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All the Math Taught at University Can Be Outsourced. What Now?

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"Those jobs are not coming back." That was the answer Steve Jobs reportedly gave to Barack Obama in February of last year, when the president asked him if it was possible for Apple to bring back the manufacture of some of its products to the United States.

Repetitive tasks such as high-tech assembly-line manufacturing, airline reservations, and customer support are not the only things that can be outsourced in the flat world of the twenty-first century. So too can many less routine tasks that require a university education in science, technology, engineering and mathematics (STEM).

In particular, procedural mathematics (solving differential equations, optimizing systems of inequalities, etc.) can be outsourced. In fact, many mathematical tasks are already routinely "outsourced" -- to machines. Admittedly, a person often has to do some mathematics to put the problem into a form where an existing software package can solve it, and sometimes a new program has to be written, which also requires human mathematical ability. But those human parts too can be outsourced, at electron speed along an ethernet cable or a wireless link. With a few keystrokes, a designer or a CTO in New York or San Francisco can send a mathematical problem to India at 5:00 PM and by 9:00 AM the next morning the solution is back, ready to be used.

In fact, this is happening now, with companies such as Infosys, Tata Consultancy, Cognizant, HCL, Wipro, and iGate Patni. For example, iGate Patni is a Silicon Valley headquartered, Indian IT outsourcing company with over 26,000 well-educated employees who perform such tasks as writing smartphone apps, handling complex financial matters, and optimizing business logistics processes.

The outsourcing of mathematics and mathematics-dependent STEM activities is only going to increase. It's a question of sheer numbers. In China, with a population of 1.3 billion, and India, population 1.1 billion, there is enormous pressure on children (both parental and self-motivational) to secure a good education leading to a secure future, and that will inevitably produce more and more highly able mathematicians, scientists, and engineers. The US, with a total population of 300 million, less than a third of each of those two giants, cannot possibly compete -- even if we were to completely overhaul our STEM education.

It's a salutary thought that, for someone like me, with bachelor and doctoral degrees in mathematics, what were once highly marketable skills that on graduation presented me with a wide choice of possible careers, are now available elsewhere, far more cheaply and in abundance. (In my case, I eventually opted for university research, but only after investigating careers with IBM and BP.) Every mathematical skill, procedure, or technique I learned over six years at university is now essentially obsolete from a US market perspective.

If we cannot compete, then we need to play a different game. Fortunately, that other game is one we already do well at: originality and innovation. Nowhere is the US lead in those areas more apparent than in those major outsource destinations.

For instance, Phaneesh Murthy, the CEO of iGate Patni, quoted in *Fast Company* last September, lamented the difficulty he has finding truly innovative thinkers in India, noting that "The U.S. education system is much more geared to innovation and practical application. It's really good from high school onward." Summarizing his views, the *Fast Company* article concluded that for the US, "To compete long term, we need more brainstorming, not memorization; more individuality, not standardization."

(This is why I am not unduly worried for my own future. I learned two things at university far more valuable than a bunch of techniques: I learned to think a certain way -- as a mathematician -- and I learned how to master new techniques quickly whenever I need them.)

For many years, we have grown accustomed to the fact that advancement in a technology-driven society required a workforce that has mathematical skills. But if you look more closely, those skills fall into two categories.

The first category comprises people who, given a mathematical problem (i.e., a problem already formulated in mathematical terms), can find its mathematical solution.

The second category comprises people who can take a new problem, say in manufacturing, identify and describe key features of the problem mathematically, and use that mathematical description to analyze the problem in a precise fashion, picking up whatever mathematical techniques are required along the way.

Hitherto, our mathematics education process has focused primarily on producing people of the first variety. As it turned out, some of those people always turned out to be good at the second kind of activities as well, and as a nation we did very well. But in today's world, and the more so tomorrow's, with a growing supply of type 1 mathematical people in other countries -- a supply that will soon outnumber our own by an order of magnitude -- our only viable strategy is to focus on the second kind of ability.

In other words, the only mathematical niche for the US -- and, luckily for us, it is a crucial niche in today's world economy -- is at the innovation end. Fortunately, innovation is an area where we still lead the world, in large part because our political system allows for and rewards innovation.

Traditionally, a mathematician had to acquire mastery of a wide range of mathematical techniques, and be able to work alone for long periods, deeply focused on a specific mathematical problem. Doubtless there will continue to be native-born Americans who are attracted to that activity, and our education system should support them. We definitely need such individuals. But our future lies elsewhere, in producing people who fall into my second category: what I propose to call the *innovative mathematical thinkers.*

This new breed of individuals (actually, it's not new, it's just that no one has shone a spotlight on them before) will need to have, above all else, a good conceptual understanding of mathematics, its power and scope -- when and how it can be applied -- and its limitations. They will also have to have a solid mastery of a few very basic mathematical skills, *but they do not have to be stellar.* A far more important requirement is that they can work well in teams, often cross-disciplinary teams, they can see things in new ways, they can quickly come up to speed on a new technique that seems to be required, and they are very good at adapting old methods to new situations.

Arguably the worst way to educate such individuals is to force them through a traditional mathematics curriculum, with students working alone through a linear sequence of discrete mathematical topics. To produce the twenty-first century, innovative mathematical thinker, you need project-based, group learning in which teams of students are presented with realistic problems that require mathematical and other kinds of thinking for their solution.

Of course, you still need a curriculum, in the sense of a list of topics that students need to master at some point or other. But it should be a short list, and should not be used as a list to proceed through topic by topic, as is current practice in the US. There needs to be a shift in STEM education from (topic-based) instruction (hashtags #traditional and #back-to-basics) to guided-discovery and project-based learning (#reform, #inquiry-based-learning). The primary focus needs to be not on what people know, but on *how they think.*

This is the promised follow-on to my previous blog on 60 Minutes *and* Khan Academy*. An earlier, somewhat different, and longer, version of this article first appeared in my "Devlin's Angle" column in* MAA Online, *in July 2010.*

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