Teaching too-hard math concepts does students no favors

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We are in the midst of a paradox in math education. As more states strive to improve math curricula and raise standardized test scores, more students show up to college unprepared for college-level math. In Maryland, 49 percent of high school graduates take noncredit remedial math courses in college, before they can take math courses for credit. In many cases, incoming college students cannot do basic arithmetic, even after passing all high school math tests. Recently, it was reported that student math achievement actually grew faster in the years before the No Child Left Behind law.

Much of the problem arises from a blind focus on raising test scores instead of teaching students to understand math. As a college physics professor and parent of three school-age children, I've seen how little understanding is conveyed by the grade-school math curricula. For example, the problems assigned to my children have become progressively more difficult through the years, to the point of absurdity. My eighth-grade daughter asked me one evening how to perform matrix inversions, a technique I teach in my sophomore-level college course on mathematical methods for physics majors.

On another night, my eighth-grader brought home a word problem that was easy for me to do with my knowledge of calculus. However, it took me a lot of thought to arrive at an explanation comprehensible to an eighth-grader. My other daughter struggled through a high-school trigonometry course filled with problems I might assign to upper-class physics majors.

At the same time, I work the summer orientation sessions at Loyola University Maryland, registering incoming freshmen for classes. Time and again, students cannot pass the placement exam for college calculus. Many cannot pass the exam for pre-calculus, and that saddles them with a noncredit remedial math course. Without the ability to take college-level math, the choices students have for majors are severely limited. It means not majoring in any of the sciences, engineering, computer, business or social science programs.

So, if eighth-graders are taught math at the level of a college sophomore, why are graduating seniors struggling? From my knowledge of both curricula, I see three problems:

- Confusing difficulty with rigor. The creators of the grade-school math curricula seem to believe that "rigor" means pushing students to do ever more difficult problems at a younger age. Rigor - defined by the dictionary in the context of math as a "scrupulous or inflexible accuracy" - is best obtained by learning age-appropriate concepts and techniques. Attempting difficult problems without the proper foundation is an impediment to developing rigor.
- Mistaking process for understanding. This is the problem with teaching eighth-graders techniques such as matrix inversion. The arithmetic steps can be memorized, but it will be a long time, if ever, before the concept and motivation for the process are understood. What, exactly, is being accomplished with such curricula? Learning techniques without understanding them does no good in preparing students for college, where emphasis is on understanding, not memorization and computational prowess.
- Teaching concepts that are developmentally inappropriate. Teaching advanced algebra in middle school pushes concepts on students that are beyond normal development at that age. Walking is not taught to 6-month-olds, and reading is not taught to 2-year-olds, because children are not developmentally ready at those ages for those skills. Because math involves knowledge and understanding of symbolic representations for abstract concepts, it is extremely difficult to short-cut development.

All three of these problems are the result of the adult obsession with testing and the need to show year-to-year improvement in test scores. Age-appropriate development and understanding of mathematical concepts do not advance fast enough to please test-obsessed lawmakers. But adults using test scores to reward or punish other adults are doing a disservice to children.

Test scores should measure learning outcomes; test scores should not be the outcomes. That distinction has real effects on how classes are taught and in the messages we communicate to students about the goals of an education.

It does not matter the exact age that you learned to walk. What matters is that you learned at a developmentally appropriate time. To do my job as a physicist, I need to know matrix inversion. It didn't hurt my career that I learned that technique in college rather than in eighth grade. What mattered was that I understood enough about math when I got to college that I could take calculus. Memorizing a long list of advanced techniques to appease test-scorers does not constitute an understanding.

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