A Classroom

TEACHING STEM IN THE YOUNGER GRADES

By Ron Schachter

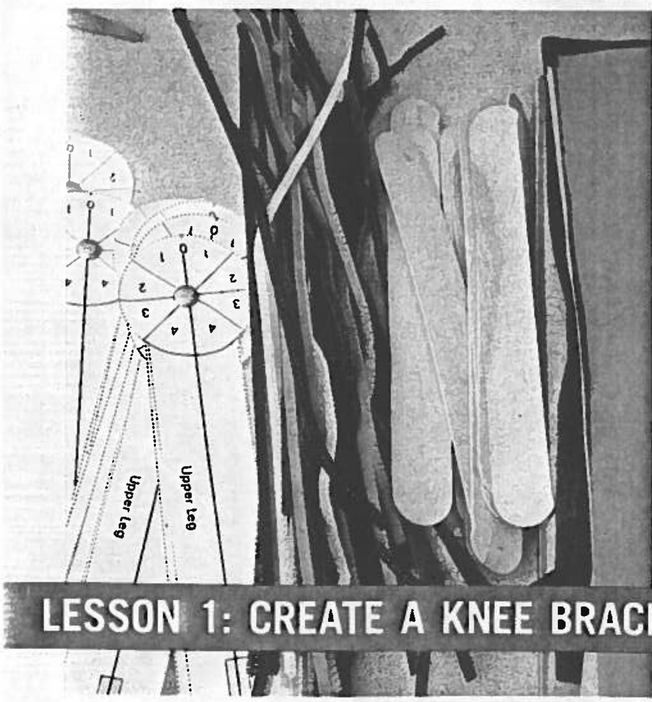
"Today we'll be working on science first," fifth-grade teacher Sherri Carvalho announces to her students—and the classroom erupts with a cheer. It's 7:45 A.M. at the Frank M. Silvia Elementary School in Fall River, Massachusetts, and the Pledge of Allegiance has barely stopped echoing from the overhead speakers. "They love science," Carvalho says. "They wish we could do it every day."

Is it difficult to imagine your own students clamoring for more lessons in physics or chemistry? Due in part to testing pressures, for years the subject has taken a back seat to reading and math. And though topics like volcanos and time travel have the potential to get kids' attention, science's status as a curricular stepchild typically translates into dull textbooks and little budget for experiments or supplies.

The tide is beginning to turn. President Obama has made science, technology, engineering, and mathematics—the so-called STEM curriculum—a priority in his educational agenda. More states are including STEM objectives in their standards. And teachers are discovering that STEM offers students unique opportunities for cross-curricular learning and for developing skills they'll need for the workplace.

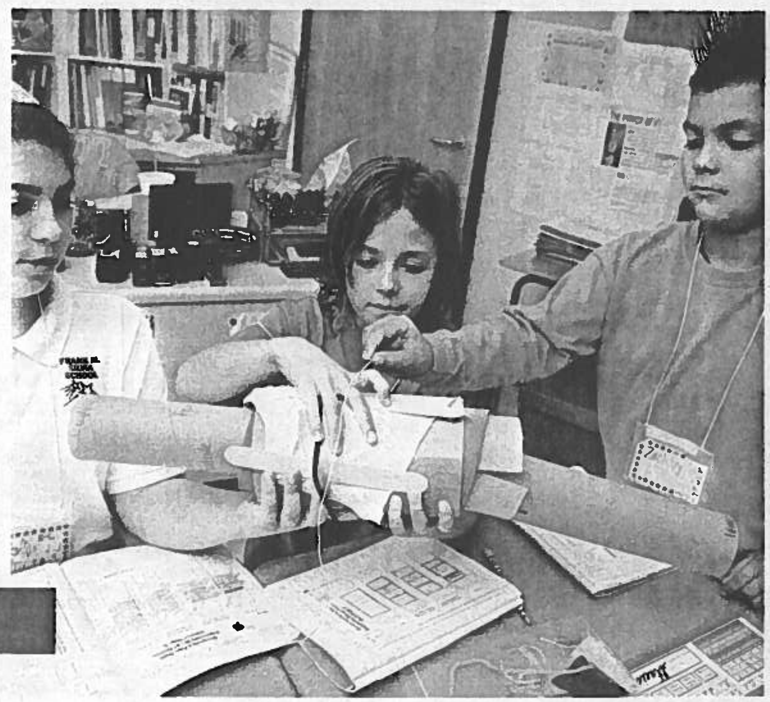
What's more, according to educators and researchers, STEM—in particular,

PHOTOS: JESSICA SCRANTON



LESSON 1: CREATE A KNEE BRACE

CHOOSE RAW MATERIALS: Carvalho makes sure to provide a variety of supplies for her students' experimentation.



BRAINSTORM AS A GROUP: Students work in groups to design and build their braces. Questioning and creativity are encouraged.

# of Engineers

engineering and its related design process—is endemic to the way kids learn.

Getting Hands-On

On Carvalho's cue, the fifth graders gather in small groups at tables or on area rugs in front of makeshift models of human knees. They'll soon be up to their elbows in building and testing workable knee braces, the crowning achievement of a two- to three-week unit in bioengineering called Brace Yourself. The unit is one of many created by an educational team at Boston's Museum of Science as part of its Engineering is Elementary (EiE) project, which seeks to promote engineering and technological literacy among children.

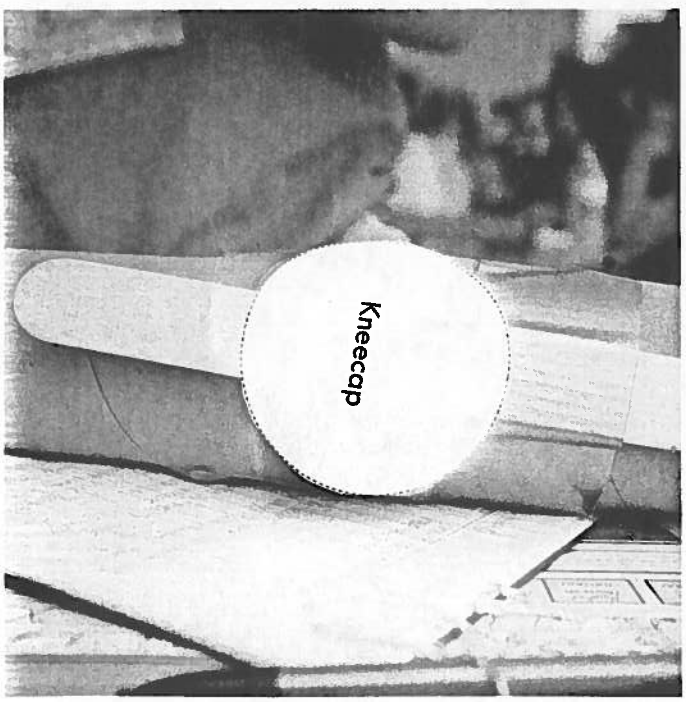
On the board, under the heading "The Engineering Design Process," Carvalho has spelled out the stages of development—Ask, Imagine, Plan, Create, Improve—along the perimeter of an oval. When the students complete the last stage, it doesn't mean they're done—it's just time to start asking more questions.

Today her fifth graders are enmeshed in the Create stage. The models consist of two cardboard cylinders—representing the thigh and lower leg bones, respectively—connected by a wiffleball that serves as the knee joint. The entire contraption is held together by elastic bands.

The class has already reviewed the materials that groups can use to build their knee braces. A list at the front of the room offers a dozen everyday options—felt, cardboard, foam, Velcro, rubber bands, pipe cleaners—followed by their characteristics, from soft and flexible to supportive and durable.

At one table, students Raistlyn Aguiar, Casey Brown, and Daniel Bouchard have agreed on a three-layer design for their brace, consisting of cloth on the outside, foam in the middle, and felt on the inside, next to the knee. "If you're an athlete and sweat a lot, it will go through the felt and stop at the foam," Raistlyn theorizes.

"Me and Casey thought of the idea of wrapping cotton on the outside," says Daniel. "If it gets wet outside, it can't get through the foam."

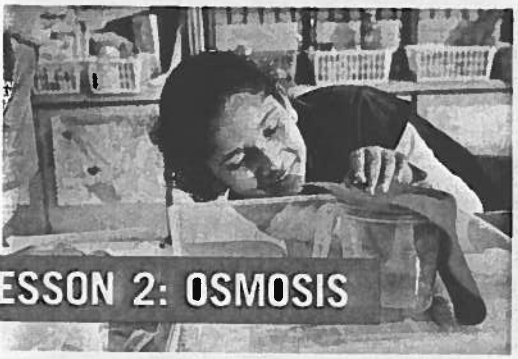


TRY LOTS OF THINGS: Many of the groups go through multiple variations of their braces to see which works best.

TEST THE MODEL: When it comes time to test their braces, Carvalho encourages her students to take their work to the next level.

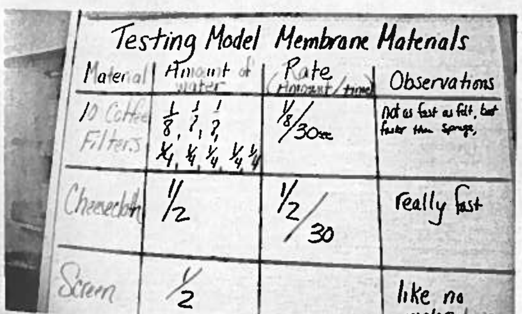
POSE THE PROBLEM: Facchiano asks: "How can a frog's skin stay moist without its drowning?"

LESSON 2: OSMOSIS



EXPERIMENT: Fourth graders test a variety of materials to see which makes the best membrane.

TRACK DATA: Students record the rate at which the water flows through each membrane.



COMPARE NOTES: At the end of the lesson, students synthesize their data and draw conclusions.

"What if we stick the layers together with Velcro?" Raistlyn suggests.

"That's a lot of Velcro," says Casey.

"And it might make the brace uncomfortable," Daniel notes.

"Yeah—but we should try it," Raistlyn insists.

The conversation turns to the tongue depressors the group is planning to use as supports. (The fifth graders use terms such as *support, durability, rigidity,* and *flexibility* as they work.) "Are we going to have a depressor at the back of the knee?" Raistlyn asks.

"No," Daniel answers. "That's the way the knee needs to bend."

"Oh, yeah," Raistlyn replies, flexing the joint in that direction.

Real Problems, Real Solutions

All the theorizing, experimenting, and back-and-forth among the students sounds like a primer in 21st-century skills. "You have to solve problems. You have to be creative," Carvalho says. "And you're able to help somebody by designing something in the real world."

Each EiE unit begins with a story that presents a real-life engineering challenge. For this unit, the class read about a young skateboarder who twisted his knee on a camping trip. He and his friends had to design a brace on the spot to get him out of the woods. After reading the story, the students got to work. They spent a few classes brainstorming and sketching out designs on paper. Now they're translating their designs into prototypes that they can assess and improve.

The fifth graders test how much their working models allow the artificial knee to flex, how well the braces hold up to use, and how easily they can be put on and taken off. Carvalho wanders among the groups, constantly referring to them as engineers and asking probing questions along the way.

"So you think it's the foam that's restricting the knee in the back?" Carvalho asks a group whose artificial knee isn't bending well with the brace on. "I know how to improve it," exclaims one team member, suggesting they cut a notch through the brace behind the knee. The students implement the fix, and the knee bends more naturally.

In the adjoining room, Jean Facchiano's fourth graders, also immersed in an EiE unit, are working to create an effective semipermeable membrane. In the story that launched the project, a youngster discovered a frog that had been displaced from its rain forest habitat by commercial development. He needed to devise a way to get the frog enough water to keep its skin moist without drowning it.

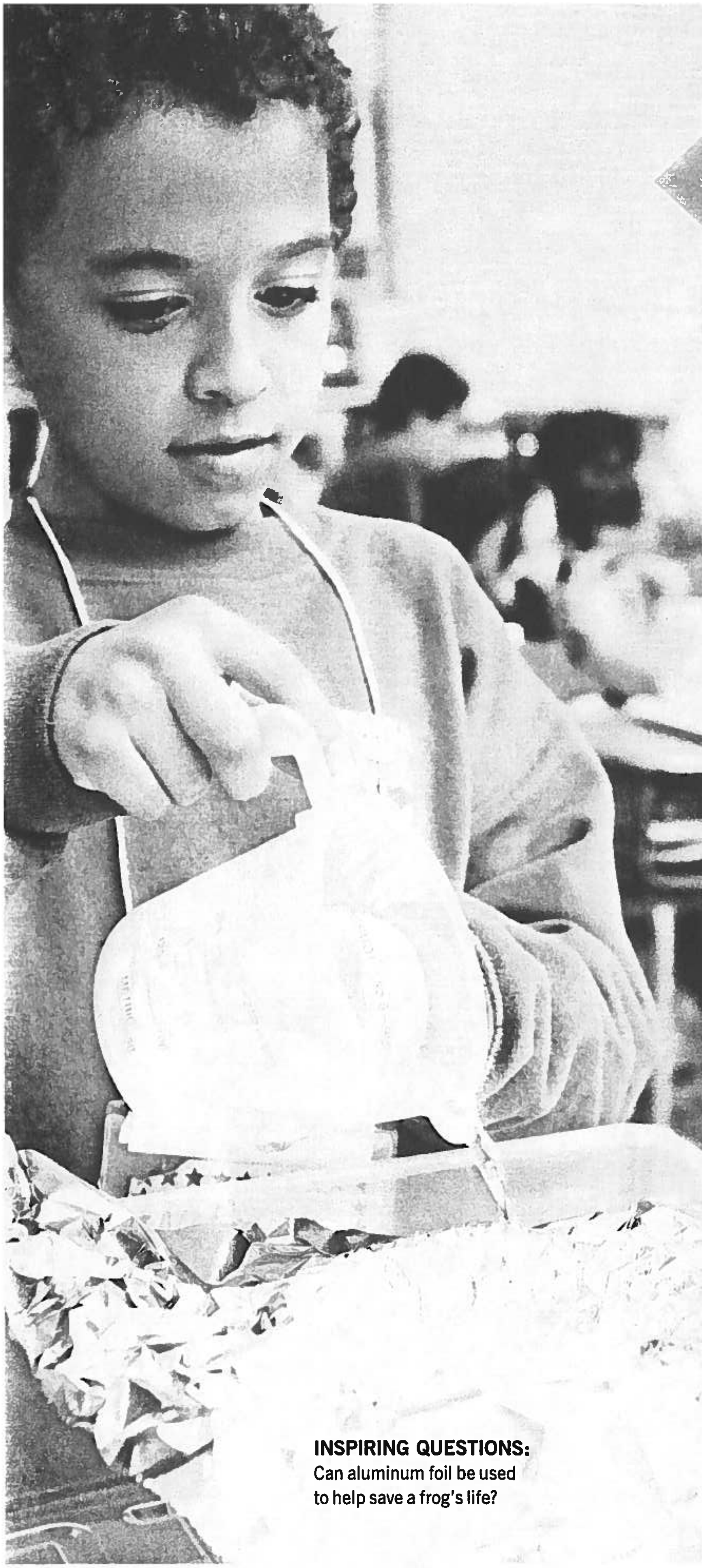
"This unit allows them to understand that a bioengineer is a real person who uses his knowledge to solve a problem," says Facchiano. Her students become personally invested in their engineering work. "They name the frog," she notes. "They don't want it to drown or not get enough water."

On this day, small teams of fourth graders test different materials, including sponges, cheesecloth, felt, and aluminum foil, determining their permeability by measuring the rate at which water passes through them and into a container below.

When a single sponge allows water to flow too fast, one girl suggests using three, just the first of several solutions her team discusses. "One of the greatest things is that these kids have to work as a team," Facchiano observes. "You've got to compromise and realize that some things don't have a single answer."

Think Like an Engineer

The unit in Facchiano's class has inspired students to conduct their own independent study as well.



INSPIRING QUESTIONS:
Can aluminum foil be used
to help save a frog's life?

HELP YOUR STUDENTS THINK LIKE ENGINEERS

While Silvia Elementary purchases its EiE materials, those connected with the progra say that a school doesn't need to invest in a formal curriculum to get started. Just use stages of the engineering design process a guide for you and your students, and watch kids get engaged in science.

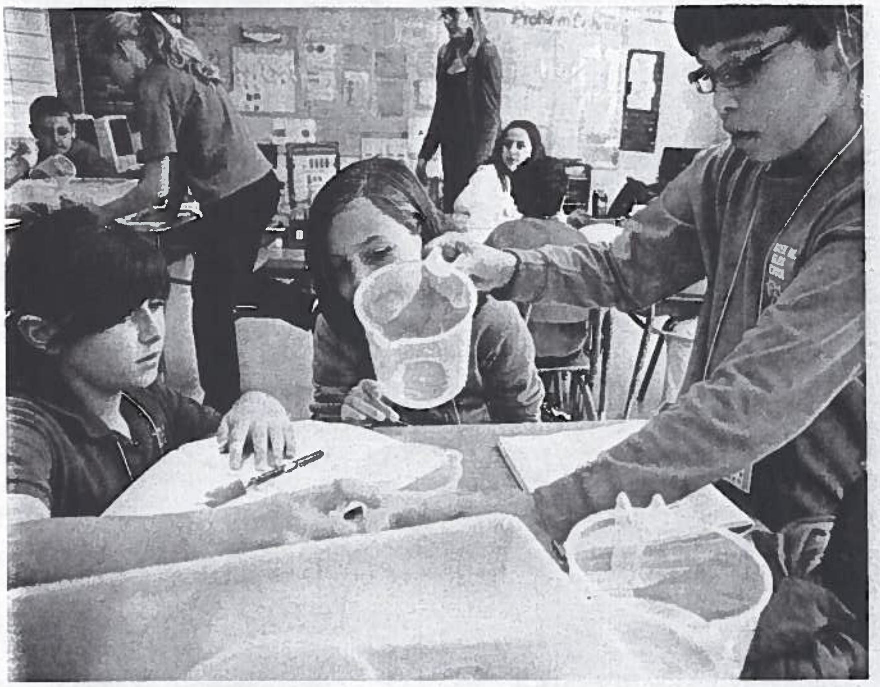
1 ASK All EiE units begin with stories pose a problem. It shouldn't be hard students to find problems they want to solve. Listen to their conversations and seize on their interests. Maybe the school's playground slide isn't as fun as it could be. perhaps the classroom hamster needs a m comfortable shelter. Keep a running list of "Challenges for Engineers."

2 IMAGINE Once you've landed on a problem to investigate, encourage students to think of as many solutio as possible. Don't put boundaries on their ativity ("We don't have the materials for tha or "Sounds expensive"). During this stage, sky is the limit, so try questions and promp such as *What if? How about? I wonder...* an *If I were...* to ignite kids' imaginations.

3 PLAN Next, it's time to get real. Ho will students transform their ideas i blueprints they can actually build? Invite small groups to brainstorm possible solutions. They should write down plans to as a record of their thinking and as a refere for the steps ahead.

4 CREATE Have lots of materials on h for students to experiment with—fo plastic, cardboard, basic building s plies. Check with your local hardware store lumberyard to see if they'd be willing to do remainders to your classroom. Encourage families to gather supplies, too.

5 IMPROVE If at first you don't succe try again. Failure is an inherent part of the engineering process, but it ca seem scary to children who've always been taught to go for those gold stars. Encourag students to embrace failure by telling them that it's valuable—and you want to see it. I students aren't failing at least once, chanc are they aren't thinking as creatively as the could be.



TRYING IT TOGETHER: Teamwork is at the heart of the engineering design process.

Fourth grader Logan St. Onge took the osmosis problem home with him. "I looked around the house for materials that might be best to use and I thought about the way I could [arrange] them," he reveals. "I'm going to leave them overnight and see whether the frog would have had enough water."

"You're starting to think like a bioengineer," Facchiano tells him.

Facchiano's students are also making connections with the larger world. "I think making designs so things will stay alive is good," says Abigail Rose. "Whenever my mom is gardening, I try to make things so the plants won't get eaten and they won't fall over."

Later this year, Sherri Carvalho will ask her students to become environmental engineers who have to clean up an oil spill. That unit had particular resonance for her students last year in the aftermath of the massive spill in the Gulf of Mexico in 2010. "They would watch what scientists were using to contain the oil," Carvalho recalls. "Where the engineers in the gulf used giant booms, the kids used cotton balls. But they understood the process involved in the cleanup."

Students are also beginning to consider the possibility of pursuing careers in engineering-related fields, Carvalho says. That marks a big difference from her experience before coming to Silvia Elementary almost seven years ago. "I would teach the required curriculum, and maybe a child would want to be a doctor or a teacher," she says. "But when you include engineering, it opens their world to a plethora of other jobs."

That comes as no surprise to EiE program manager Melissa Higgins. "Young kids are already engineers," Higgins says. "They love to solve problems. What we're doing is just providing a context in which they can use their science knowledge to solve a problem." That context has proved widely popular. Since its launch in 2003, EiE has been used by more than 32,000 teachers in all 50 states and Washington, D.C.

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—EiE's Melissa Higgins

Most of its 20 units are geared to grades 3–5, Higgins says, but some—such as designing windmills, developing a better process for making play dough, and engineering bridges—have been created specifically for younger elementary students.

In the Designing Bridges unit, for example, first and second graders apply math skills to real-life problems. "Kids love to see structures fail," she says. "We ask them to quantify the weight there is on the bridge before it fails."

Putting Knowledge to Work

Back in Sherri Carvalho's classroom, her fifth graders are quick to share their enthusiasm. "I think building stuff in 3D is exciting," says Kaitlyn Diaz. "It feels like you're a real engineer when you use the materials and plan out what you're going to do."

"I get to show my creativity about how I can help other people," says Donald Gossic. "But what I like mainly is to hear other people's ideas. That helps me work on my own project."

It's apparent that Carvalho's students have picked up valuable lessons applicable to the engineering process—and to almost any challenge they might confront. "Not everything you build will work as planned," says Hunter Cooper. "You may go through the process a hundred times, and it may not come out perfect," Kolby Peixoto chimes in.

Engineering continues to extend its scope at Silvia: This year the school is offering Engineering Adventures during its "enrichment clusters," where it joins more conventional electives such as drama, journalism, and knitting.

One adventure calls upon students to design a small parachute, which they test by timing its drop from a second-floor balcony. Along the way, Facchiano says, "They have to understand drag, suspension lines, how the parachute will open, and what types of material" will keep it aloft.

At Silvia, engineering acts as "an extension of their learning," Carvalho says. "We're saying, 'This is what you know already.'" These units let kids put that knowledge to work. □

COOL TOOLS FOR ENGINEERS

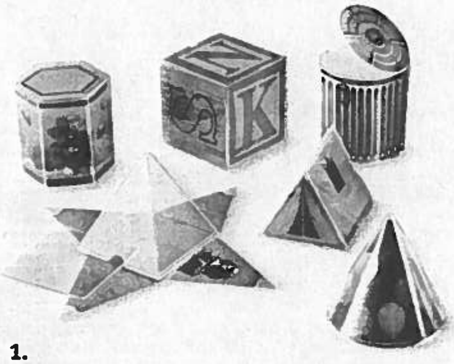
1. Geometric Shapes *learningresources.com. $36.99.* These three-dimensional shapes inspire kids to look for geometry in the everyday world.

2. Grolier *go.grolier.com.* The revised database offers limitless resources for science exploration.

3. ProtoSnap Pro Mini *sparkfun.com. $44.95.* Get control LEDs, buzzers, light sensors, and more for young inventors.

4. Techno Gears Marble Mania Vortex *tlji.com. $79.99.* Kids can see civil engineering in action by assembling this multi-pathway vortex.

Teachers' Picks
The best books and products for the classroom.



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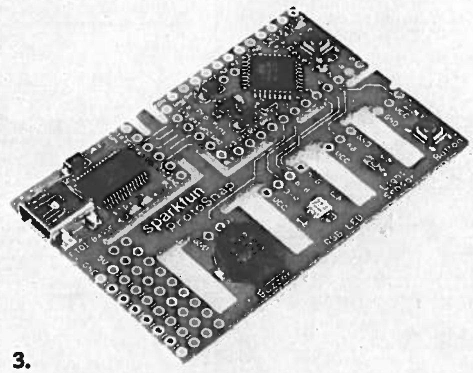

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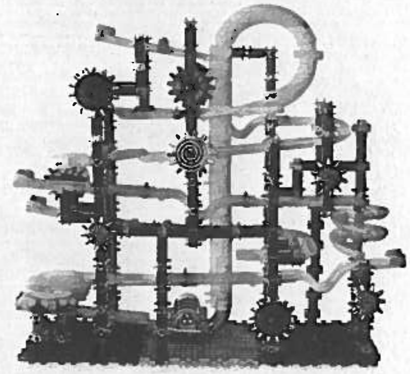

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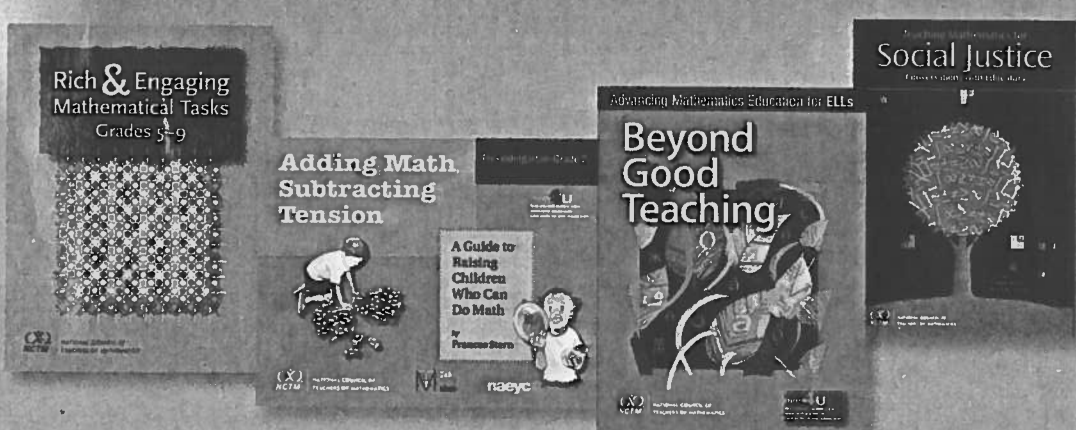

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