Math Matters: A Journalist's Guide

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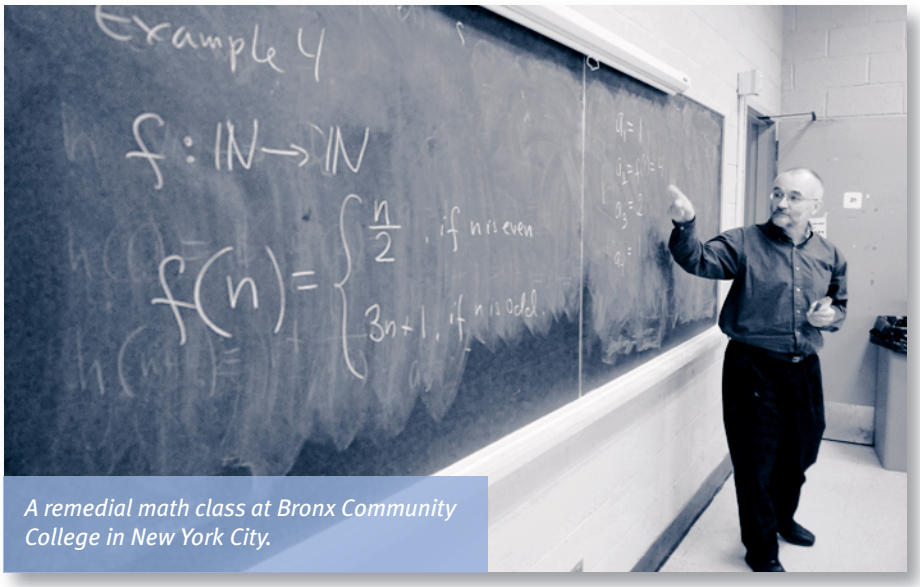
U.S. Math Education Is Broken — But How to Fix It?

As American students fall further behind counterparts overseas, experts say change must come.

By Richard Lee Colvin

It is a hot September weekday a few days after the start of school in Paramus, N.J., and 30 or so students are hunched over rows of desks reviewing arithmetic: multiplication, division and how to use those procedures in evaluating number sentences. Written on the white board is this problem: "[92 x (6-4) ÷ 8] + [7 x (8-3)]."[1]

The key to calculating what this phrase equals is to figure out which operations to do first. New Jersey's academic standards say this should be taught beginning in the third grade. But the struggling students in this Bergen County Community College classroom have all graduated from high school. They're here because their scores on the college's placement exam showed that they couldn't do basic material. And now an equation that a middle-schooler should be able to master has become a major obstacle to their chances of getting a degree.



A remedial math class at Bronx Community College in New York City.

The remedial math class is just one of dozens at Bergen, New Jersey's largest community college. And the struggles in Bergen's classrooms are echoed around the country, where 61 percent of all community college math students are still studying elementary or middle school concepts and skills. These classes are just one manifestation of what governors, business leaders, policymakers and mathematicians describe as a national math crisis. Poor math skills, these critics say, harm the nation's competitiveness, weaken its technological prowess, exacerbate inequity, shut people out of jobs and threaten voters' capacity to understand complex issues such as the cost of health care or the size of the national debt.

Two decades of international math comparisons show that the longer American students are in school, the further they fall behind their counterparts in other developed nations. (See story, pages 13-15.) William Schmidt, a Michigan State University professor who studies how U.S. students match up against those in other countries, says most American eighth-graders can't do relatively simple tasks – such as add fractions – that students in other countries master by fourth grade. According to the National Assessment of Educational Progress (NAEP), only half of U.S. eighth-graders could place three fractions – ⅓, ½, ⅝ – on a number line in order of magnitude. "This is not mental Olympics," Schmidt says. "It's not about one country doing a little bit better than others. It's really about our kids being able to function."

Part of the blame should fall on successive and often wildly contradictory waves of reform over the last half-century, from an emphasis on precise abstract concepts (the New Math of the 1960s) to the basics of arithmetic and algebra (1970s and 1980s) to a celebration of math exploration that eschews standard methods for multiplying and dividing and downplays fractions and long division (starting in 1990). Although math programs based on those last ideas continue to be widely used today – two of the most popular are Everyday Math and TERC: Investigations in Number, Data and Space – they are often unpopular with parents and criticized by mathematicians for failing to build the skills required to succeed in algebra and beyond.

These wild swings in opinion set the stage for the so-called "math wars," which continue today in school board meetings and on YouTube. (See story, page 5.) It's a debate that's particularly frustrating to experts in mathematics education because there is a broad consensus that fast, accurate calculation goes hand in hand with understanding the conceptual underpinnings of the procedures. Students also must be able *continued on page 2*

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to apply what they know to solve problems, use logical reasoning and see math as a useful tool that can be learned through effort.

The National Mathematics Advisory Panel, which included experts with a diverse range of views on these issues, concluded that math education in the United States "is broken and must be fixed. … This is not a conclusion about any single element of the system," the panel's report said. "It is about how the many parts do not now work together to achieve a result worthy of this country's values and ambitions."[2]

A STUDENT WHO IS PROFICIENT IN MATHEMATICS HAS ACQUIRED….

- ✔ Conceptual understanding of key mathematical ideas, operations, and relations
- ✔ Fluency with mathematical procedures and the ability to use them flexibly, accurately, efficiently, and appropriately
- ✔ Strategic competence, which means the ability to formulate, represent, and solve mathematical problems
- ✔ Adaptive reasoning, which is the capacity to think logically and reflectively and to explain and justify one's thinking
- ✔ A productive disposition that sees mathematics as sensible, useful, and worthwhile, and that recognizes that diligence and effort will lead to results.

Source: adapted from Kilpatrick, J., Swafford, J., & Findell, B. (2001). *Adding it up: Helping children learn mathematics.* Washington, DC: National Academy Press. Page 116.

Francis "Skip" Fennell, a member of the advisory panel who is former president of the National Council of Teachers of Mathematics, agrees. "More and more of our kids are taking algebra than ever in our history," he says, "and yet we have high school performance that is either stagnant or declining, and we have too many kids moving into higher education and having to immediately take remedial classes. To me, that suggests a system that is more than a little out of whack."

STANDARDS

All 50 states now have standards for what students should be able to do in order to be considered proficient. Although those documents vary widely, experts agree that they are too voluminous, scattered and repetitive. The National Governors Association and the Council of Chief State Schools Officers released a draft of a common set of improved standards for math and English in September 2009. The standards are meant to be rigorous, emphasizing fewer topics and reflecting what high school graduates need to know in order to be ready for college or work. "The idea here is less is more," Fennell says. "Let's ensure we're teaching what's important and ensure that kids really have it."

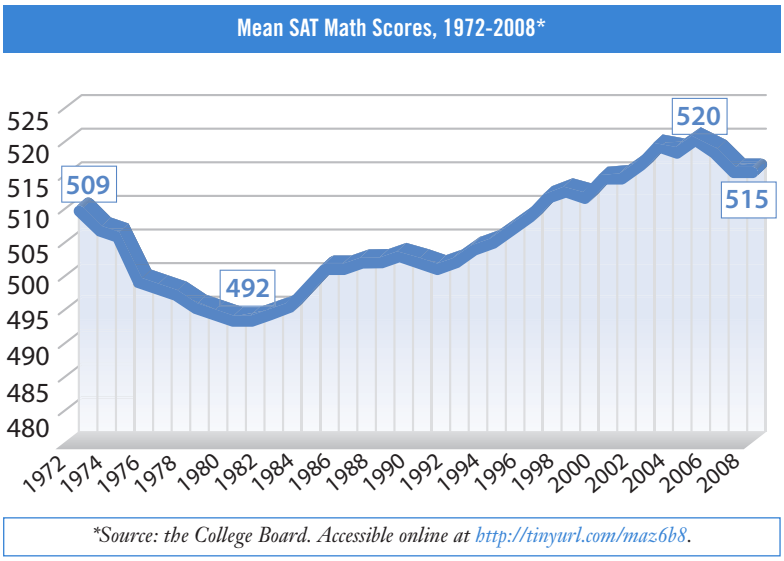
Forty-eight states – as well as Washington, D.C., Puerto Rico and the U.S. Virgin Islands – are participating in developing the standards and, it is hoped, many will adopt them as their own. But getting diverse interest groups to agree on what students should be expected to learn is a contentious, divisive process, so it may be hard to reach broad agreement. A potential danger is that the cost of getting many states to sign on would be standards so watered-down that they don't actually lead to any real change. Educators, policymakers, politicians and parents all tend to favor high standards in theory, but once they are enacted and their consequences become evident – higher drop-out rates and more students repeating grades, for instance – people's enthusiasm wanes.

CURRICULUM, TEXTBOOKS AND GRADUATION REQUIREMENTS

The purpose of standards is to send signals about what should be taught, but the signal sent by many sets of state standards is not clear. U.S. math textbooks are typically 700 to 1,000 pages long. Because they are unable to cover everything, teachers often sample the material without a coherent plan.

The advisory panel report says that elementary and middle school curricula should prepare students to take a formal algebra class by eighth grade. (See story, pages 6-7.) Students need to understand whole numbers, fractions, measurement and geometry if they are to succeed in algebra. The panel's survey of algebra teachers found that many reported their students not only didn't understand fractions or decimals but also didn't know multiplication tables or how to divide on paper. The teachers in the survey blamed overuse of calculators – a finding that would resonate in Bergen County, where community college remedial math teachers have banned calculators. But students are so dependent that some still sneak them into class or try to use the calculators on their cell phones – until they are caught by their teachers. (See story, pages 20-21.) Many states are raising the number of math courses stu-

dents have to take to graduate. The percentage of high school graduates taking either Algebra II or even more advanced math rose from 49 percent to 63 percent between 1990 and 2005. But SAT scores in math are flat, as the chart below shows, and enrollment in remediation classes is on the rise.



Source: the College Board. Accessible online at http://tinyurl.com/maz6b8.

TEACHING

One of the most notable findings of the advisory panel was that researchers have no definitive answers about what constitutes good math teaching. The panel challenged claims about the superiority of "student-centered" teaching or "teacher-directed" lessons. There is no high-quality research supporting the exclusive use of either method.

The report also found limited benefit from learning math using "real world" situations, as is commonly recommended by math teachers today. Research says students taught that way do fine on test questions that deal with "real world" situations. But students' ability to calculate accurately, solve word problems or deal with equations is not improved by such lessons.

What is clear, however, is that teachers must have deep knowledge of the math they're trying to teach and how various math concepts and skills fit together. The panel called for more math content in teacher preparation programs, more mentoring of early career teachers, and more opportunities for teachers to learn on the job.

PARENTS, CULTURE AND EXPECTATIONS

Perhaps one of the biggest barriers to increasing math proficiency in the United States is cultural. In most countries, math literacy is expected, but in the United States, it is socially acceptable to say "I hate math" or "I was never good at math." "Imagine," says Deborah Loewenberg Ball, dean of the University of Michigan School of Education, "if those same people said similar things about reading or writing: 'I never could read.'"[3]

Many Americans also are complacent about math education. In a 2007 poll of Kansas and Missouri parents, the nonpartisan polling organization Public Agenda found that only 25 percent thought their children should be studying more math and science. About 70 percent said things "are fine as they are now."[4] A 2008 Associated Press poll found that just over a third of parents thought their children needed more math instruction.

The report of the math advisory panel is one of many that have been issued over the years by smart educators and researchers committed to solving what virtually all agree is a serious problem. However, for all that is known about the problems and how to fix them, math teaching remains stubbornly fixed in place. Scholars of math education say that classes today would seem familiar to Americans who finished school decades ago. But today's graduates enter an adult world where the price they will pay for math deficiencies is far greater than that paid by their parents. Meanwhile, the cost to the nation is steep and growing steeper.

LOOKING BACK, LOOKING FORWARD

The 2008 documentary *2 Million Minutes* attempted to start a national discussion around such issues. The film looks closely at the lives and study habits of two high school students per country – one boy and one girl – in the United States, India and China. The film's conclusion? Indian students, on average, spend about 40 percent more time in high school than American students. In China, where both the school day and year are considerably longer than in the U.S., students spend about 90 percent more time in class than American kids. And these disparities only widen when one counts the number of hours spent studying outside of class. According to the film, 60 percent of U.S. college-bound seniors do no more than one hour of homework per night and none on the weekends. No such statistic is given for Chinese or Indian students, but the clear implication is that their lives consist of little more than studying. And they don't eschew challenging math and science classes like the average American student does.

The two Indian students in the documentary, Rohit Sridharan and Apoorva Uppala, envision futures in

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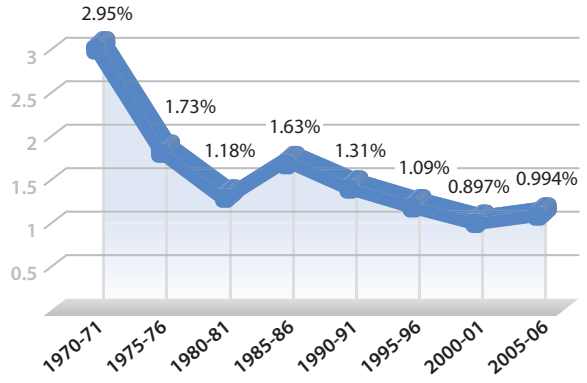
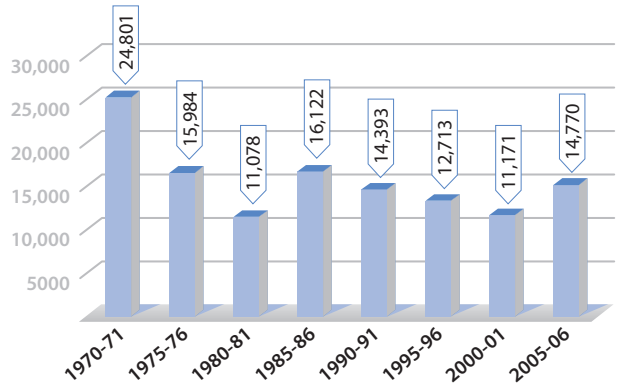
engineering because it's a "safe" career choice – one in which there is no shortage of demand, in part because so few students in other English-speaking countries pursue engineering and related fields. As the charts below reveal, only one of out every 100 U.S. college graduates in 2005-06 majored in mathematics or statistics. The U.S. now produces only about half as many math and statistics majors as it did in the early 1970s, a fact that is all the more striking when one recalls that many more people attend and graduate from college now than four decades ago.

Undergraduate Degrees in Mathematics and Statistics as % of Total Awarded



Number of Undergraduate Mathematics and Statistics Majors Per Year, 1970-2006



Vivek Wadhwa, an adjunct professor at Duke University who researches globalization's impact on the engineering profession, sounds the alarm in *2 Million Minutes*: "Unless the U.S. wakes up and realizes the new threat, realizes the fact that we're competing with anyone anywhere in the world, we're going to lose, we're not going to be the leaders in the next 30 years or so."

That so many U.S. college students steer clear of math is perplexing, especially given the healthy job market for those with strong math skills. A 2009 ranking of 200 different jobs by Careercast.com, for instance, found that America's top three jobs were: 1) mathematician; 2) actuary; and 3) statistician. The five criteria used to evaluate jobs were: stress, work environment, physical demands, income and employment outlook.

THE TOP 15 BEST AND WORST JOBS IN AMERICA

THE BEST	THE WORST
1. Mathematician	200. Lumberjack
2. Actuary	199. Dairy Farmer
3. Statistician	198. Taxi Driver
4. Biologist	197. Seaman
5. Software Engineer	196. EMT
6. Computer Systems Analyst	195. Roofer
7. Historian	194. Garbage Collector
8. Sociologist	193. Welder
9. Industrial Designer	192. Roustabout
10. Accountant	191. Ironworker
11. Economist	190. Construction Worker
12. Philosopher	189. Mail Carrier
13. Physicist	188. Sheet Metal Worker
14. Parole Officer	187. Auto Mechanic
15. Meteorologist	186. Butcher

Source: from a 2009 ranking of 200 different jobs by Careercast.com, accessible online at http://www.careercast.com/jobs/content/JobsRated_Top200Jobs.

No doubt part of the reason so few U.S. students major in math or statistics is that they leave high school with neither the desire nor the foundation necessary to do higher-level math. In order for that to change, there need to be radical shifts in U.S. thinking about math, its importance in everyday life and to our economy, and how the subject is taught in elementary, middle and high schools across the country. Only then might a simple problem involving the order of operations be readily solved by students everywhere.

[1] The correct answer is 58.

[2] United States Department of Education. (2008). "Foundations for Success: The Final Report of the National Mathematics Advisory Panel." Accessible online at http://tinyurl.com/yopzor.

[3] D.L. Ball. (2001). "Developing a mathematically proficient public: What are the problems, what do we know about them, and what would it take to solve them?" Paper prepared for the Aspen Institute congressional conference on "Promoting Excellence in the New Economy: the Challenges to National Policy," St. Petersburg, Florida, February 16–19, 2001.

[4] Kadlec, A. & Friedman, W. (2007). "Important, But Not for Me: Parents and Students in Kansas and Missouri Talk About Math, Science and Technology Education." A Report from Public Agenda, with support from the Ewing Marion Kauffman Foundation. Accessible online at http://tinyurl.com/kr9egt.

How Reporters Should Cover the Math Wars

By Richard Lee Colvin

The so-called "math wars" have raged for decades. Conflicts arise over competing views of teaching methods, educational philosophy, cognitive science, equity, race, standards and even post-modernism. Typically, math professors are at odds with education professors and math teachers. And parents worried about their kids learning the basics do battle with teachers and administrators who tell them to relax. The debate makes headlines when a school or district chooses new materials that downplay memorizing multiplication tables and teaching standard long division and fractions while relying on calculators in the early grades and substituting cutting, sorting and pasting paper for practicing number facts.

I wrote my first story about the math wars in California in 1994. I've written and read many stories on the topic since then. Here are some suggestions about what to do and what to avoid in your coverage.

- Put the debate in context. Let your readers know that the same arguments have played out in hundreds and hundreds of other places in the past two decades.

- Avoid using "traditional" and "reform" as shorthand labels for the two sides. The implication is that the traditionalists are trying to hold back progress. In fact, there's widespread agreement that math education must improve.

- Don't pit memorization and computational efficiency against conceptual understanding and using math to solve real problems. It is not a zero-sum game. All of these skills are important.

- No matter what the method or curriculum, look at whether students in the classrooms you visit are engaged in the lesson. Jeremy Kilpatrick of the University of Georgia, a leading math education expert, says: "Are students following what's going on? If kids are going to be learning math, they need to be working on math in the class, and if they are not, then they are just pushing pencils, and that is really unfortunate."

- Acknowledge that different teaching methods are appropriate for learning different skills and concepts. In some, the teacher talks more. In others, kids work in groups and talk with each other. Research has not answered definitively which methods work best and when. "I would be interested in whether the content is being developed in ways that make sense," Kilpatrick says. "What is critical is whether skills and concepts are being developed with some care."

- Whenever someone starts a sentence with "Research says ..." ask what specific research is being cited. Lots of studies are sponsored by textbook companies. Keep in mind that it's hard to prove that a program, in and of itself, *caused* children to learn. Many factors are at work.

- Talk to teachers (beyond those who are the strongest advocates of a particular method). Do they feel comfortable teaching in a new way? Do they see success? How much training have they had?

- Reach out to national experts, such as some of those listed in this publication. They can put the local events into a larger context and help you sort out the issues. And they will be seen as neutral because they aren't caught up in local controversies.

New Emphasis on Learning Algebra Raises Questions

Journalists should check if teachers, students are getting help to meet tougher standards.

By Sean Cavanagh

Few academic topics are as highly regarded by policymakers – and as feared by students and the public at large – as algebra. Across the country, state and local school officials are asking students to take more courses in that subject, and to take them earlier in school. They say they are convinced that algebra is crucial preparation for more advanced math, and a key to success in college and the workplace.

Two states, Minnesota and California, even require students to take introductory algebra, or Algebra I, in eighth grade, rather than waiting until high school – though California's policy has been blocked in court. Nationwide, the percentage of eighth-graders now enrolled in algebra (31 percent) is nearly double what it was in 1990, according to a 2008 study by the Brookings Institution.[1]

Algebra standards are also being ratcheted up at the high school level. Twenty states, plus the District of Columbia, require students to take Algebra II or its equivalent to graduate with a regular diploma, according to Achieve Inc., a Washington-based policy organization. Four years ago, only two states had that requirement. In addition, 12 states are participating in a national test of Algebra II skills, an effort that is being led by Achieve.

Despite these efforts, algebra remains a major stumbling block for many middle- and high-school students. After cruising through more basic math, many students arrive woefully unprepared for their first full algebra course and wind up having to repeat the class or scraping by with little understanding of the subject.

The public perception of algebra probably doesn't help. Many adults freely confess to having loathed algebra in school. A Web search reveals countless sites devoted to helping students fight their way through the subject – or simply allowing them to commiserate about how difficult it is.

As schools increase their expectations in algebra, education reporters have a number of questions to consider. Perhaps the most obvious one: Why does the study of algebra – with its potentially bedeviling language of *x* and *y*, equations and polynomials – matter in school, or in life? And, if it does matter, how can reporters determine whether schools are teaching the subject well and helping students who can't keep up? What might schools be doing better?

In one sense, algebra is important for very practical reasons. Research has shown that students who take algebra, and take it relatively early, are more likely to move on to advanced math in high school and succeed in college. Algebra also is found in varying amounts on state tests and college entrance exams. There's simply no avoiding it.

Even so, convincing people of the value of algebra is not easy. Henry Kepner, the president of the National Council of Teachers of Mathematics (NCTM), in Reston, Va., recalls encountering a business executive several years ago whom he was going to ask to meet with K–12 teachers to discuss math and its uses in the workplace. When the executive suggested that he rarely used algebra on the job, Kepner responded by pointing to the man's computer screen, which included spread sheets with axis and trend lines estimating profits and costs. "It took me a while to convince him, 'That's all algebra,' " Kepner recalls.

Algebra is sometimes described as the study of relationships between numbers, in which numbers are represented as symbols. Some math experts call it the study of generalized arithmetic. Arithmetic – addition, multiplication and so on – allows you to solve a single problem. Algebra allows you to create a formula or process for solving a host of problems. "If you are doing something once, you probably don't need algebra," wrote Zalman Usiskin, a textbook author and the director of the University of Chicago School Mathematics Project, in a 1995 essay. "But if you are doing a process again and again, algebra provides a very simple language for doing what you are doing."[2]

Algebra allows someone to consider multiple quantities and variables at once. To use an all-too-relevant example from today's headlines, an algebraic equation can help someone calculate the monthly payments on a home, factoring in the down payment, interest rate, length of the loan and loan adjustments over time.

In recent years, many business leaders have supported tougher requirements in algebra, arguing that improving student math skills is necessary to produce a more qualified workforce. Industry groups backed a controversial 2008 decision by the California state board of education to phase in a requirement that all students take the state's algebra test as eighth-graders. That policy, which the board described as a response to a No Child Left Behind testing requirement, was widely regarded as mandating that students take algebra in eighth grade. The Association of California School Administrators and others sued to stop the policy's implementation, arguing that the policy was approved without public input and exceeded the state board's authority. A judge blocked the policy from being implemented, and the state board is appealing that decision.

As states and districts raise expectations in algebra, how can reporters judge the impact of such policies on schools and students? One obvious, if imperfect, method is to look at test results. A few states, such as Florida, allow reporters and the public to compare students' performance in algebra against other content areas of math, such as geometry or statistics. While many factors can affect student test scores, this is at least a starting point for journalists considering the impact of algebra policies, says Elaine M. Allensworth, co-director for statistical analysis at the Chicago Consortium on School Research, who led a recent study of algebra policies in that city's schools. "At the minimum, you would expect test scores to improve," she says.

Reporters should also look at whether more students are being forced to repeat classes after algebra policies take effect. A recent study by Allensworth, for instance, found that a Chicago mandate requiring students to take Algebra I by ninth grade had not led to test-score gains for city students in math. Nor had it led to significant increases in the percentages of students taking more advanced math later in school.

The most relevant question for journalists writing about increased algebra requirements, or covering districts where large numbers of students are struggling, Allensworth argues, is: What are policymakers doing to improve student performance? Are they offering algebra teachers more training? Are they providing students extended time in algebra? What's the effect of these policies? "Just putting a standard in place does nothing," Allensworth says. "What matters are the supports for the policy."

Kepner agrees, arguing that reporters should examine whether districts are providing time for teachers to plan algebra lessons together and discuss common problems. Encouraging high school and middle school teachers – who often complain about students arriving in their algebra classes with poor skills – to work with teachers from earlier grades would be especially beneficial, he says.

At least one state, Arkansas, has sought to improve algebra instruction by phasing in a requirement that middle school teachers obtain an algebra-specific credential if they want to teach that subject in middle school. Teacher training matters, Allensworth says: As schools seek to enroll younger students in algebra, teachers are likely to be asked to work with students from a much broader range of ability levels – not an easy task.

One recent strategy for increasing students' chances for success in algebra is to revamp math instruction in early grades. In 2006, the NCTM took a major step in this area through its release of "Curriculum Focal Points,"[3] a document that sought to provide clearer guidance to preschool through eighth-grade teachers on the crucial math all students should know.

Then last year, the National Mathematics Advisory Panel, a White House-commissioned group, released its own recommendations for how to improve students' preparation for algebra. The panel's report[4] emphasized giving students in kindergarten through eighth grade a much stronger grounding in whole numbers, fractions, geometry and measurement to provide them with a springboard to algebra.

Reporters writing about eighth- or ninth-graders' struggles in algebra need to look closely at how math is being taught in elementary schools, Kepner says, because schools can and should be attempting to introduce students to algebraic thinking in elementary school. The early exposure, Kepner argues, prepares students for algebra, and makes the topic seem relevant.

When using numbers in a relatively simple math problem, a student starts to ask, "What if the numbers were different?" Kepner says. "It helps students understand, 'What does algebra do for me?' "

Some states are realizing that elementary teachers themselves need stronger math skills if they are to teach the subject effectively. Massachusetts, for example, now requires new elementary teachers to pass a separate math proficiency exam as part of the certification process. Previously, new teachers could gain certification without answering any math questions correctly because math was part of a general exam and not scored separately. Would-be skeptics of the new policy will have a tough time arguing that it is unnecessary: Only 27 percent of aspiring elementary teachers who took the math proficiency exam at its debut in March actually passed.

Reporters covering middle- and high-school math instruction should look at how district and state policies shape both teacher training and the curriculum. Often what is decided at the district and state level for elementary grades can have profound effects on what happens in middle- and high-school classrooms.

Sean Cavanagh is a staff writer for Education Week. *His beats include the curriculum areas of math and science, adult education, vocational and school-to-work issues, and dropouts. He also covers the states of Alaska and Illinois.*

[1] "The Misplaced Math Student: Lost in Eighth-Grade Algebra." http://www.brookings.edu/~/media/Files/rc/reports/2008/0922_education_loveless/0922_education_loveless.pdf

[2] Zalman Usiskin, "Why Is Algebra Important to Learn?" *American Educator*, Spring 1995.

[3] http://www.nctm.org/standards/content.aspx?id=270

[4] http://www.ed.gov/about/bdscomm/list/mathpanel/report/final-report.pdf

Story Ideas and Questions to Ask About Algebra

By Sean Cavanagh

STORY IDEAS

- What percentage of students is flunking or being forced to retake algebra, compared to other math courses? If a state or district increases its requirements, do more students drop out or repeat grades?
- Members of the public are often at a loss to explain why studying algebra is important. Talk to employers, mathematicians and college faculty, pressing them to explain, in clear terms, why students should care about algebra – other than that the subject helps students on standardized tests.
- Many school districts are experimenting with commercial "algebra readiness" programs aimed at helping students who fail algebra or have been identified as likely to struggle in that subject the following academic year. What is the percentage of students taking these "readiness" courses? Are these students succeeding when they reach algebra?

QUESTIONS TO ASK

- If a state or school district is raising its algebra requirements, what are administrators doing to make sure the policy is successful? Are they creating new professional development for teachers? Are they adjusting the math curriculum at earlier grades?
- As algebra requirements increase, what's the impact on student test scores on local and state tests? Are overall test scores increasing, and (if the data are available) are students' scores on algebra-specific questions improving?
- Who in a district or state is calling for increased algebra requirements, and why? If business leaders are asking for higher academic standards, how will their companies benefit from students' improved algebra skills?
- How are parents and community members reacting to increased algebra requirements? Do they support higher standards, even if it means that children who struggle with math will face even greater challenges?

Story Ideas about Math in the Workplace

By John Mooney

- Is there a connection between a particular level of math achievement and pay levels that cuts across many industries? Do you really need Algebra II to earn a middle-class salary?
- Journalists, admittedly not often math whizzes in their own school careers, certainly can appreciate the real-world relevance of statistics, something they confront almost daily in their own jobs. Yet, few school districts offer courses in the basics of this important subject. Why is this the case? And why don't more districts offer other clearly useful math-related courses, such as how to manage personal finances?
- How does job-related math education in the United States compare to other countries? What do students in Germany, India or China learn and at what ages?
- How do companies compensate for the lack of math skills in their employees? Is on-the-job remedial education effective?
- Does the rapidly changing technological landscape – with more and more tools available for doing quick and easy calculations – mean most workers need fewer math skills?

Why Some Claims for High-Level Math Don't Compute

Critics question whether all workers need to know Algebra II, as proponents contend.

By John Mooney

Do people really need to know the high school staples of algebra, geometry and trigonometry after graduation? Policymakers and educators often argue that math education is critical to the nation's economic survival, but reporters who look closely at this widely accepted claim will find a much more nuanced picture.

A Wood Construction Facility at Seattle Central Community College in Washington State

photograph by Joe Mabel

This push for more advanced math skills grows out of a decades-long effort by groups of business leaders, politicians and educators to counteract competition from countries like China and India, which have made great strides in upgrading the technical skills of their labor forces while keeping wages much lower than in the United States. Other worrying trends include the poor showing of U.S. students on international math and science comparisons and alarm about a reported shortage of Americans trained for high-tech jobs, especially engineering. At the same time, many companies say that even entry-level manufacturing jobs now require a greater degree of math competency. But is there merit to such claims?

One of the most prominent groups in this movement is Achieve, Inc., a nonprofit education reform organization that works with states to raise academic standards and graduation requirements. Achieve has called for all high school students to be proficient in at least Algebra II. The group's American Diploma Project, a set of graduation standards that includes a requirement for Algebra II, has been adopted by more than 30 states. Achieve pushes its message by pointing out that precalculus and trigonometry are needed for many high-paying jobs in business, finance and health science. Even construction work clearly requires geometry. "You see it in the basic 3:4:5 triangle," says Kate Blosveren, a senior policy analyst for Achieve. "In math class, that's the Pythagorean theorem. In construction, it's the 3:4:5 triangle."

Companies that need more highly skilled workers have also been at the forefront of the movement to improve math education. One example is Verizon, with 220,000 employees around the world who need strong math skills no matter what their job, the company claims. Network engineers are at the heart of the business and need to understand the language of IP addresses and subnets, binary codes and octets. "Without networks, we're not much more than a marketing company," says Alberto Canal, a spokesman for the corporation's human resources division.

But its workers at lower levels also need to be adept at calculation, Canal says. That's true even in jobs where the computation may not be apparent to the consumer. For example, the 40,000 customer service representatives must be able to compute and compare calling plans quickly. The computer will do the math, but the representatives must know which questions to ask. "Customer service representatives need to *continued on page 10*

A Sample Question for Electrical Contractors

Here is a sample question from the apprentice test for electrical contractors, who must take a year of algebra for certification.

Consider the following formula: $y=3(x+5)(x-2)$.
Which of the following formulas is equivalent?

a. $y=3x^2+9x-30$ b. $y=x^2+3x-10$
c. $y=3x^2+3x-10$ d. $y=3x^2+3x-30$

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be able to work out rate arrangements live, right then and there," Canal says. "It's in the context of problem-solving, which package works best for a customer. That's a very real example of math skills."

ACT, the organization that administers college entrance exams, also bolsters the argument for more advanced math in a series of case studies of companies like Subaru, Dow Chemical and the Energizer battery company. Applied mathematics is one of five skills considered most critical to Energizer's hiring, right down to the bottom rung of employees. "Production machine operators – entry-level positions – must count incoming materials, determine the number of finished products, and count raw materials needed to run orders," an ACT report says. "These tasks require mathematical reasoning, critical thinking, and problem-solving techniques applied to work-related problems."

Some of these assertions about the importance of math are clearly true; no one disputes that network engineers, for example, need sophisticated skills to do their jobs properly. But when reporters hear that Algebra II is necessary for what is basically counting – as in the case of machine operators – it's time to push back.

In fact, not everyone agrees that all graduates – regardless of career goals – need to have specific math skills. Anthony Carnevale, director of the Georgetown University Center on Education and the Workforce, has long maintained that Algebra II is mostly useful as a kind of marker for overall ability or educational achievement. In other words, an employee who has mastered Algebra II could be expected to master complex tasks on the job, even if they are not math-related. Carnevale has analyzed federal labor data from interviews of workers in 1,000 occupations and found problem-solving and critical thinking more directly related to higher earnings. "It seems that math ability, that is Algebra II and beyond, is being used as an initial screen, but most occupations really don't require a sound knowledge of trig functions or the quadratic equation," he says.

Others say the gateway remains basic algebra (a job requirement in many trades), with Algebra II an important stepping stone to calculus and higher math skills but not an end in itself. Joseph Rosenstein, a math professor at Rutgers University who has been critical of the Achieve standards, says that if a student isn't going on to calculus, such concepts as complex numbers, rational exponents and cube roots have little value. "If you think about it, a class in statistics would be more important than Algebra II, in reading charts and determining probability," he says.

Even in industries that are highly dependent on technology, math is just one of a number of important skills. Peapod, Inc., the online grocery giant, uses a sophisticated network of software systems and inventory controls. Behind its creation and management is an intricate web of equations and flow charts, requiring the expertise of engineers, programmers and finance specialists. But Thomas Parkinson, a co-founder and now chief technology officer, says some of his best programmers are also often artists and musicians able to see the multiple dimensions of a problem. "Frankly, spatial ability is more important than math," says Parkinson.

An Aircraft Maintenance Training Facility at South Seattle Community College in Washington State

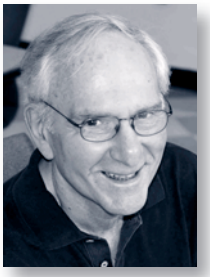
photograph by Joe Mabel

And in Peapod's on-the-ground operations, advanced concepts are hardly necessary to determine how long it will take to make a delivery or how to best position packages in the delivery truck. The inventory staff who are the high-tech equivalent of stock boys and baggers just have to follow the coding on the computers they wear on their wrists. And the GPS in their trucks can provide the most direct routes. "To be honest, a lot of the math is done for them," says Nancy Kazarian, human resources director at the Chicago distribution center. "It's pretty mistake-proof. It tells them exactly what they need to do."

John Mooney is a longtime education writer in New Jersey, previously on staff with the Bergen Record *and* Newark Star-Ledger. *In addition to free-lancing for the* New York Times *and other newspapers, he is launching a state news and information service focusing on education.*

Why Very Young Children Can – and Should – Learn Math

Early lessons help preschoolers succeed later on and stimulate rapidly developing minds.



Can young children learn mathematics? What is the best way to teach them? Herbert P. Ginsburg, a developmental psychologist at Teachers College, Columbia University, has been studying those questions for more than 25 years. The following questions and answers were mostly adapted from his chapter on early mathematics education in *Handbook of Child Development and Early Education* (Guilford Press, 2009).

Q ***Why should journalists care about early mathematics education?***

A As early as preschool and first grade, children in East Asian countries like Japan, South Korea and Singapore do significantly better than American children. Although middle- and higher-income American children do very well on average in international comparisons, low-income children do not. That brings down the rating for the country as a whole. Early math education could help those children succeed later on. Research also shows that early math – when done appropriately – can help all children do better once they get to school, and math can stimulate young children's naturally active minds so they enjoy school more.

Q ***Why are adults often reluctant to consider teaching mathematics to young children?***

A In the United States, there is widespread fear and loathing of mathematics, which is often based on people's memories of their own unhappy school experiences. Many early childhood educators also believe that math is bad for young children because they are not ready for it and will become anxious if they cannot succeed. Developmentally inappropriate math classes would indeed have that effect, but well-designed programs would not.

Q ***Can little children really learn mathematics?***

A The overwhelming body of research conducted over the past 25 years suggests that contrary to popular opinion, young children can learn both concrete and abstract mathematics. And what's more, they often enjoy it. From birth to age 5, young children develop informal mathematical ideas about numbers, shapes, space, patterns, and other mathematical topics. For example, they can see that one plate has five cookies and another has three, and they understand that five is more than three. They can easily distinguish between a circle and a square, although they may not know the words for these shapes. They can locate objects in space.

Q ***How powerful is the math that young children learn?***

A Modern research has shown that children's minds are complex. From an early age, they seem to understand some abstractions involving numbers (for example, that the order of counting a group of objects does not matter, so long as you count each object only once) and are even concerned to know what is the "largest number," clearly a very abstract mathematical issue. They do not simply remember the isolated "addition facts" but instead can spontaneously develop, without adult help, various general methods or strategies for figuring them out. At the same time, children display certain kinds of mathematical ineptitude. For example, they have difficulty understanding that a set of seven objects spread out in a long line is the same number as a set of seven objects arranged in a shorter line. Children's mathematics is a kind of hidden world that adults have to learn to see.

Q ***What is the best way to teach mathematics to young children?***

A The leading professional organizations in the field recommend that early mathematics instruction cover the "big ideas" of mathematics in such areas as number and operations, geometry (shape and space), measurement, and "algebra" (particularly patterns). The research-based expectation is that early math education should involve topics more challenging than those usually taught. This is not the kind of mathematics early childhood teachers usually teach. Nor is it the trivial mathematics of the drill sheets. It is a more genuine mathematics than either of these, and children can benefit greatly from learning about it under teachers' guidance.

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Q ***Does this imply a "push-down" curriculum?***

A Not at all. That would be a disaster – just as it often is for the children in the higher grades! The proposal is not to give young children textbooks, worksheets, and all the deadly drills that too often characterize (unsuccessful) elementary mathematics education. The goal is rather to engage children in "big ideas."

Q ***What else does early mathematics involve?***

A Mathematics involves not only the content – the big ideas – but also ways of thinking. Children need to mathematize – to conceive of problems in explicitly mathematical terms. One of the functions of mathematics education is to help children advance beyond their informal, intuitive mathematics.

Q ***How can we help children to learn big ideas and to think mathematically?***

A First, the preschool classroom or child-care center should contain a rich variety of objects and materials – such as blocks, water tables and puzzles – that can set the stage for mathematics learning. Modern electronic toys and computers can be useful, too. The second important component is play. Children have a good time when they play, and it stimulates cognitive development. We know that children do indeed learn a good deal of everyday mathematics on their own in the course of free play. Third, projects can help teachers capitalize on children's natural curiosity and can help them learn that making sense of real-life problems can be stimulating and enjoyable. These three components are most effective if they are part of a well-planned curriculum that covers big concepts – like numbers, shapes and patterns – in the context of specific and exciting activities. To succeed, a curriculum needs to be of high quality and needs to be implemented well.

Q ***What does good implementation of a curriculum involve?***

A It involves intentional teaching of a planned sequence of activities. The early childhood educator needs to teach the material in an intentional, organized manner, while at the same time being sensitive to individual children's interests. The teacher needs to provide thoughtful but firm guidance. Good teaching is in many ways like good parenting. And like good parenting it does not always produce immediate (or long-term) success!

Q ***How can you possibly use a single curriculum with a diverse group of children?***

A Dealing with varying abilities is always a problem, no matter what the age of the students or the subject being taught. Early childhood mathematics education is no different. It cannot meet the needs of all children, and it often must fail. Teachers must do their best and what is best depends on the individual teachers and on the individual students they are trying to teach.

Q ***What should journalists be looking for in the classroom?***

A I'm not sure that a brief visit to a classroom will do them much good. But they can try to determine if kids look bored, are restricted to chairs, or seem to be harshly disciplined. On the positive side, they can observe how the teacher talks to the kids. Does she try to explain, use reasonably complex language, and try to engage the kids in some kind of dialogue rather than just lecture to them or tell them what to do?

Q ***What stories should we be writing about early mathematics?***

A The most relevant story, I think, is about whether a district or some other education authority is trying to promote education – literacy, math, science – for young children. If so, what kind of approach are they taking? Do they favor drill? Do they rely exclusively on play? Do they try to promote some intentional teaching? Are they trying to use some of the new math and science curricula? And are they trying to institute long-term, intensive professional development for their teachers?

Q ***What mistakes have you seen in coverage?***

A I haven't seen many stories on the topic, at least as far as preschool is concerned. But here are some things to avoid: Don't assume that any one curriculum or method is a magic bullet. Everything can be done badly. Don't assume that early math education is simple or easy. It takes a lot of skill to do it well. Don't forget that at the heart of education at all levels is the teacher, and that most preschool teachers have not been trained well in doing math education. But they should be, and that requires commitment and resources from the appropriate educational authority.

U.S. Math Education Has a 'Ham Butt Problem'

International comparisons reveal that some of our practices are holding students back.

By Justin Snider

Ever heard of the "ham butt problem"? Here's how Erin McKean, founder and CEO of the online dictionary Wordnik, recently described it: "Woman's making a ham for a big family dinner. She goes to cut the butt off the ham and throw it away, and she looks at this piece of ham and she's like, 'This is a perfectly good piece of ham. Why am I throwing this away?' She thought, 'Well, my mom always did this.' So she calls up Mom, and she says, 'Mom, why'd you cut the butt off the ham when you're making a ham?' She says, 'I don't know, my mom always did it!' So they call Grandma, and Grandma says, 'My pan was too small!'" [1]

The "problem" at the heart of McKean's anecdote is this: People too often fall into the trap of thinking that the way things are is the way they've always been – which, it follows, is the way they must always be. We don't stop to ask ourselves *why*. Nowhere is this truer than in education. High school English teachers make their students read certain novels for no other reason than that they read them in school, as did their parents and grandparents. Think of *Catcher in the Rye*, *Old Man and the Sea*, *Siddhartha* or *The Scarlet Letter*. Masterpieces? Not really. Worthy of reading because previous generations have read them? Maybe.

Similar thinking prevails in American math classes. The familiar high school sequence – Algebra I, geometry, Algebra II, trigonometry – is so widespread and deeply ingrained that it's easy to forget that it's not the only way for students to master mathematics. And, in fact, it might not even be a particularly efficient or effective way to teach math. If we look at countries that outperform the United States on international math assessments like the Trends in International Mathematics and Science Study (TIMSS), some of what we do starts to look very odd. Math curricula in other parts of the world are often structured quite differently than those in the United States.

But it's not just curricula: Math classes elsewhere generally have a very different look and feel. For instance, math teachers in America devote much more class time to reviewing concepts than to introducing or practicing new content. In contrast, teachers in countries that outperform the United States tend to spend significantly less time on review (see Figure 1). Reporters who cover mathematics in U.S. classrooms should be aware of such differences so they can better understand and question what they observe.

William Schmidt, an expert on math education at Michigan State University, says American math curricula suffer from the mile-wide, inch-deep phenomenon: far too many topics, all of which are covered superficially. At former Secretary of Education Rod Paige's Mathematics Summit in February 2003, Schmidt spoke of the arbitrary way in which textbooks and state standards present math topics. "Teachers are expected to introduce relatively advanced mathematics in the earliest grades," he says, "before students have had an opportunity to master basic concepts and computational skills." [2]

At the same time, most U.S. math curricula continue to focus on basic computational skills through eighth grade. The result? Many American students master neither basic computation nor advanced mathematical concepts. By the end of eighth grade, Schmidt estimates, U.S. students have fallen two or more years behind their peers in high-achieving nations.

In Japan, a typical lesson might consist of three individually presented problems, which take about 15 minutes each. Discussions are "organized so as to make connections and relationships explicit," according to an

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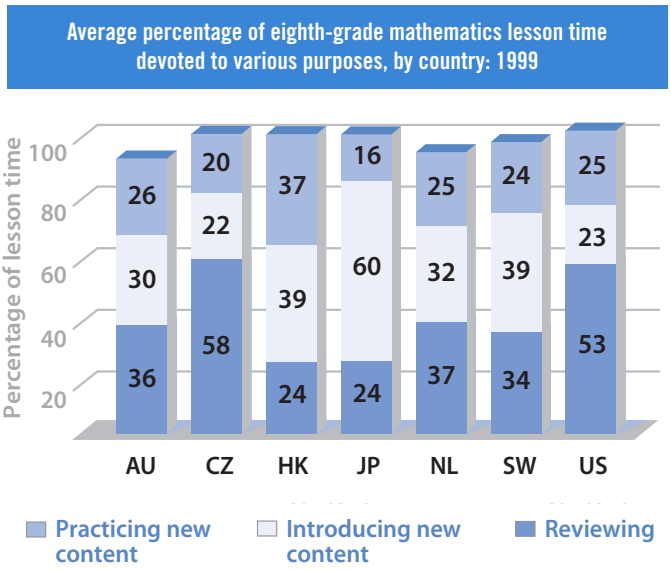
FIGURE 1



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analysis of the TIMSS 1999 Video Study that appeared in *ON-Math*, a journal published by the National Council of Teachers of Mathematics.[3] In Hong Kong, three-quarters of class time is on work in which the whole class participates and the teacher does almost all of the talking.[4]

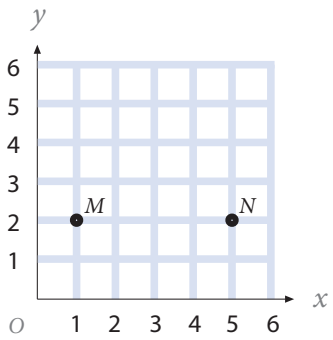
The picture that emerges from international comparisons of math instruction is that there is no one best way to teach math. In many Asian countries, lectures are more common than in the United States. In Switzerland, working in pairs or groups is the norm, whereas in the Netherlands, students often work alone and only seek help from peers or the teacher when they're stuck.[5]

So if the key to high math achievement isn't a particular pedagogical approach, then what *is* the answer? Schmidt and fellow researchers say it comes down to three essential things: the coherence and depth of the curriculum, the quality of assessments and the content knowledge of teachers. A close look at international data suggests they're right. Reporters should zero in on these three ingredients when covering math instruction.

CURRICULUM

The vast majority of American eighth-graders have little or no familiarity with geometry, which shouldn't be a surprise: They are busy with pre-algebra. Most do not encounter geometry until 10th grade. Contrast this with math instruction in many Asian and Eastern European countries: eighth-graders in these regions, according to Schmidt, have moved on to the study of algebra, geometry and basic trigonometry. Consequently, the problem[6] below in Figure 2 – taken from the 2007 TIMSS – isn't hard for them:

FIGURE 2



Two points *M* and *N* are shown in the figure above. John is looking for a point *P* such that *MNP* is an isosceles triangle. Which of these points could be point *P*?

a. (3,5)
b. (3,2)
c. (1,5)
d. (5,1)

At least 75 percent of eighth-graders in Taiwan, South Korea, Singapore, Japan, Hong Kong, Slovenia, Lithuania and Russia answered this question correctly in 2007. The worldwide average among participating countries was 57 percent. In the United States, however, only 45 percent of eighth-graders got this question right. Why? The concept of an "isosceles triangle" – one with two sides of equal length – doesn't appear on most American students' radar until 10th grade.

ASSESSMENTS

The quality of assessments – whether at the local, state or national level – matters because teachers learn over time what is commonly tested and, in response, often recalibrate what and how they teach. This is the "what gets taught is what gets tested" trend that Linda Perlstein writes about in *Tested: One American School Struggles to Make the Grade* (Henry Holt, 2007). American math assessments are heavy on multiple-choice questions, no doubt in part because they are easy and inexpensive to grade.

But multiple-choice questions often mask more than they reveal; two students might correctly bubble-in answer "C" on a given question, and yet there's no way of distinguishing the student who guessed and got lucky from the student who worked out the problem and knows with 100 percent confidence that she's right. Multiple-choice tests are particularly poor at telling a teacher where a student's thinking went wrong. Did the error result from a sloppy miscalculation or a fundamental misunderstanding? There's no way to know.

Reporters should not shy away from asking teachers, schools, districts and states why they so often rely on multiple-choice assessments. Teachers should be able to articulate why they have opted to use a given assessment method (multiple choice, matching, fill-in-the-blank, open-ended or "constructed" response, essay and so forth). Justifying the use of a multiple-choice test by saying "It's just the way we've always done it" is insufficient – another instance of the "ham butt problem."

How do high-performing countries assess their students' math skills? A 2009 study by the American Institutes for Research that analyzed math assessments given to third-graders in Massachusetts and Hong Kong found a "greater depth of mathematical understanding required to solve many items on the Hong Kong assessment, compared with Massachusetts items."[7] Massachusetts was chosen because it is the highest-scoring state in the nation on the National Assessment of Educational Progress (NAEP) and it ranked fourth internationally on the 2007 TIMSS. Hong Kong topped the list.

The study's authors found that 71 percent of the questions on the Massachusetts exam were multiple choice, while in Hong Kong only 14 percent were (see Table 1). An even greater discrepancy was found in "computational difficulty": 97 percent of the Massachusetts questions were of low computational difficulty, compared to 61 percent of the Hong Kong questions. More challenging assessments typically lead to higher expectations and more thorough instruction, which in turn lead to higher student achievement. America has a lot to learn from other countries when it comes to meaningful assessment.

TABLE 1

COMPARISON OF 3RD GRADE MATH ASSESSMENTS IN MASSACHUSETTS AND HONG KONG

	MASSACHUSETTS MCAS Spring 2007 (35 questions)	**HONG KONG 2007 Territory-Wide Spring Assessment (36 questions)**
Number of questions by "strand," or area of math	Number: 17 **(49% of test)**	Number: 15 **(42% of test)**
	Measurement: 4 **(11%)**	Measurement: 12 **(33%)**
	Geometry: 4 **(11%)**	Geometry: 7 **(19%)**
	Data: 6 **(17%)**	Data: 2 **(6%)**
	Algebra: 4 **(11%)**	Algebra: 0 **(0%)**
Multiple-choice questions	25 **(71%)**	5 **(14%)**
Computational difficulty of questions	Low: 34 **(97%)**	Low: 22 **(61%)**
	Medium: 1 **(3%)**	Medium: 14 **(39%)**

Source: American Institutes for Research

TEACHERS

It's no secret that American elementary and middle school teachers often have weak math skills.[8] And obviously it's difficult to learn math from someone who doesn't understand the subject. Some policymakers are now seeking to fix this "ham butt problem" in a concrete way. In early 2009, Massachusetts became the first state to begin requiring elementary teachers to pass a mathematics subtest before earning certification. Just 27 percent of those taking the test at its first administration achieved passing scores.[9] And yet the bar isn't particularly high; the concepts tested require only a modest grasp of algebra, geometry and probability. Massachusetts Education Commissioner Mitchell D. Chester wasn't surprised by the low results, which confirmed in his mind why such a test is necessary in the first place.[10] The new Massachusetts regulation declares that a passing acquaintance with math is no longer acceptable among elementary teachers: "Candidates shall demonstrate that they possess both fundamental computation skills and comprehensive, in-depth understanding of K–8 mathematics. They must demonstrate not only that they know *how to do* elementary mathematics, but that they *understand* and can explain to students, in multiple ways, *why it makes sense*."[11]

This is a start. But while Massachusetts is far ahead of most states in this regard, it remains woefully behind many other countries. Liping Ma, a former senior scholar at the Carnegie Foundation for the Advancement of Teaching, has shown how and why Chinese teachers tend to be more successful than their American counterparts in teaching math to elementary students.[12] The Chinese teachers she interviewed – none of whom had college degrees – were much more likely than American teachers to display a "profound understanding of fundamental mathematics," a term she coined that is now in wide use among math experts.

In Singapore, where students typically top the TIMSS rankings, future teachers graduate in the top third of their high school class and receive a free, four-year education courtesy of the government. Stanford professor Linda Darling-Hammond, an expert on teacher quality, reports that beginning teachers in Singapore earn more than beginning doctors.[13]

This, of course, is worlds apart from what we do in the United States. But that is hardly reason not to question why we do things the way we do. Journalists can add a rich international angle to their reporting by looking at how other countries tackle fundamental issues like curricular coherence, student assessment and teacher quality. In the process, journalists just might discover that some countries have never had a "ham butt problem" because they've always used properly sized pans.

[1] At the 2007 TED (Technology, Entertainment, Design) conference. A video of her talk can be accessed at http://www.ted.com/talks/erin_mckean_redefines_the_dictionary.html.

[2] A transcript of Schmidt's talk is available online at http://www.ed.gov/rschstat/research/progs/mathscience/schmidt.html.

[3] Givvin, K., Jacobs, J. & Hollingsworth, H. (2006). "What Does Teaching Look Like Around the World?" In *ON-Math*, *4*(1). National Council of Teachers of Mathematics.

[4] Ibid.

[5] Ibid.

[6] This question comes from the 2007 Trends in Mathematics and Science Study (TIMSS-4), available online at http://nces.ed.gov/pubs2009/2009001.pdf.

[7] Leinwand, S. & Ginsburg, A. (2009, April). "Measuring Up: How the Highest Performing State (Massachusetts) Compares to the Highest Performing Country (Hong Kong) in Grade 3 Mathematics." American Institutes for Research. Page 4. Available online at http://tinyurl.com/ne9k38.

[8] See, for instance, Ball, D.L., Hill, H.C. & Bass, H. (2005, Fall). "Knowing Mathematics for Teaching." *American Educator*. Available online at http://tinyurl.com/kqxocr.

[9] See Commissioner Mitchell D. Chester's memorandum to the Massachusetts Board of Education (dated May 13, 2009), available online at http://www.doe.mass.edu/boe/docs/0509/item3a.html.

[10] Ibid.

[11] Massachusetts Department of Education. (2007, July). "Guidelines for the Mathematical Preparation of Elementary Teachers." Page 15. Emphasis in the original. Available online at http://www.doe.mass.edu/mtel/mathguidance.pdf.

[12] Ma, L. (1999). *Knowing and Teaching Elementary Mathematics: Teachers' Understanding of Fundamental Mathematics in China and the United States.* Mahwah, NJ: Lawrence Erlbaum Associates.

[13] Darling-Hammond, L. (2008, February 14). "How They Do It Abroad." *Time* magazine.

Math Teachers: Shortage Eases, but Issues Remain

Researchers target high turnover, inadequate preparation as challenges needing attention.

By Sarah Neufeld

In recent years, school district administrators have searched far and wide to find qualified math teachers. They've traveled abroad to recruit, reimbursed for tuition costs, and offered stipends and signing bonuses. The Obama administration says recruiting and retaining quality math teachers, particularly for the neediest schools, must be a national priority.

So what's behind this shortage? Are colleges of education failing to turn out enough qualified candidates? Is lack of support for new math teachers driving them away?

Richard M. Ingersoll, a University of Pennsylvania education and sociology professor, has generated substantial discussion with his research concluding that there actually isn't a lack of teachers in math and the other traditionally hard-to-staff subject, science. The problem, Ingersoll says, is poor working conditions – particularly at schools serving impoverished populations – that cause teachers to leave long before retirement age. In 1999–2000, the most recent year for which Ingersoll had data, 8,021 math teachers entered the field, twice as many as the number who retired. But 13,750 math teachers quit that year.

"We actually produce enough folks," Ingersoll says. "It's just that the turnover is such that we have these staffing problems in particular types of schools."

Secondary schools in high-poverty areas, both urban and rural, have the most trouble finding and keeping math teachers. "Almost every urban area has massive challenges and problems," says Henry Kepner, president of the National Council of Teachers of Mathematics (NCTM). "The rural areas, it's almost a disaster for math." Kepner also says that schools in the Southwest have had trouble with math vacancies because of rapid growth in that part of the country.

But this year, some districts that have long struggled to find math teachers suddenly seem to have enough, the result of the economic downturn. States such as California are confronting the prospect of widespread teacher layoffs. In New York City, a hiring freeze left 39 newly minted math teachers – all of whom spent the past year earning master's degrees funded by the nonprofit group Math for America – scrambling without placements.

"We don't need any more math teachers in Baltimore City, first year ever," says Linda Eberhart, the math coordinator in the Baltimore school district, where last year 90 percent of new high school math teachers and half of new middle school math teachers were recruited from the Philippines.

Meanwhile, alternative certification programs for math teachers are seeing applications on the rise. Layla Avila, a vice president of the New Teacher Project, a national nonprofit that trains career-changers to work in urban and rural districts, says the challenge is making sure applicants are committed to a long-term change. "We don't want people who think, 'I can do this for a couple of years and then go back to my old job,' " she says.

If the shortage of teachers might be easing, for now at least, the debate over what type of preparation is required for a successful math teacher continues to intensify – as schools and teachers face ever-increasing pressure to raise student test scores in math.

A college major in math education might be ideal, but Kepner points out that colleges have never produced a lot of math majors of any type, much less majors in math education.

The NCTM maintains that secondary math teachers should have the equivalent of a major in mathematics, but often they do not. Some enter classrooms after only a few weeks of review in the subject from an alternative certification program and then begin work on master's degrees while they are teaching.

Kepner says people switching from math-oriented careers often have limited exposure to the entire subject – an engineer, for example, might have an extensive

calculus background but never have taken a class in statistics – and need well-rounded training. And knowing math doesn't automatically translate into being able to teach it effectively. Math teachers have to know math in a way that's different from mathematicians; they need to be able to look at students' incorrect solutions to a problem and diagnose the conceptual or procedural error that led them to that result.

In elementary grades, where teachers are trained as generalists in colleges of education, many mathematicians believe that math preparation is grossly inadequate. A recent report by the National Council on Teacher Quality (NCTQ)[1] says that "teaching elementary math requires much greater competency than is generally presumed." It recommends that states require elementary teachers to demonstrate proficiency at least through Algebra II as a condition for admission to education school. But such knowledge is not required to pass even the licensing exams that teachers take at the end of degree programs.

"If we are serious about making sure we stay globally competitive, individuals who were themselves unable to master even high school-level math or science courses should not teach these subjects to the next generation, no matter what level they plan to teach: elementary, middle or high school," the report says.

Last year, NCTQ evaluated the elementary education programs at 77 colleges and universities and found that "almost anyone" can get through the math requirements; even the people teaching math to elementary teacher candidates are "not professionally equipped to do so," it said.

A growing number of schools are hiring math specialists to make up for teachers' shortfalls, according to a report released last year by the National Mathematics Advisory Panel.[2] The panel concluded that "the mathematics preparation of elementary and middle school teachers must be strengthened" and recommended research on the use of full-time math teachers in elementary schools.

While mathematically oriented people can often earn more money for arguably less demanding work in other fields, Ingersoll found in his research that money didn't drive math and science teachers from the profession more than it did teachers of other subjects. The most common complaints, he says, were students misbehaving and – an issue easier to resolve – administrators not allowing teachers to be a part of school decisions. Those problems are most acute in the neediest schools, and teachers often leave after a few years for easier assignments in the suburbs.

> **"Math teachers have to know math in a way that's different from mathematicians; they need to be able to look at students' incorrect solutions to a problem and diagnose the conceptual or procedural error that led them to that result."**

UTeach at the University of Texas at Austin has gained national attention for its work preparing math teachers early. The program, which places undergraduate math and science majors in education classes and gives them student-teaching experience from as early as freshman year, is being replicated at 13 other universities around the nation. It has graduated 500 students so far, and 80 percent are still teaching after five years.

Math for America (no relation to Teach for America), founded by billionaire Jim Simons, is also growing, having expanded from New York to four other cities. It pays for fellows to spend a year earning master's degrees in math education before teaching in high-need schools and provides them a $100,000 stipend over five years. Retention is a big emphasis, with a monthly social event and two or three professional development sessions a month. The retention rate after the first five years is more than 90 percent.

While new-teacher recruitment efforts are often covered in the media, reporters covering the math teaching profession should return to explore their impact. How many math teachers are still there after two years? Five years? How many quit mid-year? If your district has recruited math teachers abroad, how long do they stay? What kind of support do they receive? How do average tenures compare at the urban versus suburban schools in your region? What math preparation is required of teachers by colleges of education and alternative certification programs in your area?

This year, there are also many story possibilities involving the recession's impact on math teacher recruitment and retention: How many math teachers is your school district hiring and how many are leaving in comparison with past years? Has the district made hiring commitments it isn't keeping? What's happening with applications?

Sara Neufeld, a Baltimore-based reporter, has written about education for the past nine years. She covered schools for six years at the Baltimore Sun *and three years at the* San Jose Mercury News.

[1] *http://www.nctq.org/p/docs/nctq_nmsi_stem_initiative.pdf*

[2] *http://www.ed.gov/about/bdscomm/list/mathpanel/report/final-report.pdf*

How an Education Reporter Schooled Herself in Math

Enrolled in an Algebra II class, a journalist conquers her fears and starts a discussion.

By Liz Willen

After two years on the education beat, *Washington Post* education reporter Michael Alison Chandler noticed she was doing more stories about math: new graduation standards, training issues for math teachers, pressure to develop a math-savvy workforce.

As Chandler thoroughly wrote and reported each new trend and issue, a nagging fear followed her: Could a math-phobic reporter who dodged the subject whenever possible do a thorough job of covering math?

"I started thinking about what I was missing. How would I see the world differently if I had more math skills?" Chandler says.

Her daring solution? Go back to high school, enroll in Algebra II, and blog about it for the *Post* in "X = Why? A year reliving high school math."

Attending an Algebra II class at Fairfax High School in Virginia and blogging about it gave Chandler a valuable opportunity to re-examine the quality of her own math education 15 years earlier at a private, all-girls high school in Ohio. Being back in a classroom offered a close-up view of teaching and learning that few reporters experience; it also prompted her to consider questions she could not answer while scrambling to cover the standard education beat menu of budget battles and test score debates.

"There were more math stories and standards stories coming up, and the paradox is that while I've always thought math was important, it was as small a part of my career as I could make it," Chandler says. "Both my parents taught writing. They never encouraged me to do math. I never had a real reason to focus on it."

Chandler suddenly had a reason. With the help of a prep book, a tutor and about 12 hours of preliminary homework, she took her seat in class last September "to revisit high school algebra and find out what I might be missing and what it might take to create a generation of students who aren't afraid to call themselves math people."

Chandler came to class every other day at 7:20 a.m. both to learn math and to report on its meaning and impact in her blog. At 32, she cut something of an odd figure in a classroom of 27 teenagers in Fairfax County, a high-performing district that is the 12th largest in the country, with 169,000 students. "I was older than their teacher, but I wasn't a teacher," Chandler says. "They knew I was a reporter, but I never had a well-defined role. I think they were a little suspicious… but I was an adult, so they weren't sure what to do about me."

In an early blog posting, she laid out some of her reasons for taking math and exploring math trends. "Algebra has been creeping into middle schools and elementary schools at an alarming rate," Chandler wrote. "And advanced algebra is required increasingly for all students, not just the nerdy ones. A national testing obsession is causing everyone to pay closer attention to pesky

math scores. And chief executives and politicians are trying to drum up workers for a changing technology-based economy that they maintain is built upon an invisible mountain of equations."

Beyond chronicling her struggles with a graphing calculator and unfamiliar equations, Chandler used the blog to introduce math topics ranging from quadratic equations to teacher quality, all while attempting to create a dialogue with readers. She tackled the topic, "Aspiring Elementary Teachers Fail New Math Test"; posed the questions: "Is Math Fun? Should It Be?"; and described efforts to encourage Native American girls in science and math.

Fairfax High School Principal Scott Braband welcomed Chandler's presence in class and the blog because he felt it would showcase the work of teachers, help connect math class with "real world applications," and give parents a close-up view of what their children were learning.

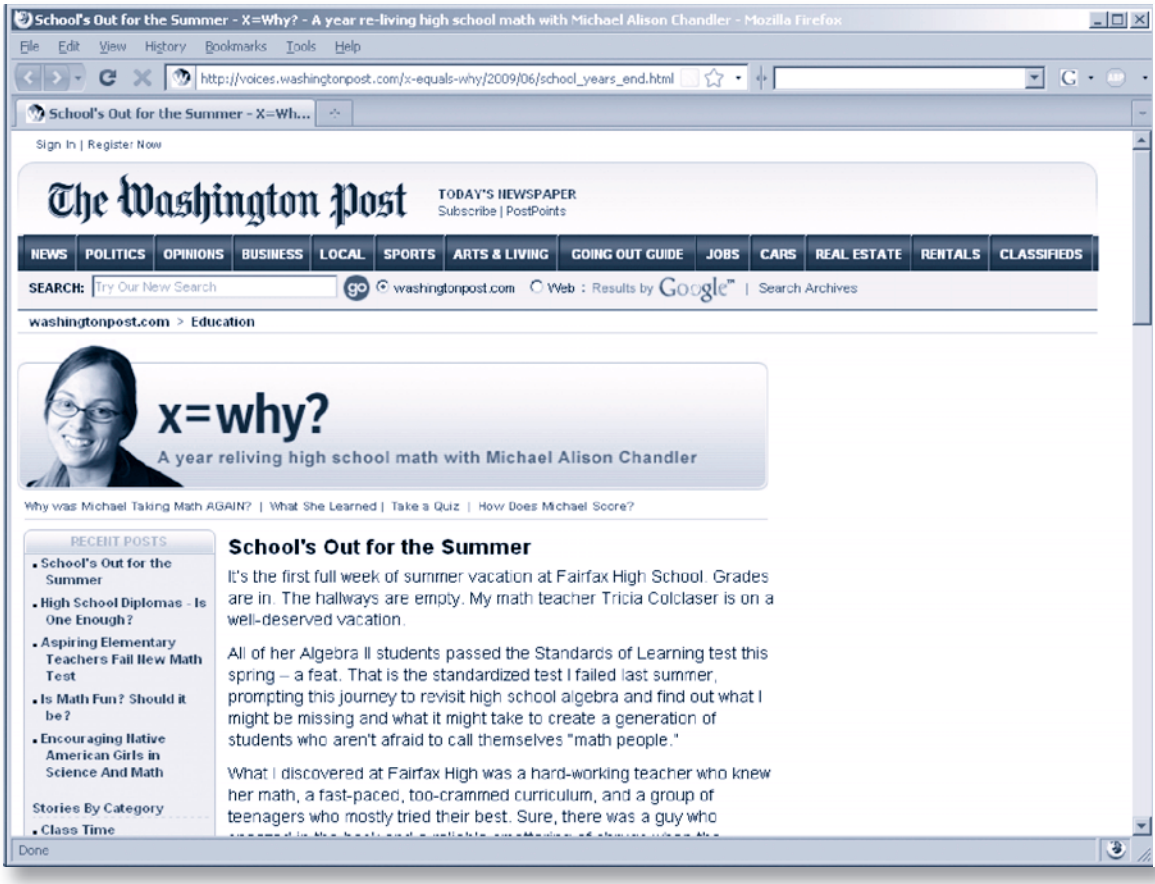
Chandler made it through the first semester with an A – "barely," as she put it – and spent the second half of the year auditing the class instead of participating as a student. As she scrambled to catch up, the class moved quickly through topics and reviewed them repeatedly. Ultimately, she found "a hard-working teacher who knew her math, a fast-paced, too-crammed curriculum, and a group of teenagers who mostly tried their best."

Chandler's editor, Nick Anderson, considered the blog a worthwhile experiment, especially because it inspired readers to tell their own stories about the different ways math is taught from school to school and classroom to classroom.

As the blog evolved, Chandler found it easier to get some items in the print edition, where space is at a premium, while others remained online only. Some topics generated a great deal of comment and debate, others less so. The paper learned lessons about blogging (timing and frequency are critical) along with insights from blog contributors about math education.

At times, the dual role of journalist and student created some discomfort for Chandler, who became part of the classroom dynamic and even posted her quizzes and scores on the blog, although not those of her students. "I felt a little weird about exposing the students and the teacher," she says. "I felt that I owed them a little more. In some ways, it was uncomfortable."

It wasn't always possible to remain a critical and neutral observer in class, as Chandler fought to keep up with both math and the demands of the education beat. That conflict was the reason why she decided to audit the class during the second semester.



Chandler finished her last blog entry in June 2009, concluding that lessons she'd learned had influenced both her journalism as well as her math phobia. Her lack of math skills had left her feeling vulnerable in a battered economy, especially with a troubling shakeout in the newspaper industry beset by declining advertising revenues.

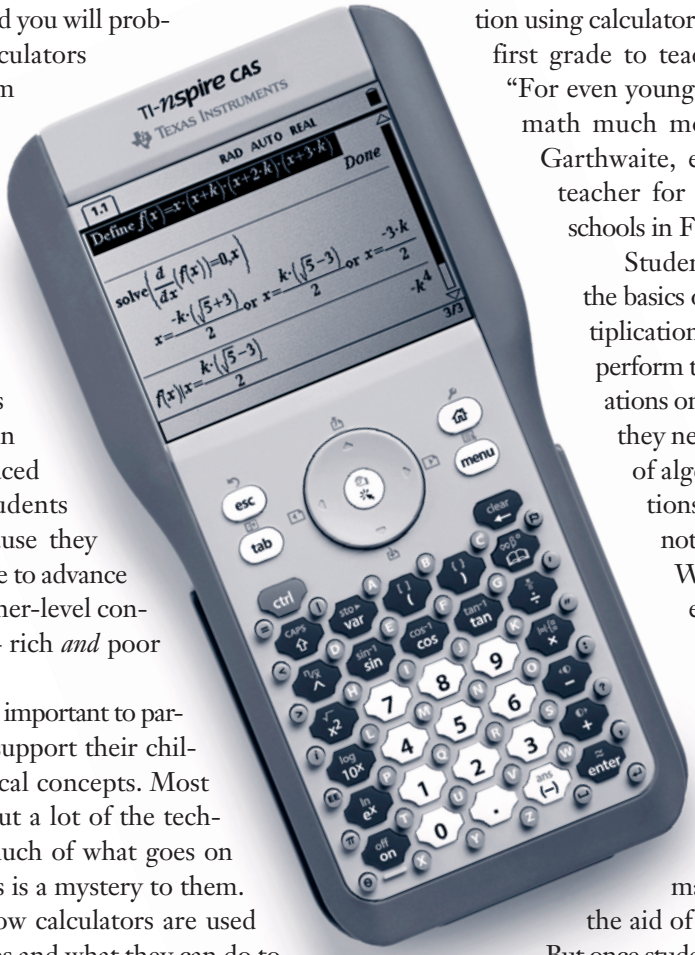
Chandler has since enrolled in a financial planning class for women and acknowledged in her final blog entry that she was "tackling the numbers in my credit report (ugh) and my bank statements right now," and had plans to study more statistics and economics. And, she added, "Who knows, someday I might even take calculus."

How Calculators Are Changing the Math Classroom

Devices help teachers cover more ground, but students still must understand the basics.

By Emily Sachar

Walk into almost any classroom in America – from elementary school on up – and you will probably see students using calculators and other tools that perform instant computation. The smart story today is not the 20-year-old debate about whether this technology belongs in schools. That fight is over. Instead, reporters should focus on how these new tools have transformed the way math is taught and learned. When should calculators be introduced to young children? Are students better problem-solvers because they have these tools? Are they able to advance more quickly and master higher-level concepts? And are all students – rich *and* poor – able to benefit?



These stories are critically important to parents, who often struggle to support their children's mastery of mathematical concepts. Most parents learned math without a lot of the technology available today, so much of what goes on in their children's classrooms is a mystery to them. They need to understand how calculators are used in their district at various ages and what they can do to help their children succeed in math. Parents also want to know whether their local schools are making the best use of the technology that's available. Are the teachers well-trained? Has the district developed a consistent philosophy for calculator use?

The answers to such questions play out in different ways, depending on the grade level. The federal government supports effective use of technology in mathematics instruction through research programs at the National Science Foundation and the U.S. Department of Education, but does not write calculator policies for schools. Instead, it is the responsibility of state education departments to weigh in on technology use in grade-by-grade math standards that guide state testing programs and textbook selection. Individual districts then determine how they will incorporate calculators and other math technologies as well as how teachers will be trained to use these tools.

Math standards in more than a dozen states mention using calculators as early as kindergarten or first grade to teach kids number patterns.[1] "For even young kids, calculators just make math much more efficient," says Susan Garthwaite, elementary math resource teacher for the 138 public elementary schools in Fairfax County, Va.

Students still need to understand the basics of addition, subtraction, multiplication and division and be able to perform those and other simple operations on their own – just as later on, they need to understand the basics of algebra so that graphing functions makes sense and they're not just punching random keys. Without that basic knowledge, students can become so calculator-dependent that they can't do division or multiplication by hand. The 2008 National Mathematics Advisory Panel report[2] stressed the absolute necessity of mastering these skills without the aid of technology.

But once students have gained that fluency, calculators can enable them to move forward quickly. By the third or fourth grade, students are learning to use basic four-function calculators. Teachers can focus instructional time on word problems and the logic of math.

Calculators can also be a great boon to students who enjoy thinking about mathematical concepts but are terrified of numbers because they fear making computational errors. "Nothing suggests that calculators are damaging students," says Henry Kepner, president of the National Council of Teachers of Mathematics (NCTM). "Make sure kids understand the work they're doing, then teach them how to work the calculator appropriate to the subject they're studying, then let them use it to take the drudgery out of math."

From middle school on, the math curriculum virtually requires calculators for students to keep up, and many teachers have made dramatic changes in the way they

teach. "I find myself asking higher-order questions and skills of my students," says Natalie Jakucyn, who teaches pre-calculus to sophomores at Glenbrook South High School in Glenview, Ill. "They are thinking about mathematical problem-solving from many more perspectives than when I was in school." Her students use the $150 TI-Nspire CAS (Computer Algebra System) from Texas Instruments.[3]

Many teachers believe the benefits extend far beyond school. They say students need to feel comfortable with technology starting at an early age in order to be ready for the working world. "It is my job to prepare students for their future, not my past," says Peg Cagle, an eighth-grade math teacher at the Lawrence Gifted Magnet School in Los Angeles. "We are digital immigrants and our kids are digital natives."

The ability to apply technology appropriately has become the hallmark of a good math and science education. The NCTM strongly endorses calculator use: "Calculators and other technological tools, such as computer algebra systems, interactive geometry software, applets, spreadsheets, and interactive presentation devices, are vital components of a high-quality mathematics education," the NCTM says in its March 2008 position statement on the use of technology in math instruction. "With guidance from effective mathematics teachers, students at different levels can use these tools to support and extend mathematical reasoning and sense-making, gain access to mathematical content and problem-solving contexts, and enhance computational fluency."

Some issues for reporters to explore:

- At what age should calculators be introduced and what mathematical concepts do students need to understand before they can use these tools effectively? Is fluency with basic mental math a prerequisite for success in more challenging mathematics?
- What is the research on the effectiveness of calculators? According to data from the National Center for Education Statistics, calculators don't have much of an impact on test scores in fourth grade, but do appear to make a big difference by eighth grade. Researchers Jeremy Roschelle and Lawrence Gallagher of SRI International in Menlo Park, Calif., have found that the correlation between frequent calculator use and high scores holds true for eighth-graders from all economic backgrounds. Roschelle suspects that poor teacher training accounts for the weaker scores for fourth-graders.
- What tasks should not be performed on a calculator? Some educators think that certain "real world" tasks, like learning to make change, should be taught in a hands-on way using real money. What other kinds of learning experiences are better without calculators?
- How are teachers in different grades trained to use calculators in class? Older teachers often are reluctant to use these tools, especially in the early grades. How do districts overcome this opposition?
- How does technology affect the way learning disabled students learn math? Do calculators help or hurt youngsters who have trouble reading numbers and understanding numerical concepts?
- Are the benefits of technology shared equally by rich and poor kids? Calculators used in advanced high school math classes are generally under $200, but even that amount can be daunting for some families. What are schools doing to bridge that gap? Cagle, for instance, has one class set of calculators, so she does not give homework that requires calculator use. But she does give tests that require calculators. Teachers like Cagle often juggle class sets among all of their students or even among various teachers. How does that affect students' comfort level and expertise with these tools?

Emily Sachar is a two-time winner of the Grand Prize for Distinguished Education Reporting from the Education Writers Association. She has been an education reporter for Newsday *and* New York Newsday *as well as a math teacher in the New York City public school system.*

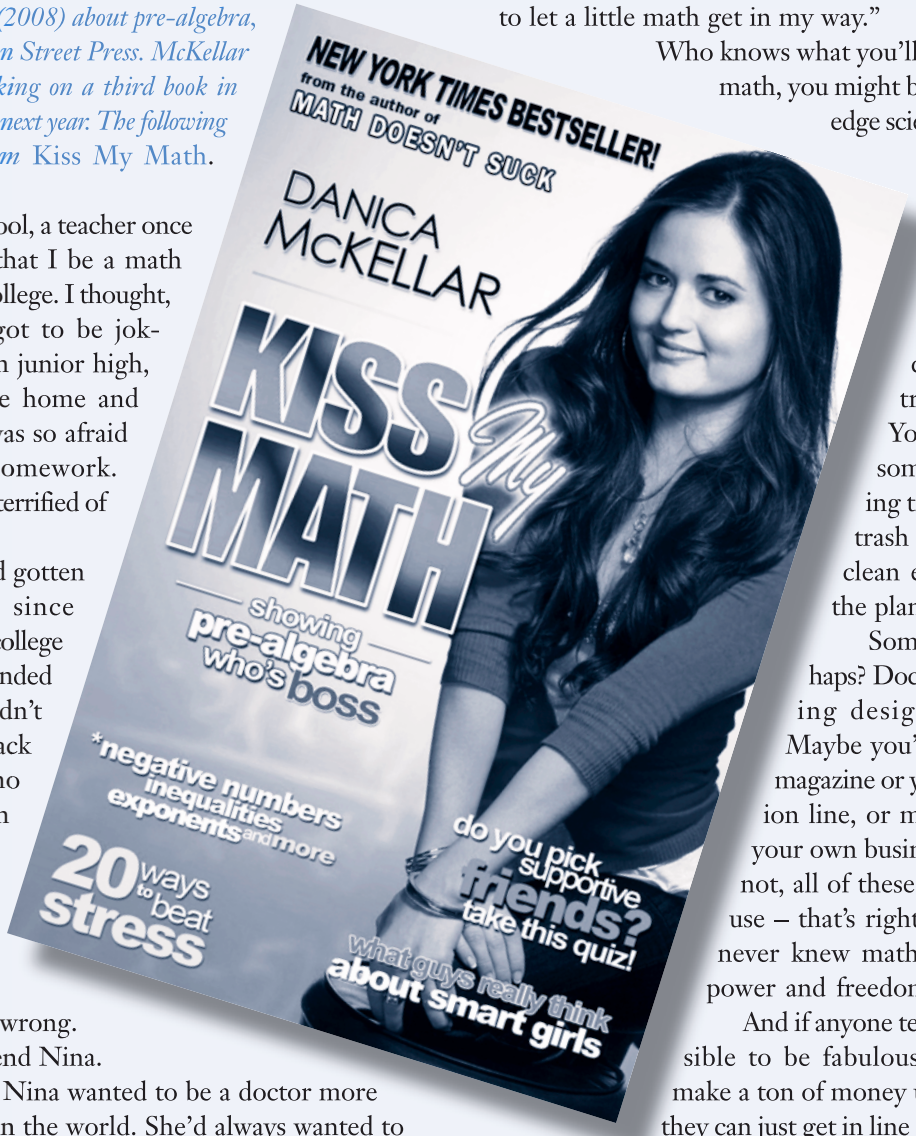
[1] See the Fordham Foundation's January 2005 analysis of state math standards, available online at *http://www.edexcellence.net/doc/mathstandards05FINAL.pdf.*

[2] *http://www.ed.gov/about/bdscomm/list/mathpanel/report/final-report.pdf.*

[3] Texas Instruments provided support for this publication.

Actress Danica McKellar Extols the Wonders of Math to Girls

Journalists writing about math should look beyond the usual suspects. A good example is actress Danica McKellar, best known for her roles on The Wonder Years *and* The West Wing. *But as co-author of a theorem that bears her name (The Chayes-McKellar-Winn Theorem), she is also an internationally recognized mathematician and an advocate for math education. A* summa cum laude *graduate of UCLA with a degree in mathematics, McKellar has tried to encourage girls' interest in math with two best-selling books,* Math Doesn't Suck: How to Survive Middle School Math Without Losing Your Mind or Breaking a Nail *(2007) and* Kiss My Math *(2008) about pre-algebra, both from Hudson Street Press. McKellar is currently working on a third book in the series, due out next year. The following is excerpted from* Kiss My Math.



In high school, a teacher once suggested that I be a math major in college. I thought, "Me? You've got to be joking!" I mean, in junior high, I used to come home and cry because I was so afraid of my math homework. Seriously, I was terrified of math.

Things had gotten better for me since then, but still – college math? That sounded really hard; I didn't think I could hack it. Besides, who studies math in college other than people who want to be math teachers, right?

Boy, was I wrong. Just ask my friend Nina.

In college, Nina wanted to be a doctor more than anything in the world. She'd always wanted to deliver babies! She was smart, funny, and totally capable of doing whatever she set her mind to – until she found out that calculus was a required course. The idea of taking calculus scared her so much that she dropped out of the pre-med program and gave up her dream!

And Nina isn't the only one. Believe it or not, lots of people change their majors and abandon their dreams just to avoid a couple of math classes in college.

So, what does "kiss my math" mean?

It means: "Um, excuse me, I'm going to do whatever I want with my life, and I'm sure as heck not going to let a little math get in my way."

Who knows what you'll do? Armed with math, you might become a cutting-edge scientist and develop your own line of all-natural makeup or therapeutic high heels. You might discover a cure for cancer or travel into space. You might create some cool engineering trick that destroys trash or creates super-clean energy and saves the planet!

Something else, perhaps? Doctor, lawyer, clothing designer, architect? Maybe you'll work for a big magazine or your favorite fashion line, or maybe you'll start your own business. Believe it or not, all of these fabulous careers use – that's right – math. Betcha never knew math could give you power and freedom in those areas.

And if anyone tells you it's impossible to be fabulous and smart and make a ton of money using math, well, they can just get in line behind you – and kiss your math.

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Resources on Math: Reports, Publications and Web Sites

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Web Sites

Achieve, Inc.
http://www.achieve.org/

Achieve is an independent, bipartisan, nonprofit education reform organization that helps states raise academic standards and graduation requirements, improve assessments and strengthen accountability. Achieve's *Math Works* advocacy kit *(http://www.achieve.org/MathWorks)* provides resources that make the case for why all high school students should engage in rigorous math course-taking.

Charles A. Dana Center, The University of Texas at Austin
http://www.utdanacenter.org/

The Dana Center provides Texas education leaders with new knowledge about teaching and learning, and supports K-12 teachers and leaders working to implement high academic standards for all students.

Conference Board of the Mathematical Sciences
http://www.cbmsweb.org/

The Conference Board of the Mathematical Sciences (CBMS) is an umbrella organization consisting of seventeen professional societies, all of which seek to increase or diffuse knowledge in the mathematical sciences. Its purpose is to foster understanding and cooperation among these national organizations to promote research, improve education and expand the uses of mathematics.

National Council of Teachers of Mathematics (NCTM)
http://www.nctm.org/

NCTM is a public voice for mathematics education, providing vision, leadership and professional development to support teachers in ensuring equitable and high-quality mathematics learning for all students.

The Mathematical Association of America (MAA)
http://www.maa.org/

The MAA is the largest professional society that focuses on mathematics accessible at the undergraduate level. Its mission is to advance the mathematical sciences, especially at the collegiate level.

Recent Hechinger Publications:

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July 2008

Leadership and Learning
July 2008

The Hechinger Institute on Education and the Media at Teachers College, Columbia University, is dedicated to promoting fair, accurate and insightful coverage of education, from pre-kindergarten through graduate school, in all forms of media. The Institute holds seminars for national audiences of journalists, publishes guides and primers such as this as resources for journalists, and offers online courses and Webinars. The publications are available on our Web site, along with other resources, commentaries and analyses of education coverage. Journalists from news organizations such as National Public Radio, the *Los Angeles Times*, *Washington Post*, *Boston Globe*, *Chicago Tribune*, *Christian Science Monitor*, *Philadelphia Inquirer*, *Miami Herald*, *USA Today* and others are regular participants. The Institute is named in memory of the late Fred M. Hechinger, a former Teachers College trustee and education editor of the *New York Times*. Support for the Institute and its work comes from a variety of national foundations including The Broad Foundation, Bill & Melinda Gates Foundation, Joyce Foundation, Kauffman Foundation, Lumina Foundation for Education, the Spencer Foundation, and The Wallace Foundation.

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The Ewing Marion Kauffman Foundation

was established in the mid-1960s by the late entrepreneur and philanthropist Ewing Marion Kauffman. Based in Kansas City, Mo., the Kauffman Foundation seeks to foster a society of economically independent individuals who are engaged citizens, contributing to the improvement of their communities. In service of this vision, and in keeping with its founder's wishes, the foundation focuses its grant-making and operations on two areas: advancing entrepreneurship and improving the education of children and youth.

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