

Content Knowledge: the Long Pole in the Math Tent

National Math Panel

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I'm Tom Fortmann, an applied mathematician with a PhD in Electrical Engineering from MIT. I have worked in both academia and industry, as a professor, an engineer, and a high-tech executive, and more recently as a volunteer teacher of mathematics.

Working in a variety of urban schools, I soon realized that students' appalling math deficits are grounded in elementary school, where teachers lack knowledge of the subject. I founded the Massachusetts Mathematics Institute (MMI), a professional development program inspired by the Vermont Mathematics Initiative (VMI), and attended by 1,000 or more K-8 teachers since 2003.

Based on pretests and classroom interactions, it's clear that a large majority of K-6 teachers do not understand K-6 mathematics (i.e., elementary arithmetic), and many middle-school math teachers are similarly deficient. Indeed, the publishers alluded to this yesterday when they said that textbooks are bloated to compensate for teachers' inability to explain mathematics. This is a national problem, vividly documented by Liping Ma, but I regret to report that the teachers in her study were well above average.

A large majority of our participants cannot correctly answer pre-test questions about fractions, decimals, or percents; do not understand place value; cannot locate rational numbers on a number line; and are surprised to learn that addition and subtraction are inverse operations. In one group of veteran 5th-and 6th-grade teachers, only 24% were able to find two numbers between $1 \frac{2}{5}$ and $1 \frac{41}{100}$. Only 43% correctly answered the question "75 is 30% of what number?"

The Panel's charge is to use scientifically-based research and focus on the preparation of students for algebra, but algebra is simply out of reach when teachers do not comprehend and are intimidated by the very concept of a variable. Moreover, how much research do we need to confirm what Will Rogers observed nearly a century ago? He said "You can't teach what you don't know, any more than you can come back from where you ain't been."

I hasten to add that none of this is the fault of current teachers: a random sample of 100 people off the street would yield the same results. It *is* the fault of our current system, where most high-school graduates don't have even a working knowledge of K-8 mathematics and preservice teachers are not required by either colleges or states to learn the mathematics they need in elementary classrooms.

Prof. Bisk's comments raise this latter issue; addressing it aggressively in college programs and certification requirements will eventually produce future generations of teachers with adequate math content knowledge. In the meantime, we need comprehensive professional development for current teachers. It must be rigorous, challenging, and extensive; learning mathematics cannot be made easy and decades-old deficits cannot be erased overnight.

I also have good news to report: most teachers in our programs realize their own shortcomings and are anxious to learn the mathematics that they know they need in the classroom. They work very hard, make substantial progress, and feel good about their accomplishments. Most importantly, they gain confidence that they can understand and do real mathematics, and that they can impart real mathematical understanding to their students.

Teachers' content knowledge is the long pole in the math tent. Curricular materials cannot compensate for its absence. Neither old-fashioned curricula that rely on rote memorization nor new-fashioned ones that rely on pseudo-mathematics will help. Moreover, research comparing such curricula is futile unless the teacher understands the subject.

We need, first and foremost, teachers who know the mathematics and, second, curricula that meld skills with understanding to support those teachers in presenting real, substantive mathematics. The new "Focal Points" presented yesterday appear to be a giant step in that direction.

Thank you.

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