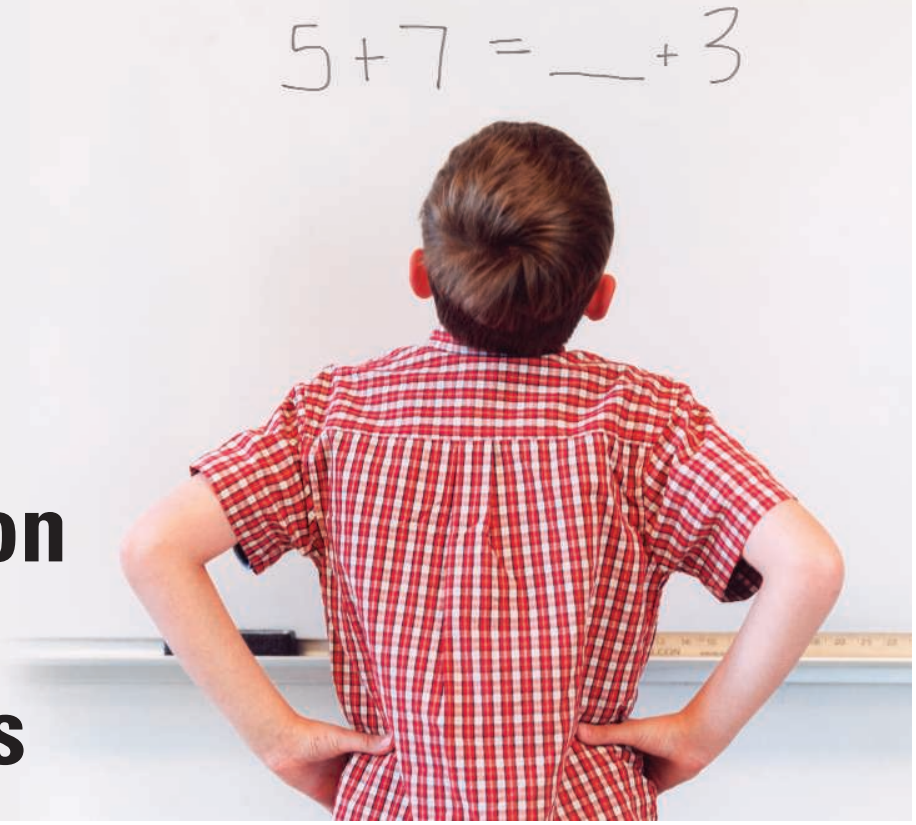

For years, mathematicians and math educators have blamed one another for the inadequacies of U.S. mathematics education. But both sides may finally be headed toward agreement on how to fix the system

Finding Common Ground in the U.S. Math Wars

LIKE A SHERIFF SUMMONED TO RESTORE order to a lawless town in the Wild West, Richard Schaar knew that taking on the Math Wars would be a rough assignment. An applied mathematician and former president of the calculator division at Texas Instruments (TI), Schaar was part of an industry-led panel trying to improve U.S. science and math education a few years back when he realized that a huge schism in the community would likely block any effort to reform elementary and secondary school mathematics.

"I hate labels, but in general the professional mathematicians were on one side, and the math educators were on the other," says Schaar, describing a debate, triggered by a huge backlash to a 1990s reform movement, that has persisted despite mounting concern about how poorly U.S. students fare in international comparisons. "The argument over direct instruction versus discovery learning, as the two sides are commonly described, was pulling the field apart. The mutual respect had gone away. And in that climate, any attempt to improve math standards at the state level would have been doomed to failure."

The solution seemed obvious to him: Bring together a handful of top guns from each side and hope for harmony rather than bloodshed. And that's exactly what Schaar has done, in the Common Ground initiative (www.maa.org/common-ground). The six-member group has made modest but impressive progress over the past 18 months in finding agreement on issues that for the last decade have led mathematicians and math educators, in the words of one mathematics society executive, "to sit on the sidelines and lob bombs at each other." (To be fair, both sides claim to be appalled by the analogy to warfare. But they use combat imagery repeatedly in conversations as a shorthand to describe their experiences.)

The Common Ground initiative is one of several hopeful signs that the two sides may be ready to call a truce and work together to improve U.S. mathematics education. Last month, the country's largest group of mathematics educators, the National Council of Teachers of Mathematics (NCTM), endorsed a short list of math skills, by grade, that every elementary and middle school student needs to master. These skills, called Curriculum Focal Points, are an attempt to correct what math educators decry as "mile-wide, inch-deep" curricula in most U.S. schools that leave many students unprepared for high school and, ultimately, precludes them from pursuing careers in science and engineering. This week, the Department of Education named mathematicians, educators, and community leaders to a presidential panel that will review the state of mathematics education (see p. 982). Observers are hopeful that the easing of tensions will improve the quality of the panel's recommendations on bread-and-butter issues such as student instruction, teacher training, and the additional research needed to enhance each area, not to mention make those recommendations easier to sell.

"I think Common Ground is a historic and groundbreaking exercise," says Frances "Skip" Fennell, a mathematics education professor at McDaniel College in Westminster, Maryland, and NCTM president. "I worked in the education directorate at NSF [National Science Foundation] in the late 1990s, and I was blown away by the anger in the community. This is exactly what we need to get things moving forward."

All for algorithms

Professional mathematicians blame themselves for some of those angry words. They were heavily involved in a major reform of the U.S. mathematics curriculum in the 1960s, after Sputnik, that was widely criticized as too difficult for the average student. In response, mathematicians largely withdrew from the fray and were silent when math educators promulgated the next round of reforms in response to a 1983 report that said low student achievement in reading and math was putting the country at risk. "There's been a divide between education and subject matter fields for a long time, but it's had its worst consequences in math," notes Roger Howe, a Yale University mathematician who has thought hard about the mathematical foundations of elementary principles such as place value. And when the mathematicians belatedly discovered aspects of the new courses that they didn't like, they unleashed their wrath upon federal officials and math educators, castigating them at every opportunity for demanding too little of students and watering down their discipline.

Given the rancorous tone of the debate, Schaar knew that he needed to sign up leading figures from both sides. He spent a year picking his team: two mathematics professors who have been sharp, public critics of the reform curricula (R. James Milgram of Stanford University in Palo Alto, California, and Harvard University's Wilfried Schmid) and three math educators in the forefront of those reforms

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(Deborah Loewenberg Ball of the University of Michigan, Ann Arbor; Joan Ferrini-Mundi of Michigan State University in East Lansing; and Jeremy Kilpatrick of the University of Georgia, Athens). In December 2004, the same month he retired from TI, Schaar convened the first meeting of the Common Ground initiative, with himself as facilitator.

Six months and six meetings later, the group issued a three-page document describing a handful of principles that should guide math education from kindergarten through high school. The principles include the automatic recall of basic facts, the importance of abstract reasoning, the need to acquire a mastery of key algorithms, and the judicious use of calculators and real-world problems. Two months ago, an expanded group met for a weekend to tackle the topics in greater detail, and last week, initial working papers from that meeting were posted. The core group met again last weekend to plot its next steps, as well as to clarify its earlier statement about setting high expectations for students—one that's been misinterpreted as an argument for making calculus a required course in high school.

The document doesn't say when or how any of the concepts should be taught. Common Ground is not a curriculum, Schaar points out. The most its participants can hope to achieve is to influence the process by which states develop standards, adopt textbooks, and develop the assessment tools to measure what students should be learning. Even so, their carefully worded statements on selected topics reflect hard-fought compromises on core issues that have roiled the community for more than a decade and that, once resolved, could pave the way for continued progress.

"There will always be differences," says Milgram, who in 2000 testified before Congress that "the sad state of U.S. mathematics education" is the result of "a constructivist philosophy" promoted by NCTM standards and endorsed by NSF and the Department of Education, the two leading federal sources of support for teaching mathematics. "But if we can agree on the essential content that students need to know, then the other fights become manageable. And I'd say that there has been far more agreement than disagreement."

Ball, who has done pioneering work on what math teachers need to know to do their jobs well (i.e., not just how to teach long division but also to understand why Susie's method is incorrect), believes that the process has been just as important as the product. "Our goal was to provide leadership to the field, to say to everybody: 'If we can do it, then the rest of you can, too.' And I think we've shown that it's possible to come together on many of the flash points."

One major flash point is the use of algorithms—how to do long division, for example—and the memorization of the facts upon which they are based. Many mathematicians maintain that current state standards and instructional materials downplay the use of such time-tested algorithms or allow students to bypass them entirely by using calculators. So when Common Ground asserts that "students should be able to use the basic algorithms of whole number arithmetic fluently, and they should understand how and why the algorithms work," the participants are trying to stitch up a vast rift in the community.

"Of course kids have to know how to compute and know their basic facts. But they also have to make sense of what they are being taught and explore the ideas with open-ended problems," says Sybilla Beckmann Kazez, a mathematician at the University of Georgia, Athens, who is well respected by both camps. "If you put it that way, everybody would agree." Schaar concurs that the initiative has only scratched the surface on this contentious subject: The question of algorithms "is an incredibly challenging area that will require additional exploration."

Getting to the (focal) point

NCTM's new curriculum focal points, covering prekindergarten through grade eight, are also just beginning their long journey through the educational system. (The document won't even be released publicly until fall, officials say, although drafts have circulated and the council's executive board approved the latest version last month at the organization's annual meeting in St. Louis, Missouri.) With three per grade, the focal points address what math educators decry as overly broad and shallow curricula in most U.S. schools that hinder mastery and prepare students poorly for college-level work.

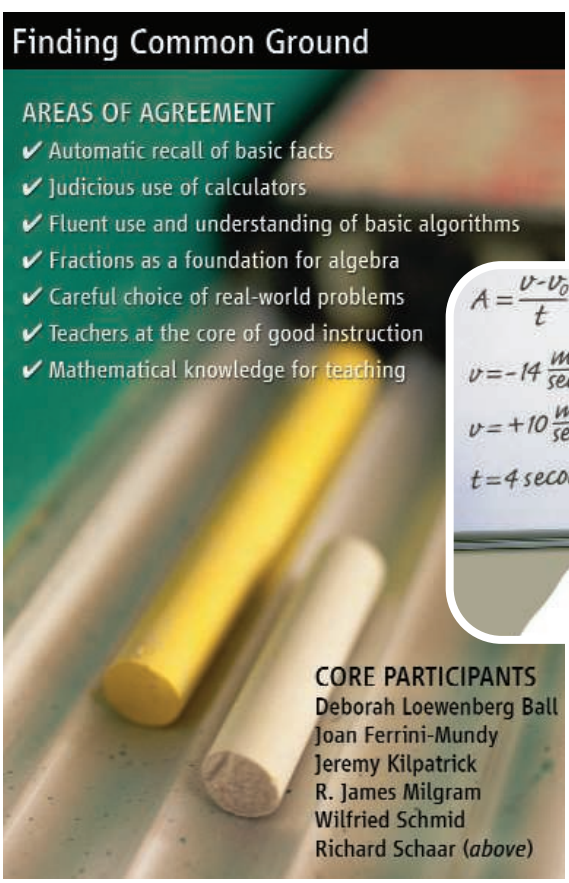
NCTM President Fennell says the focal points are intended to provide "curricular relief" to elementary and middle school teachers whose school districts expect them to achieve as many as 100 objectives in mathematics. Many of those objectives span several grades, with teachers expected to tailor them to the maturing child. But there's no urgency because teachers know that their students will get another bite of the apple the following year.

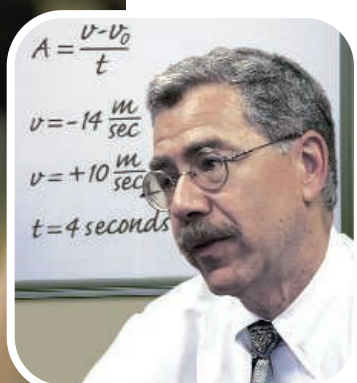
"While lots of things are important, we're saying to teachers that here are three things you need to zero in on," says Fennell. "For example, we'll teach some probability in the fourth grade. But it's not as important as multiplication," which takes center stage alongside fractions and decimals and the concept of area. Second graders should concentrate on addition and subtraction, place value, and linear measurement, says NCTM, even if their teachers also touch upon other topics.

Although focal points must first be woven into state and district guidelines to have any real effect, the council's action already represents a significant move toward common ground: Professional mathematicians love to attack the 1989 and 2000 NCTM standards, and they see focal points as a tacit admission that some of their criticisms were on the mark. They also welcome the message that, for most students, less is more.

"The idea of coming up with a few topics that should be addressed in K through 8 is a very needed step," says Richard Askey, a professor emeritus of mathematics at the University of Wisconsin, Madison, and an outspoken critic of earlier NCTM standards and curricula based on them. "I think that publishers, who now have to deal with all [different] state standards, will also like the idea" of a limited number of key objectives for each grade.

Jane Schielack, a mathematician and math educator at Texas A&M University in College Station who led the NCTM task force that assembled the focal points, agrees that they are very much a product of the





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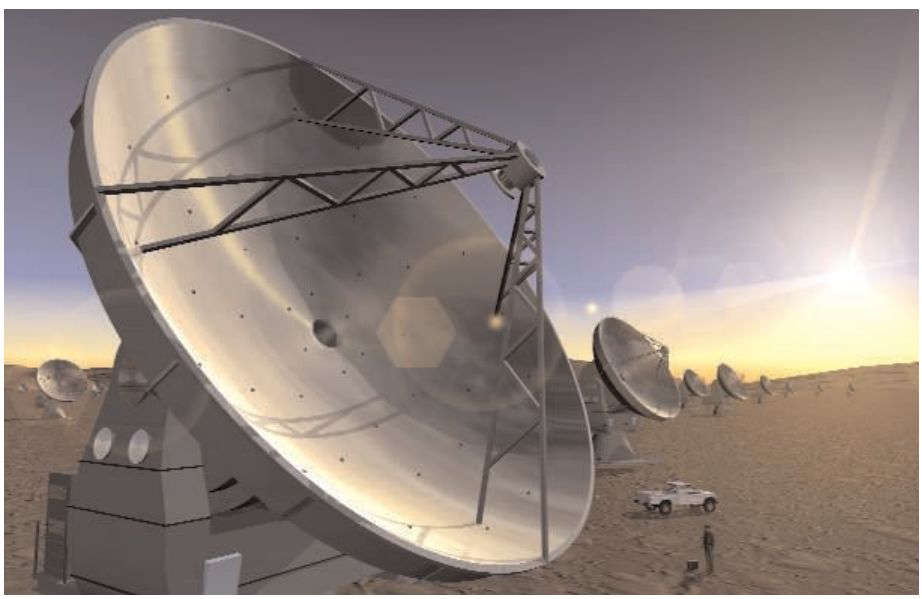
times. "This is something we couldn't have done 4 or 5 years ago," she says. In addition to the greater emphasis on accountability spawned by the 2001 federal No Child Left Behind law, Schielack cites the growing recognition that some countries, notably Singapore and China, excel on international student comparisons because of a national curriculum that focuses on a small number of topics and policies that give teachers the necessary training and resources to get the job done. "That's the biggest difference between the United States and the top-achieving nations," agrees Milgram. "Having NCTM come out with a statement to this effect should make an enormous difference on what we expect kids to learn."

Even so, nobody expects Common Ground and focal points, by themselves, to usher in a golden age of quality mathematics education. There's too much that remains to be done. "It's a long, long journey," says Hung-Hsi Wu, a mathematician at the University of California, Berkeley, who runs summer institutes for classroom teachers whose grasp of basic mathematics is often poor or nonexistent. "Better mathematics education in the United States won't take place in the next 10 years. I think it will take 30 years."

At the age of 60, Schaar doesn't plan on staying in the line of fire for quite that long. But he's not ready to saddle up and ride out of Dodge. Schaar believes that Common Ground, funded by NSF and TI and staffed by the Mathematical Association of America, has restored a measure of civility to the debate. And this month, after a coalition of 16 leading mathematical societies applauded his 2-hour presentation and told him to keep up the good work, he said that kind of support is exactly what's needed.

"I'm not looking for an endorsement," he says. "I'm looking for help in getting more people involved." A bigger "in" crowd means fewer outcasts. And that's good news for a sheriff.

–JEFFREY MERVIS



All together now. For different observing jobs, ALMA's 50 antennas can be rearranged with a giant purpose-built truck.

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ASTRONOMY

After a Tough Year, ALMA's Star Begins to Rise at Last

Cost hikes, scarce labor, and management changes have buffeted the first global telescope array, but new funding agreements may augur smoother sailing ahead

The world's largest ground-based astronomy project, the Atacama Large Millimeter Array (ALMA), is back on track after a tumultuous couple of years that have seen costs balloon by about 40% and the capability of the enormous microwave telescope scaled back.

ALMA, with an overall budget now in the region of $1 billion, is a collaboration between the United States, the European Southern Observatory (ESO), and Japan, plus minor partners Canada and Spain. As a result of skyrocketing prices in commodities needed to build its antennas and huge hikes in labor costs in Chile, where ALMA is being built, astronomers have had to go cap in hand to their funders for more money. ESO agreed to swallow its share of the increases last autumn, but it was not until last week that the U.S. National Science Foundation (NSF) won agreement from its governing board. "It's been a fairly intense 18 months," says astronomer Christine Wilson of McMaster University in Hamilton, Canada, chair of ALMA's scientific advisory committee.

"I'm told that most big projects go through something like this," Wilson says. "Cost increases are a given." But for researchers waiting to see whether funders would keep faith with the project, the process has been nerve-wracking. "We were holding our breath back in the summer and fall for ESO," Wilson says. "It's been a very stressful situation for everyone in the project." U.S. team members had to await the outcome of a series of cost reviews, but in a meeting on 10 May, the National Science Board gave NSF permission to increase U.S. spending on ALMA from $344 million to $499 million, subject to the approval of Congress. According to ESO's Thomas Wilson, European project scientist on ALMA, during these discussions there was an unspoken warning from the funders: "This is it. Don't come back and ask for more."

ALMA, the first truly global effort in ground-based astronomy, grew out of three separate projects. U.S. astronomers started discussing a Millimeter Array in the mid-1980s; European plans for a Large Southern Array took shape about a decade later. ESO and the U.S. National Radio Astronomy Observatory (NRAO) in Socorro, New Mexico, began discussions on merging the two projects in 1997 and in June 1999 agreed to build a joint instrument comprising 64 12-meter antennas spread over an area up to 12 kilometers across. The array took its new name from Chile's Atacama desert, where researchers had found a wide plateau, the Llano de Chajnantor, which at 5000 meters altitude is high enough and dry enough to avoid most of the atmospheric water vapor that blocks signals at the wavelengths ALMA is designed to receive.

The push for such an instrument came because better receivers, fast digital electronics, and antenna design were improving the capabilities of millimeter-wave telescopes. Astronomers calculated that a large number of receivers arranged as an interferometer could rival the resolutions of the best optical instruments, such as Hubble and ESO's Very Large Telescope in Chile. At millimeter and submillimeter wave-

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