a problem with the idea that equations can have negative roots. As to calculus, no chance at all.

How, then, could Will even understand the problems that the MIT professor was setting his class? However gifted, he would have to have spent less time in his cups, and more time on his books.

If practice is the key to being good, what is the key to being bad? There are many reasons for being bad at arithmetic, just as there are for being bad at any school subject. But school math is like a house of cards: the cards in the bottom layer must be firmly and accurately constructed if they are to support the next layer up. If the lower level is shaky, the house will eventually fall down.

If a pupil, for whatever reason, misses out at Stage N, then it will be hard to build Stage N + 1 securely, and if N and N + 1 are shaky, then Stage N + 2 will be even more fragile. The gap between the concepts currently being taught in class and the pupil's understanding will get wider and wider.

Math more than any other subject is sensitive to earlier failures to understand. How well children understand depends on how well they learn at each stage, and this in turn depends on how well the curriculum is designed and the teaching is carried out.

Pupils who slip behind incur unwanted reactions from peers, teachers, and parents, lowering their confidence and enjoyment of math. A likely consequence is avoidance, as far as possible, of anxiety-inducing, self-esteem-lowering math tasks. And that means not practising.

As the chasm of incomprehension gets wider, class performance will get worse, anxiety will increase, and practice will be avoided even more: a vicious circle.

When the grasp of current concepts is sure and performance on current tasks is good, however, teachers are encouraging, confidence rises, enjoyment of numbers increases, practice increases. Such a virtuous circle, I would argue, is possible for almost every child.

(Adapted with permission from What Counts: How Every Brain is Hardwired for Math - see review on p.3)