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## David Mumford and Sol Garfunkel

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# Bottom Line on Mathematics Education

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First some axioms: Mathematics is honestly useful for all citizens. It can help them in school, at work, as citizens and in their daily lives. This is the reason we teach mathematics every year from kindergarten through the end of high school. The mathematical education of the general public is a priority of our educational system above and beyond the education of future mathematicians and scientists.

What follows from these axioms is that we need a system of mathematics education that seeks first and foremost to recognize the mathematical needs of average citizens and is designed to ensure that those needs are met, while hopefully meeting the needs of students who can and want to learn mathematics as a discipline. And we need to acknowledge that for quite a while now we have been doing precisely the reverse. In other words, we have designed a system for the mathematically motivated and talented and let others drop away -- without regard to whether they would be able to use the fragmentary mathematical

understandings with which they were left.

The latest attempt at mathematics education reform, the Common Core State Standards in Mathematics (CCSSM) exemplify this failed approach. Will it help us do better as a country on international comparisons? Possibly. Will it create a more balanced playing field across the country? Very Likely. Will it make it easier to identify talented mathematics students earlier in their school careers? Almost certainly. Will it move us toward a more quantitatively literate population and work force? Absolutely NOT!

The CCSSM are being marketed as College and Career-Readiness Standards, with the implication that they are for everyone. This is falsity in advertising. If we want future adults to learn to use mathematics then we must show them how mathematics is used in ways and situations that are genuine and that are relevant to their own experience. This isn't really all that hard. The truth is that most mathematics was invented to solve very practical and interesting problems. Rather than spend year after year learning more and more abstract and sophisticated tools, we can take some of that time to use those tools to build real things. Mathematics is a system that enables us to model the world. We need to let students in on this fact -- to actually have them use the mathematics they are learning to do what it was meant to do -- give them a greater ability to understand the world around them.

The standards and the high stakes tests that are being developed (from 3rd grade on!!) will certainly make for more consistency from state to state. But consistency should not be a goal in itself. The mathematical literacy of the next generation is a goal we should be working towards. And in order to achieve that goal we need a true reorganization of the mathematics that we teach -- keeping the why we teach it prominently up front for all to see.

#### **What might this brave new world look like?**

- For one thing, it's obvious that everyone's lives revolve around money and certain types of math are an essential in mastering fiscal challenges. It is not hard to compare the real cost of leasing vs. buying a car if you know the right math but nearly impossible without it. Problems in school based on analyzing the actual budgets of people, businesses and countries could improve our pathetically math-impoverished political discourse.
- Everyone says computer technology should be used in schools but why let the computer be another incomprehensible technological mystery? Teach everyone the rudiments of programming and what goes on inside that box. "But is this Math?" we hear you saying. YES: writing computer code teaches you how to be precise and formal and makes concrete mathematical recipes like that for long division. They are what we call algorithms, and this sort of training is a paradigm for rational thinking.
- Data need not be something we leave to white-coated experts. Students can get tons of data on prices from newspapers and go to town with means and standard deviations. We would suggest asking students to tally their caloric intakes and find the correlation between this and their weights -- but maybe some math is too painful to see. Nonetheless, adults struggle to absorb medical recommendations based on very similar statistics ('lies, damned lies and statistics' as a well-known figure said), and arguing about the validity of statistics can't start too early.
- One could go on. The key lesson is that so much of what is going on in the world can be modeled mathematically. Maps, music, the range of a rifle, how to rig elections, the sustainability of a fishery -- you name it!

The CCSSM do try to include some applications like this. But instead of building theory step by small step out of easily absorbed and useful applications, they tag on an application or two as an afterthought to a heavy slog through abstraction. Math Professors know well how to explain math to graduate students but they seem to have forgotten how high they have climbed into the clouds and what is going on down here on the earth.

*David Mumford is a retired math professor who taught for more than 40 years first at Harvard University and then at Brown University. He is a recipient of a MacArthur Grant, a Fields Medal, the Shaw and Wolf Prizes. He is a past President of the International Mathematical Union. He has worked extensively in both pure and applied mathematics, in algebraic geometry and computer vision and is the author of numerous books including "Indra's Pearls" for the general public.*

*Sol Garfunkel, is the Executive Director of the Consortium for Mathematics and its Applications and has dedicated the last 35*