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## FEATURES

ILLUSTRATIONS BY JAMES LAISH


Cover Story

# Preparing Future Engineers Around the World

**Overseas and at home, innovations abound in science, technology, engineering and math instruction. An expanded cover story explores ideas and approaches in Finland; South Africa, Japan, Israel; France; Brazil, China, Canada, and Singapore. In the United States, the state of Massachusetts and the University of Colorado stress the "E" in STEM.**

**From planes to PCs to Kevlar, the sun never sets on the products of American ingenuity. But the original engine of U.S. innovation – STEM education – is no longer world class. A half century after the start of the space race, the nation that put a man on the moon faces a gathering storm of faltering schools and squeezed budgets that undermine its competitiveness. Once a world leader in the proportion of its citizenry with college degrees, the United States has fallen to ninth place. Foreign firms now earn a majority of U.S. patents. In 2009, 55 percent of U.S. engineering doctorates went to foreign nationals.**

**The latest comparison of student achievement by the Organization for Economic Cooperation and Development showed this country had slipped to below average in education performance. Finland again led the world in math, science, and literacy, with scant difference in the performance of urban, rural, affluent, or low-income students. Their peers in South Korea, Shanghai, and Singapore are up there, too. What U.S. Education Secretary Arne Duncan calls a "brutal truth" about the global achievement gap gained significance with last month's release of the nation's science "report card" showing only a third of American students were proficient and fewer than 2 percent were advanced.**

**Dubbing this "our generation's Sputnik moment," President Obama has called for investment in K-12 STEM (science, technology, engineering, and math) education, hosted science fair winners at the White House and State of the Union address, and even appeared on Mythbusters. The marketplace of ideas is a global one, however. Many of the countries out-educating America today studied our industrial and school systems and replicated the best. Now, by borrowing fresh ideas from abroad, U.S. policymakers and engineering educators can help strengthen the domestic K-12 pipeline and not only prepare more students for STEM majors and careers but improve learning in all subjects.**

**The following sampler highlights innovations from the worldwide STEM education bazaar. Some harness technology. Others, including those in Colorado and Massachusetts, leverage state content standards and hands-on learning. Japan went back to the future, reviving the venerable abacus. Could slide rules make a comeback, too?**

**Enjoy the trip. – Mary Lord**

## FINLAND
## IT'S ALL ABOUT TEACHERS

Mention Finland, and most Americans think of Sibelius symphonies or today's popular Angry Birds mobile-phone game. The country enjoys another claim to fame, however: world-class K-12 education. Only a handful of nations come close to matching Finland in math, science, and literacy, and none boasts such uniformly high achievement rates across regions and income levels. If American students could match their Finnish peers, McKinsey & Co. estimates, the U.S. economy would be 9 to 16 percent larger and generate as much as $2.3 trillion more annually. How could a nation of 5.5 million people and 2 million saunas produce 15-year-olds on par with Asia's whiz kids?

Finnish scholars and results from the Organization for Economic Cooperation and Development's latest Program for International Student Assessment offer some clues — and lessons. Administered every three years in dozens of countries, PISA seeks to gauge how well students can apply what they've learned in science, math, and reading. Finland and other high-performing nations share several traits, including trust in educators, highly selective teacher-training programs, and strong national standards that local schools create curricula and assessments to meet.

Finns credit teacher quality for their STEM success. "In Finnish culture, there is a long tradition of valuing the education of teachers," and respect for educators has "deep roots in our society," says Pekka Lintu, Finland's ambassador to the United States. Only top students qualify for teacher preparation programs; with 10 applicants for every spot, only the best of the best get in. A high proportion of elementary teachers have

STEM degrees; roughly 20 percent in math and a similar percentage in science. Thus, even very young children receive quality instruction that prepares them for chemistry and physics in fifth and sixth grades.

Surprisingly, money is not a big factor in Finland's STEM achievement. The country spends less on education per student than most other developed economies, and beginning teachers, who all hold master's degrees, earn the same as flight attendants, notes Pasi Sahlberg, director of the Ministry of Education's Center for International Mobility and Cooperation.

Another surprise: Finnish teachers log far fewer hours in the classroom than their global counterparts — about 6,000 hours a year versus 8,000 in America, PISA reports. Finnish science teacher Mikko Korhonen discovered the heavier instructional workload during a Fulbright exchange at a Maryland high school last fall. More arresting, though, was that "assessments and testing here is totally different." Finland has zero standardized tests. Instead, teachers create their own quizzes and other checks on progress.

Perhaps Finland's biggest lesson lies in the learn-by-doing approach its teachers favor. "I try not to give them answers right away," explains Helsinki middle school math and science teacher Kaisa Sahlberg. "I like them to think and try and even make mistakes and then try again." In one lesson, for instance, Sahlberg mixes a compound of table salt, sand, and iron powder and asks student teams to return each element in three beakers, using supplies available in the lab. Her only instructions: Start with small amounts when unsure what might happen. Students must learn to use magnets properly, extract dissolved salt by boiling water, filter the sand, and finally burn the paper without setting off fire alarms. One girl, a Boston transplant, says she hates the idea of returning to her American school, where students never did anything in the lab and had more homework. "I don't know what the truth is," reflects Sahlberg, "but we really seem to stress our kids so little compared to other countries, and still our kids learn!" – *by Mary Lord*

## SOUTH AFRICA
### 'THANX! U HELPD ME'

Ask any South African high school mathematics teacher what keeps students from doing homework, and a likely answer is: "MXit." Roughly half of all teens from poor townships average an hour a day using this wildly popular instant-messaging service for mobile phones (think Facebook via cell). For some, however, chatting on MXit has improved their understanding of math.

Computer programmer Laurie Butgereit recognized the chat service's potential as a math tutoring platform when she began logging on during her lunch break to help her MXit-addicted son with his homework. Before long, nearly a hundred of his classmates were bombarding Butgereit with questions. "I couldn't cope," says the American-born Java expert. So she asked her employer, the Council for Scientific and Industrial Research, to help her create a nationwide service that would link volunteer tutors on PCs with confused math students on cellphones. Dr. Maths on MXit launched on Feb. 1, 2007, with just 14 students from a single school. The organizers kept quiet about the service, fearful of overwhelming their first few tutors, all engineering students from the University of Pretoria. But Dr. Maths users spread the word, and by midmonth, 429 high school students were IM-ing questions. Today, with zero advertising, the service

reaches 19,000 teens across South Africa and offers advice on physics, chemistry, biology, accounting, and information technology. Its 100 tutors are still mostly engineering students.

Demand can outstrip the tutors' ability to keep up. Butgereit figures that a tutor can reasonably juggle 30 inquiring students an hour. At times, they face 80, and with half of all South African high school seniors failing math, the need remains desperate. The economics of the text-only system are astoundingly cheap, however. A single, unmanned desktop PC connects far-flung tutors on the Internet with their texting teens. For students, who pay cellular operators approximately 30 U.S. cents per megabyte for data, the text-only messages use so little bandwidth that an extended exchange over quadrilateral equations costs a fraction of a penny. Moreover, mobile phones often provide the students' only online interaction; in 2009, just 5 percent of South African households had PCs with Internet access.

Explaining parabolas to callers looking at a 2-inch screen and typing on 12 keys does create challenges. Tutors ask callers to use the exponential sign "^" so that five cubed becomes 5^3. One tutor even creates little graphs out of dashes and plus signs that he copies and pastes into his explanations. "We make our own rules and work around the limitations," says University of Pretoria informatics student and tutor Naeem Ismail. "We've found a solution to every problem."

Tutors are instructed to let the students think for themselves, rather than giving away answers. Consider this exchange about factorizing trinomials:

> **Student:** nw wat bout x^2-5x-6
> **Dr. Maths:** so you need to find two numbers that multiplied give you -6 and added give you -5. that means one of the numbers must be negative and the other positive
> **Student:** +6 -1 ?
> **Dr. Maths:** does +6 -1 give you -5?
> **Student:** o i c! -6 +1
> **Dr. Maths:** very good
> Student: thanx! u helpd me stax!

Because of privacy concerns, Dr. Maths has no access to information that would identify students who use the service. This has made quantifying the service's benefits impossible. Butgereit is convinced, however, that its viral growth proves its effectiveness. "The evidence that it works is that they tell their friends about it," she says. And sometimes pupils text their own evaluations of Dr. Maths. As one satisfied student jotted at 9:19 one night: "u guys r gonna b a hit!"–by Don Boroughs

## JAPAN
## BACK TO THE FUTURE

Forget graphing calculators. The hottest tool for learning math in this high-tech powerhouse is a relic from Japan's preindustrial past: the venerable abacus. At a time when ubiquitous digital devices are blamed for making people "dumber," the world's original calculating device, known as the *soroban*, is more essential than ever, advocates contend. "When you do all your figuring on a computer or calculator, the process of

calculation becomes a 'black box,'" says Hiroshi Nakayama, director of the League of Japan Abacus Associations. "But with the *soroban*, number crunching takes place right before your eyes."

Or, more precisely, *behind* them. The true measure of a *soroban* student is not merely being able to flip through arithmetic problems quickly and efficiently but acquiring a secondary skill known as anzan — moving those beads mentally, without the assist of a physical tool. "Anzan enables you to visualize the beads in your head," says Hanaka Iwai, a *soroban* instructor in suburban Tokyo. "So even if you don't have a *soroban* handy, you can literally carry the device in your brain."

Parents are flocking to enroll their kids in extracurricular programs like the one Iwai and her sister, Haruka, run out of a tiny storefront.

On a recent Saturday afternoon, the pleasantly ramshackle classroom full of long, low-slung desks bursts with second and third graders brandishing grownup-size *sorobans*; these can handle numbers up to 23 digits long. A spell seemed to befall the children as Hanaka clicked her stopwatch. And then they were off! Flying thumbs and index fingers mimicked the act of manipulating beads as pupils mentally raced through addition lists of three-digit numbers, completing 10 problems in three minutes flat. Children are considered *soroban*-ready as soon as they can count to 10, though the sisters say the tool is so intuitive that a 4-year-old can get the hang of it within six months. The benefits of becoming a walking calculator were evident to second grader Mi Tsugiura. "I like it," he said. "I can help my mom figure out her change at the store."

While empirical evidence remains thin, many parents and even some school officials believe that the mental gymnastics of *soroban* training prime children for any kind of learning — in any subject. The once underperforming Amagasaki school district in western Japan has become a pioneer in the back-to-the-abacus movement. Since 2009, all 43 of its elementary schools have offered an hour each week of *soroban* instruction and start the day with 10 minutes of *soroban* drills. Test scores are up, and backers say the regimen boosts confidence, improves memory, strengthens insight, and develops both the brain's creative side and analytic side.

Hanaka Iwai says abacus training is a powerful tool for concentration. "I'll be working on one problem, and the next thing I know, I've finished five," she says. "*Soroban* really hones your ability to focus. It's a skill which can be applied to any field. You just don't get distracted easily."

Japan's abacus association has commissioned a study, due out in 2012, on the feasibility of reintroducing *soroban* and *anzan* into the mainstream curriculum. Educators urge caution, however. "While computing is the basis of math, it's only one aspect of the subject," warns study panel member Tsukane Ogawa, of Yokkaichi University, in a pamphlet about the project. "In a highly evolved science and technology era, it's not enough — as it was 400 years ago — to be able to calculate quickly and accurately. Students must acquire many math concepts, so boosting computing skills in an efficient manner is important. Whether this is best done via *soroban* or conventional teaching is what we're trying to find out." Meanwhile, a popular iPhone app ensures the abacus won't fall from fashion anytime soon. — *By Lucille Craft*

## ISRAEL
## BEYOND PROGRAMMING

Kindergartens where youngsters can play online games? High schools that require students to build websites or 3-D computerized models of such complex objects as aircraft? These are among the approaches some Israeli schools are testing in a unique, government-approved program to boost children's understanding of — and passion for — computer science. By emphasizing theory with hands-on activities, its creators hope to move schools beyond today's tech equivalent of shop class and perhaps replace computer-science offerings in place since 1995.

"When you study physics, you don't just learn how to repair a TV set; you study the basics of physics," explains Judith Gal-Ezer, vice president for academic affairs and professor of computer science at the Open University of Israel, who is one of the curriculum's designers. Students, she contends, should "not just learn a programming language or applications, but become acquainted with the entire way of thinking of computer science."

The pilot program covers two kinds of student. There's a 270-hour course for those with a general or limited interest in computers, and a 450-hour version for those who may want to pursue computer studies after graduation. Both devote at least 180 hours to the theoretical basis of computer studies, including key concepts for solving algorithmic problems and how to apply them to a programming language. Students learn modularity, or how to solve big problems by breaking them into small ones. Later, they get to tackle more advanced problems, such as searching and sorting. "These are the basic concepts of computer science, and they are being stressed at all levels," says David Ginat of Tel Aviv University's Science Education Department, who wrote the textbooks for the basic courses.

Theoretical material is combined with hands-on experiences. Teachers introduce relevant parts of a programming language, then have students apply it in the computer lab — a concept the curriculum's developers call the "zipper approach" since it has "a little bit of this followed by a little bit of that and so on until finally forming a unified whole," says Ginat. Students learn to distinguish between errors of logic and those caused by incorrect use of an algorithm while programming, as well as the pros, cons, and limitations of debugging by testing. Even teachers and students in the general-interest group have a variety of optional courses, from highly theoretical material such as computational models to programming — though the latter, too, is only a means to get a computer to carry out an algorithm, notes Gal-Ezer.

The computer-graphics course, which incorporates the basics of computational geometry and linear algebra, exemplifies this concept. Students learn about three-dimensional graphics and their use in such fields as architecture, games, and topographical mapmaking. They study the algorithms for drawing, smoothing and clipping lines, and removing hidden lines discarded after designing. Ultimately, students can place a ball anywhere on a screen and program a robot to roll it through a maze. The advanced curriculum includes some 90 hours of more complex software design.

Teachers remain key to successful implementation, of course. At a minimum, they should have a bachelor's degree in computer science and a governmental teacher's license, says Gal-Ezer, who's now helping design a distance-learning program to train these pioneering educators. — *by Joshua Brilliant*

## FRANCE
## A HELPING HAND FOR SCIENCE

In 1995, Georges Charpak, a French Nobel Prize-winning nuclear physicist and engineer, became alarmed at the state of science teaching in France's primary schools: It was almost nonexistent. So with the assistance of the country's Academy of Sciences, Charpak helped design a science teaching regimen modeled on a successful program in Chicago developed by his friend and fellow Nobel laureate Leon Lederman.

The result was *La main à la pâte*, now used in more than 3,000 pilot classrooms scattered around France, each supported by one of 20 regional centers. A phrase meaning "helping hand" or collaborative effort, *La main à la pâte* stresses a hands-on, inquiry-based approach to teaching youngsters scientific concepts and procedures. Students are encouraged to use arguments and reasoning, and to pool their ideas and observations. They all must put their theories to the test as well as keep a notebook documenting the entire process in their own words. The earlier children are exposed to science, the program's designers reasoned, the more likely they are to develop a lifelong interest in the subject. "It makes use of their natural curiosity," explains *La main à la pâte* director David Jasmin.

Another important element of the program is the ongoing involvement of scientists and engineers, who assist in the designing of projects and materials, and in teacher-training efforts. Professional development of primary school teachers is critical because most lack science backgrounds. "Many are not at ease with science," Jasmin says. So beyond having access to ready-to-use materials, teachers can post questions and quickly receive answers from scientists or engineers on *La main à la pâte*'s website. The project also has a cadre of 1,500 science and engineering undergraduates who work with teachers in the classroom.

The program features two types of projects. Some are grounded in basic science, such as having students build an electric circuit or play games with magnets to learn about magnetism. The others are seven-to-eight -week-long themed projects dealing with important issues that have strong science, engineering, and math elements, such as global warming, healthcare, biodiversity, and eco-housing.

*La main à la pâte*'s pilot classrooms serve as working models of how the program's inquiry-based teaching methods can be implemented by all teachers. And the program makes all of its materials available free from its website to teachers nationwide. That approach has paid off. The website now has an impressive 200,000 visitors a month, and the Ministry of National Education says the number of primary school teachers using inquiry-based methods for science instruction has jumped from around 30 to 40 percent in 2007 to 57 percent today. The project also has a thriving international component: It has formed idea-sharing partnerships with education groups in more than 40 countries. Seventy-five percent of its $1.37 million annual budget comes from French government agencies, 12 percent from the European Union, and the rest from various private sources.

Charpak died last September at age 86. But he lived to see his "helping hand" grab hold of success. — *by Thomas K. Grose*

## UNITED STATES
### GIMME AN E...

Engineering has long played the Rodney Dangerfield of K-12 education: It gets no respect. Despite a flurry of urgent reports stressing the importance of each STEM discipline, curricula in most states concentrate on science and math. Not so in Massachusetts. A decade ago, the Bay State created a separate strand in its science standards for technology/engineering, putting the subjects on par with traditional sciences. That has translated into classroom instruction, since engineering counts for 25 percent of the grade on science assessments administered to all fifth and eighth graders, and "made it possible for engineering to become part of the routine," says Jake Foster, director of science and technology/engineering (STE) at the Massachusetts Department of Education. Notably, Massachusetts students outscored their peers in all other states — and many countries — on recent international math and science comparisons.

Boston's Haley Elementary School offers a glimpse of how engineering can inspire even very young, at-risk children and transform K-12 education. In this innovative pilot program, STEM serves as "a framework for engagement" rather than a content-driven specialty class, says principal Ross Wilson. "It's the umbrella" under which students develop an understanding of their communities and world along with creativity, problem-solving skills, and a sense of active stewardship. Instead of learning about biology and environmental science from textbooks, for instance, students tend a schoolyard garden, build solar ovens, and create models of green buildings. Outside partners such as the Audubon Society help teach earth science. Fourth- and fifth-grade students study the ecology of Boston Harbor in the fall, spend winter in a boatyard designing and building a boat they will sail in the summer, then cap the experience probing Boston's African-American maritime history. "The boat-builder is an expert in physics," notes Wilson. "All the math and science is in the room."

Though few schools, even in Boston, have embraced and embedded STEM as dramatically as the Haley pilot school, "engineering is certainly becoming a bigger part of the curriculum," says Massachusetts STE director Foster. It's perhaps no coincidence that the Museum of Science, Boston, developed the Engineering Is Elementary curriculum, now in use in all 50 states. While engineering is cropping up in more K-12 classrooms nationwide, other states have yet to elevate it to the level of a core discipline as has Massachusetts. But this may soon change. A new federal law authorizes the National Science Foundation to explore the value of K-12 engineering, and Congress has also been considering the Engineering Education for Innovation Act, which includes grants and other incentives to make engineering part of every student's three Rs. — *by Mary Lord*

## UNITED STATES
### TEACHER-FRIENDLY ENGINEERING

Having engineering professors develop curricula to teach the discipline's fundamentals to K-12 students? That notion was "considered edgy and bizarre," recounts Jacquelyn F. Sullivan, associate dean for inclusive excellence at the University of Colorado-Boulder's College of Engineering, of her pioneering efforts in the 1990s to do just that. Even a decade later in 2002, when Sullivan attended a National Science Foundation conference on K-12 engineering education, she was one of only four university academics there who were creating lessons for school kids. So Sullivan and the others — who hailed from Duke, Tufts, and Oklahoma

State universities — decided to pool their resources into a one-stop, free online shop of lesson plans for K-12 teachers.

Several years and an initial NSF grant later, TeachEngineering.org took flight. It's now a nationally recognized digital library brimming with hundreds of engineering lessons for primary and secondary students, all linked to state and national standards. The site's ethos is: Keep it simple, keep it cheap, and keep it hands-on. It recognizes that most U.S. math and science teachers have no training in their subjects, while seeking to ensure that schools in low-income areas can afford the lessons. The average cost of materials for a class of 25 is $8, usually for stuff easily found in grocery or hardware stores. TeachEngineering now boasts well over 900 lessons and activities. Each lesson's hands-on element stresses the links to engineering science or design. For instance, a fourth-grade lesson teaches students how engineering and architecture interact by having them build a model parking garage. The offerings include units of varying length, from short activities to full courses.

Based on advice solicited from 80 teachers, the lessons all use the same template, which includes a background briefing for the teachers and an assessment tool so they can gauge if students "get it."

TeachEngineering eventually opened itself to contributors; so far, academics from 19 universities have submitted lessons. Each lesson gets vetted by one teacher and one engineer — the site relies on 59 volunteer reviewers — plus one internal editor. There's currently a queue of around 300 lessons awaiting approval, and many won't make the cut. "We're pretty picky," Sullivan admits.

The website has experienced a growth spurt lately. Between December 2009 and November 2010, it averaged 560,000 unique visitors, a 34 percent increase from the previous 12-month period. Last October, it had 85,000 visitors, a 55 percent jump from October 2009. "It's gone wild," Sullivan says. Why? Possibly because in 2009, the lessons were cross-aligned with state content standards, so a teacher in, say, Idaho can easily find lessons from other states that fit Idaho's science standards. That big upgrade was handled by Oregon State University information-systems students. The site also has been boosted by links from such education websites as netTrekker.

TeachEngineering operates on a shoestring. It has gotten several NSF grants totaling around $2.4 million, enough cash to give it a "backbone" of financing. But mostly, Sullivan and colleagues manage the site "as a labor of love." And love's labor is never lost. — *by Thomas K. Grose*

## BRAZIL
## BRAIN FORESTS

Brazil is not known as an educational powerhouse. Its federally controlled K-12 system is laden with waste and high teacher-pension costs, the Economist reports. Meanwhile, many schools lack adequate equipment or even such basics as running water. Students typically attend school for only half the day until they drop out — the average age is 13 — or finally graduate in their mid-20s. But a pathbreaking initiative by a U.S. scientist, backed by the Ministry of Education, is tackling these systemic problems. Its unusual catalyst for educational and social change? Hands-on labs, a rare commodity even in affluent nations.

“Science can be a driving agent of transformation; not only economic transformation like we know here in the United States and Europe, but also social transformation,” declares Duke University neurobiology Prof. Miguel Nicolelis, who spearheaded the initiative. A native Brazilian, he directs the Edmond and Lily Safra International Institute of Neuroscience of Natal (ELS-IINN), a research organization that has joined with government-funded groups, the local university, and some private partners to expand the initiative.

Launched in 2003, a research institute and school known as the “Campus of the Brain” began with students age 10 and older in some of the worst-performing schools and districts in Natal, a coastal city in northeastern Brazil. The idea was to establish facilities where students could work with real scientists on authentic, hands-on projects outside of school — and where researchers could study science teaching and learning. This “extra” education would allow participants a full day of learning, half in public school and half with two science teachers in classes of 25 students each, up through university entrance. Some 21 middle school students currently assist the institute’s scientists much as undergrads would at a university lab. Four worked on a scientific magnetic resonance machine to find in-ground oil pockets.

The concept quickly caught on. Today, the program has expanded to include first graders, and another school has been built in the neighboring state of Bahia to the south, pushing total enrollment to 1,400. Beyond merely teaching science, the institutes, run by ELS-INN scientists, include women’s health clinics where real-life applications of the scientific method help students see their lab work’s importance and instill a sense of community. Construction soon will begin on a full-time school that will automatically enroll every child of women treated in the clinic from womb through higher education.

Students aren’t the only ones benefiting from the institute’s fresh approach. Teachers from across Brazil are being trained by seasoned instructors in hands-on science education. Some go on to become educators in the program; others return home with improved teaching skills and a better understanding of science.

Confident of the institute’s approach, Brazilian officials have integrated it into the government’s huge investment in education. The budget for educational programs has quadrupled in recent years to $26.2 billion – a full 4.2 percent of GDP and the biggest jump in education spending of any nation, reports UNESCO. Private partners contribute at least one real for every federal one.

For Nicolelis, student happiness is the main measure of success. Before they joined Campus of the Brain, he notes, these kids were considered “hopeless.” Now, they have life goals, with the right tools to achieve them. The students, who are performing nearly as well on national standardized tests and in class as peers in some of Brazil’s best schools, also care more about their communities. Those results have prompted plans to expand the Natal pilot program to 15 other locations nationwide, reaching 1 million students in the next four years. “It’s the largest education revolution in the world right now,” Nicolelis says. Hyperbole? Maybe not: Mexico and South Africa have expressed interest in replicating the program. — *by Jaimie Schock*

## CHINA
## EAST-WEST FUSION

If there is a magic formula for mathematical prowess, China has it nailed. Chinese students routinely outperform their American peers on international math and science comparisons, and Shanghai's 15-year-olds recently bested world leaders Singapore and Finland by a stunning margin on the latest Organization for Economic Cooperation and Development assessment. For the United States, it was a "wake-up call," as Education Secretary Arne Duncan put it.

Now the Yew Chung International School of Beijing, a dual-language immersion program serving students from preschool through fifth grade, is taking China's traditional math-teaching approaches a step further by joining them with Western techniques.

Every subject is covered in Mandarin and English by Chinese and Western teachers working together in one homeroom. For the most part, the curriculum for geography, science, and other subjects is the same in both languages. That's not true for math.

Consider the fifth-grade class taught by Joanne Mackey, who hails from England, and Chinese native Julie Lei. To help students learn how to do long division, find the least common multiple, or calculate the greatest common factor, Mackey uses a step-by-step method found in British classrooms. The system is designed to ensure students can "explain why every step works so they have systematic problem-solving skills that enable them to think outside of the box," she says.

By contrast, Lei teaches sophisticated "shortcuts" for finding the answers to the same math problems — tricks she says most Chinese children can readily handle by the end of middle school. Lei also requires rote memorization, a common trait in education across all subjects in China. At the start of each math class, for example, students recite multiplication tables in Chinese, which Lei contends gives children "a strong mathematics foundation that makes it easier for them to advance more quickly in the subject."

This blend of teaching strategies may have been unintentional. However, results so far suggest it has powerful potential: that emphasizing creativity and problem-solving together with memorization and speed can accelerate learning even among already strong math students.

The school's Asian students, many of whom arrive with solid math skills, quickly advance to coursework that is two-to-three grade levels higher, the school says. The Western curriculum also enhances critical thinking skills, an oft-cited weakness of Chinese programs. U.S. pupils at the school, who typically lag their Asian peers in math, also progress rapidly; many return home to discover they are well ahead of their American classmates, school administrators say. Both groups undoubtedly benefit from another hallmark of Asian education systems: discipline and constant test preparation. Chinese school days also tend to be longer than in America, and students watch less TV.

Mackey and Lei see nothing magic in what they do. Their success lies in striking the right balance between Eastern and Western techniques. "I do value some of the rote learning that we have banished from the U.K. and from the West as well," says Mackey. While hands-on activities have merit, at some point "actually you do need to go home and learn your multiplication tables. It is not fun, but I do think it is quite valuable." — *by Lara Farrar*

## CANADA
## CREATIVE VOLUNTEERING

A high school science camp experience convinced Isabel Deslauriers that science not only was fun but could provide a career some day. Later, studying electrical engineering at Montreal's McGill University, she wanted to help other teens find their science calling, too. So she joined Let's Talk Science, a volunteer science-outreach program that connects undergraduates and professionals with K-12 students in "hands-on, minds-on" science activities. Working with local high school teachers, Deslauriers created an eight-week program in which kids built a robot car with sensors that could be programmed to follow a predetermined course. "It involved aspects of mechanical, electrical, and computing engineering," she recalls. "At the beginning, the kids were almost scared about touching pieces of the car. At the end, they were so into it."

LTS, a national nonprofit dedicated to improving science literacy by bringing the subject to life, has inspired scores of Canadian youngsters to take similar plunges. Its flagship outreach program boasts more than 2,200 volunteers from 32 universities and colleges, as well as faculty researchers and professionals from science, engineering, and technology companies. These experts visit classrooms and community groups to provide activities and experiments, update teaching material, act as mentors, and supervise science projects. "It runs the full gamut," says LTS president Bonnie Schmidt, who founded the organization when earning her doctorate at the University of Western Ontario, London in 1993. "You think of the kind of hands-on experience that you want kids to have, and they do it. Plus, it's tailormade for each class — not pre-canned." An undergraduate iodine-clock reaction experiment, for example, was modified by LTS volunteers from Dalhousie University in Halifax to make it more engaging and accessible for ninth graders. Along with chemical reactions and catalysts, the teen-friendly science lesson — which was featured on the Journal of Chemical Education's September 2010 cover — included real-world applications that affect everything from the making of plastics to how our bodies work.

One reason for the success of the program, contends Schmidt, is the training each volunteer receives. "We want to help people with the expertise and the content [so they] understand how to bring science and engineering to life for whatever age learner they deal with," she says. LTS developed a three-hour multimedia workshop called Science With Impact, which teaches each new volunteer about learning theories and best practices in education.

In addition to its volunteer outreach program, LTS offers an array of educational resources for youngsters ages 3 to 6 called "Wings of Discovery." Currently used in 1,500 early childhood education centers across Canada, it includes a host of projects like Trip to My Community, which uses a toy top to teach such concepts as force, energy, and friction. LTS's latest venture, an interactive teen website called CurioCity launched in 2010, focuses on topics that matter to teens, such as health, the environment, entertainment, and sports. "Kids see subjects like math, physics, and engineering as important to society, but they don't see it as relevant to their lives," Schmidt explains. "CurioCity is one of our efforts to help change that." Next challenge: persuading teens to clean their rooms. — *by Pierre Home-Douglas*

## SINGAPORE
## EDGY, YET PRACTICAL

Walk the gleaming halls of the School of Science and Technology (SST) in Singapore and a glance reveals it's no typical secondary school. Its 400 students all carry laptops. Classes are small and often multidisciplinary, with lots of engaging, collaborative projects. Singapore's rigorous education system has long produced academically strong students. Since the 1990s, however, the country has sought to diversify the educational experience and staked its economic future on becoming a scientific and technological powerhouse. The SST, which opened in January 2010, is what that vision looks like in practice.

"For a while, there was concern that perhaps the kids were very textbook smart but not so in tune with world issues," says SST vice principal Chew Wai Lee. "So what we strive to do here is introduce the academic concepts set in an authentic context."

Like Singapore's three other Specialized Independent (private) Schools, the SST focuses on applied learning of all subjects, not just science and math. Students enter in year 7 (around age 12) for an accelerated four-year program that prepares them for junior college or one of Singapore's polytechnic schools. After two years of foundational studies, students choose from five applied subjects: biotechnology; design studies; environmental science and technology; fundamentals of electronics; and media studies. Teachers often assign "performance tasks" where students are asked to link what they've learned in the classroom to something practical. For a class focusing on art, media, design and technology, for example, students visited a nursing home and were asked to design or improve upon things used by the elderly residents on a daily basis.

Because the SST only has younger students at present, "their performance tasks are very, very simple," Chew says. "But I foresee that when they're in year 9 and 10, they will be able to do more scenario-based problem-solving on a larger scale." The SST also is committed to turning its students into global citizens. Last year, all the students went on a week-long, school-sponsored trip to meet peers in China, Vietnam and Cambodia. Their teachers accompanied them and taught demonstration lessons in English to the overseas students. This January, the SST hosted a student-teacher exchange from China.

The school, which partners with Nanyang Technological University and industries to provide internships and other special programs, currently occupies a temporary space. Plans call for moving next year to a newly constructed, 7.4-acre campus, complete with state-of-the-art science labs, design studios, eco-garden and other facilities. "Teenagers want to know why they're learning," Chew says. "So it's basically engaging not just their heads but their hearts and their hands." Feet, too—the new site includes a soccer field. *—By Corinna Wu*



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