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How to Fix Our Math Education

By SOL GARFUNKEL and DAVID MUMFORD

THERE is widespread alarm in the United States about the state of our math education. The anxiety can be traced to the poor performance of American students on various international tests, and it is now embodied in George W. Bush's No Child Left Behind law, which requires public school students to pass standardized math tests by the year 2014 and punishes their schools or their teachers if they do not.

All this worry, however, is based on the assumption that there is a single established body of mathematical skills that everyone needs to know to be prepared for 21st-century careers. This assumption is wrong. The truth is that different sets of math skills are useful for different careers, and our math education should be changed to reflect this fact.

Today, American high schools offer a sequence of algebra, geometry, more algebra, pre-calculus and calculus (or a "reform" version in which these topics are interwoven). This has been codified by the Common Core State Standards, recently adopted by more than 40 states. This highly abstract curriculum is simply not the best way to prepare a vast majority of high school students for life.

For instance, how often do most adults encounter a situation in which they need to solve a quadratic equation? Do they need to know what constitutes a "group of transformations" or a "complex number"? Of course professional mathematicians, physicists and engineers need to know all this, but most citizens would be better served by studying how mortgages are priced, how computers are programmed and how the statistical results of a medical trial are to be understood.

A math curriculum that focused on real-life problems would still expose students to the abstract tools of mathematics, especially the manipulation of unknown quantities. But there is a world of difference between teaching "pure" math, with no context, and teaching relevant problems that will lead students to appreciate how a mathematical formula models and clarifies real-world situations. The former is how algebra courses currently proceed — introducing the mysterious variable x, which many students struggle to understand. By contrast, a contextual approach, in the style of all working scientists, would introduce formulas using abbreviations for simple quantities — for instance, Einstein's famous equation $E=mc^2$, where E stands for energy, m for mass and c for the speed of light.

Imagine replacing the sequence of algebra, geometry and calculus with a sequence of finance, data

and basic engineering. In the finance course, students would learn the exponential function, use formulas in spreadsheets and study the budgets of people, companies and governments. In the data course, students would gather their own data sets and learn how, in fields as diverse as sports and medicine, larger samples give better estimates of averages. In the basic engineering course, students would learn the workings of engines, sound waves, TV signals and computers. Science and math were originally discovered together, and they are best learned together now.

Traditionalists will object that the standard curriculum teaches valuable abstract reasoning, even if the specific skills acquired are not immediately useful in later life. A generation ago, traditionalists were also arguing that studying Latin, though it had no practical application, helped students develop unique linguistic skills. We believe that studying applied math, like learning living languages, provides *both* useable knowledge and abstract skills.

In math, what we need is “quantitative literacy,” the ability to make quantitative connections whenever life requires (as when we are confronted with conflicting medical test results but need to decide whether to undergo a further procedure) and “mathematical modeling,” the ability to move practically between everyday problems and mathematical formulations (as when we decide whether it is better to buy or lease a new car).

Parents, state education boards and colleges have a real choice. The traditional high school math sequence is not the only road to mathematical competence. It is true that our students’ proficiency, measured by traditional standards, has fallen behind that of other countries’ students, but we believe that the best way for the United States to compete globally is to strive for universal quantitative literacy: teaching topics that make sense to all students and can be used by them throughout their lives.

It is through real-life applications that mathematics emerged in the past, has flourished for centuries and connects to our culture now.

Sol Garfunkel is the executive director of the Consortium for Mathematics and Its Applications. David Mumford is an emeritus professor of mathematics at Brown.