**Why Johnny Can’t Add Without a Calculator**

Technology is doing to math education what industrial agriculture did to food: making it efficient, monotonous, and low-quality.

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When Longfellow Middle School in Falls Church, Va., recently renovated its classrooms, Vern Williams, who might be the best math teacher in the country, had to fight to keep his blackboard. The school was putting in new “interactive whiteboards” in every room, part of a broader effort to increase the use of technology in education. That might sound like a welcome change. But this effort, part of a nationwide trend, is undermining American education, particularly in mathematics and the sciences. It is beginning to do to our educational system what the transformation to industrial agriculture has done to our food system over the past half century: efficiently produce a deluge of cheap, empty calories.

I went to see Williams because he was famous when I was in middle school 20 years ago, at a different school in the same county. Longfellow’s teams have been state champions for 24 of the last 29 years in MathCounts, a competition for middle schoolers. Williams was the only actual teacher on a 17-member [**National Mathematics Advisory Panel**](http://www2.ed.gov/about/bdscomm/list/mathpanel/report/final-report.pdf) that reported to President Bush in 2008.

Williams doesn’t just prefer his old chalkboard to the high-tech version. His kids learn from textbooks that are decades old—not because they can’t afford new ones, but because Williams and a handful of his like-minded colleagues know the old ones are better. The school’s parent-teacher association buys them from used bookstores because the county won’t pay for them (despite the plentiful money for technology). His preferred [**algebra book**](http://www.amazon.com/gp/product/0395430569/ref=as_li_ss_tl?ie=UTF8&tag=slatmaga-20&linkCode=as2&camp=1789&creative=390957&creativeASIN=0395430569), he says, is “in-your-face algebra. They give amazing outstanding examples. They teach the lessons.”

The modern textbooks, he says, contain hundreds of extraneous, confusing, and often outright wrong examples, instead of presenting mathematical ideas in a coherent way. The examples bloat the books to thousands of pages and disrupt the logical flow of ideas. (For instance, the [**standard geometry book for Fairfax County**](http://www.amazon.com/gp/product/0395977274/ref=as_li_ss_tl?ie=UTF8&tag=slatmaga-20&linkCode=as2&camp=1789&creative=390957&creativeASIN=0395977274), which is used in schools around the country, tries to explain what a mathematical point is by analogy to pixels on TV screens, which are not in fact point-like.) Teachers at other schools in the county have told him that they would rather use the old books, too, but their principals would kill them. Other teachers have told me the same about new technologies—they, like Williams, think the technologies are ineffectual, but lack his courage to oppose them.

According to an [**October 2011 report**](http://www.parcconline.org/sites/parcc/files/PARCCMCFfor3-8MathematicsFall2011Release.pdf), 89 percent of high school math teachers think their students are ready for college-level mathematics. But only 26 percent of post-secondary teachers think the students are ready once they get there.

This shortfall in mathematical preparation for college-bound students has existed for a long time, but it is being exacerbated by the increased use of technology. College-level math classes almost never use graphing calculators, while high-school classes invariably do. College professors want their students to understand abstract concepts; technology advocates claim their products help teach students such abstractions, but in practice they simply don’t.

Math and science can be hard to learn—and that’s OK. The proper job of a teacher is not to make it easy, but to guide students through the difficulty by getting them to practice and persevere.  “Some of the best basketball players on Earth will stand at that foul line and shoot foul shots for hours and be bored out of their minds,” says Williams. Math students, too, need to practice foul shots: adding fractions, factoring polynomials. And whether or not the students are bright, “once they buy into the idea that hard work leads to cool results,” Williams says, you can work with them.

Educational researchers often present a false dichotomy between fluency and conceptual reasoning. But as in basketball, where shooting foul shots helps you learn how to take a fancier shot, computational fluency is the path to conceptual understanding. There is no way around it.

The fight between those who seek a way around hard work (a “royal road to geometry,” in Euclid's famous phrase), and those who realize that earned fluency is the only road to understanding goes back millennia and became particularly acrimonious in America in the last half-century in the so-called math wars. On one side are education researchers like Constance Kamii, at the University of Alabama, who [**argues that teaching children to add and subtract is harmful**](https://docs.google.com/viewer?a=v&pid=sites&srcid=ZGVmYXVsdGRvbWFpbnxjb25zdGFuY2VrYW1paXxneDo3ZjQxN2IzMTNjMTQ4ODU3). This camp says it has insights into the way children learn that warrant departure from traditional ways of teaching math. On the other side is the consensus of working scientists and mathematicians as well as teachers like Williams, who notes that it took very smart adults thousands of years to develop modern mathematics, so it makes sense to *teach*it to students rather than get them to “discover” it themselves.

What is new to this fight is the totalizing power of technology. [**A 2007 congressionally mandated study**](http://ies.ed.gov/ncee/pdf/20074005.pdf) by the National Center for Educational Evaluation and Regional Assistance found that 16 of the best reading and mathematics learning software packages—selected by experts from 160 submissions—did not have a measurable effect on test scores. But despite this finding, the onslaught of technology in education has continued. The state of Maine was the first to buy laptops for all of its students from grades seven to 12, spending tens of millions of dollars to do so, starting with middle schoolers in 2002 and expanding to [**high schools in 2009**](http://www.maine.gov/tools/whatsnew/index.php?topic=MLTINews&id=69209&v=Details).

The nation is not far behind. Though no well-implemented study has ever found technology to be effective, many poorly designed studies have—and that questionable body of research is influencing decision-makers. Researchers with a financial stake in the success of computer software are free to design studies that are biased in favor of their products. (I’m sure this bias is, often as not, unintentional.) What is presented as peer-reviewed research is fundamentally marketing literature: studies done by people selling the software they are evaluating.

For instance, a meta-analysis of the [**effectiveness of graphing calculators**](http://education.ti.com/sites/US/downloads/pdf/research_khojou_jaciw.pdf) from Empirical Education Inc. reports a “strong effect of the technology on algebra achievement.” But the meta-analysis includes results from [**a paper**](http://www.jstor.org/discover/10.2307/749612?uid=3739584&uid=2129&uid=2&uid=70&uid=4&uid=3739256&sid=47699079791017) in which “no significant differences were found between the graphing-approach and traditional classes either on a final examination of traditional algebra skills or on an assessment of mathematics aptitude.” In that same paper, calculators were marginally helpful on a tailor-designed test. The meta-analysis included the results of the specially made test, but not the negative results from the traditional exam.

Despite the lack of empirical evidence, the National Council of Teachers of Mathematics takes the [**beneficial effects of technology as dogma**](http://www.nctm.org/about/content.aspx?id=14233). There is a simple shell game that goes on: Although there is no evidence technology has been useful in teaching kids math in the past, anyone can come up with a new product and claim that *this* time it is effective.

Though serious empirical research fails to show any beneficial effects of technology, it also doesn’t demonstrate any harm. The emphasis on technology is in part damaging because of its opportunity cost, both in effort on the part of policymakers and in terms of money. It also distracts from the real problem: teachers who don’t understand enough about math or science. This has been a problem for a long time.

A [**report earlier this year**](http://promse.msu.edu/_documents/PROMSE-%2520The%2520Quest%2520for%2520Coherence.pdf) from Michigan State University showed that K through eight teachers with no math specialization (the vast majority—more than 90 percent of K through six teachers and more than two-thirds of sixth- to eighth-grade teachers) got only half the questions right on a base-line test meant to see whether they knew the material they were supposed to be teaching.[**\***](http://www.slate.com/articles/technology/future_tense/2012/06/math_learning_software_and_other_technology_are_hurting_education_.single.html#cx) The good news is that most teachers are aware of their own limitations: Only about 10 percent of the nonmath specialization K through eight teachers said they were “confident to teach all topics” in math.

The real shortfall in math and science education can be solved not by software or gadgets but by better teachers. Programs like Wu’s can make more teachers more like Williams. That’s where efforts should be focused, not on imagined technological solutions, which obscure more than they reveal.

In this, the new [**Common Core standards for math**](http://www.corestandards.org/assets/CCSSI_Math%20Standards.pdf), which were adopted with lightening speed by 45 states and Washington, D.C., fall short. They fetishize “data analysis” without giving students a sufficient grounding to meaningfully analyze data. Though not as wishy-washy as they might have been, they are of a piece with the runaway adaption of technology: The new is given preference over the rigorous.

Computer technology, while great for many things, is just not much good for teaching, yet. Paradoxically, using technology can inhibit understanding how it works. If you learn how to multiply 37 by 41 using a calculator, you only understand the black box. You’ll never learn how to build a better calculator that way. Maybe one day software will be smart enough to be useful, but that day won’t be any time soon, for two reasons. The first is that education, especially of children, is as much an emotional process as an imparting of knowledge—there is no technological substitute for a teacher who cares. The second is that education is poorly structured. Technology is bad at dealing with poorly structured concepts. One question leads to another leads to another, and the rigid structure of computer software has no way of dealing with this. Software is especially bad for smart kids, who are held back by its inflexibility.

John Dewey, the father of American education reform, defined miseducative experiences as those that have “the effect of arresting or distorting the growth of further experience.” “Growth,” he wrote, “depends upon the presence of difficulty to be overcome by the exercise of intelligence.” The widespread use of computer technology is inimical to the exercise of intelligence. I fear this is no more than shouting into the wind, but resist it while you can, because once it gets locked in—as our food system is, to monocultures and antibiotics in factory farms—it will be even tougher to get away from.













