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STEM's newest darling: Robotics

It's the 21st century's newest must-study subject. So how can schools get more students exposed?

By Michael Fitzgerald | OCTOBER 02, 2014

PORTER GIFFORD

First-graders at private Shady Hill School in Cambridge learn basic algorithmic thinking and teamwork as they figure out how to make programmable robotic toys move.

IT'S LATE AUGUST, and workers inside the Eliot K-8 Innovation School's Upper School building on Commercial Street in Boston's North End are still unpacking on the second floor, attaching legs to the tables students will use in the new robotics classroom. Boxes and furniture are scattered in the hallway.

But Traci Walker Griffith, principal of the Eliot School, doesn't see the clutter. She sees a new opportunity to teach all-important STEM subjects — science, technology, engineering, and math. Starting in just a few days, students will get to work on those robotics tables. And she is convinced that this year's kindergartners will have mastered a host of 21st-century skills as well as problem solving, teamwork, and persistence by eighth grade. But then, "I live in utopia," says Walker Griffith, whose blue eyes blaze with the energy that has helped transform the Eliot School from the lowest-ranked elementary school in the state to one that, despite expanding, still has to turn away families eager to land a spot there.

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At Brookline's Beaver Country Day, a private school for grades 6 through 12, teachers are working to integrate programming into all of their subjects. The message Andrew Brooks wants to share — he's the school's mohawked innovator-in-residence, with a PhD from MIT in electrical engineering and computer science — is that robotics is not about building real-life C-3POs, quasi-humans. "We need to get away from that," he says. Instead, it's a way of combining sensors, computer programming, and actuators (a type of motor) to solve problems in the physical world. Those problems might include finding a new way to block out scenes in a Shakespeare play or building a self-deodorizing sports duffel bag or designing an agricultural system that knows when to water itself — all projects Beaver students have taken on in the past year.

At private Shady Hill School in Cambridge, engineering first showed up in the curriculum 21 years ago. Instructor Barbara Bratzel had a student teacher who connected her with Chris Rogers, a professor at Tufts who was looking to test techniques for training teachers. "I

wanted to put it in the classroom because I could see how excited people get by it," says Bratzel. Robotics was added in 1998, and from the start her students were thrilled to learn by using Legos and motors in a robotics-heavy STEM class called Physics by Design.

To Bratzel, one of the most attractive aspects of robotics is that students spend most of their time doing rather than listening to a teacher talk. "It's such an engaging and powerful way of teaching that the kids learn the stuff better," she says. "I would say that about engineering in general. It gives them ownership of concepts in a way they don't get from traditional classrooms."

In 2013, Shady Hill introduced its kindergartners and first-graders to Bee-Bots, simple programmable toys that teach algorithmic thinking (algorithms are like recipes for working through a problem). Even though "science has always been about nature at that age," says department chair Tracy Polte, "we decided [robotics] needs to be taught and reaches a whole different group of kids."

And in fourth grade at the school, robotics is woven into many aspects of the curriculum — kids build tools to solve problems from *Aesop's Fables,* for example, one year helping the fox finally get those grapes. In Physics by Design, eighth-graders take on a series of three-week robotics projects, including a challenge to see who can build the slowest snail. The record was set a few years back when a team created a motor that had to turn 4.7 x 10 to the 107th times for its wheel to turn once.

SUZANNE KREITER/GLOBE STAFF

At the Eliot in the North End, eighth-graders make a vehicle out of a cup, paper clips, Life Savers, and plastic bags in their engineering and robotics course.

PRIMARY AND SECONDARY SCHOOLS across the United States, and certainly in the Boston area, are looking at packed school days and limited budgets and deciding it's worth the investment to add course work in robotics. Over the past 18 years, the Tufts Center for Engineering Education and Outreach has instructed thousands of teachers in how to teach robotics to kids. And today thousands of high schools and, increasingly, junior highs and middle schools send teams to compete in FIRST Robotics and VEX Robotics events — a 21st-century version of debate club, basically an extracurricular academic sport.

In the Boston area, the push may be related to the field's role in the local economy. IRobot, which makes military and consumer robots, and industry-focused startup Rethink Robotics are here, and so are Kiva Systems, which automates warehouses and is owned by Amazon.com, and Boston Dynamics, the Google-owned maker of the robot cheetah and

various machines designed to simulate human functions. Kids who *get* robotics should be able to walk into good jobs, goes the thinking, and companies, seeing the value of a pipeline of educated workers, are sending scientists and engineers into classrooms as volunteers.

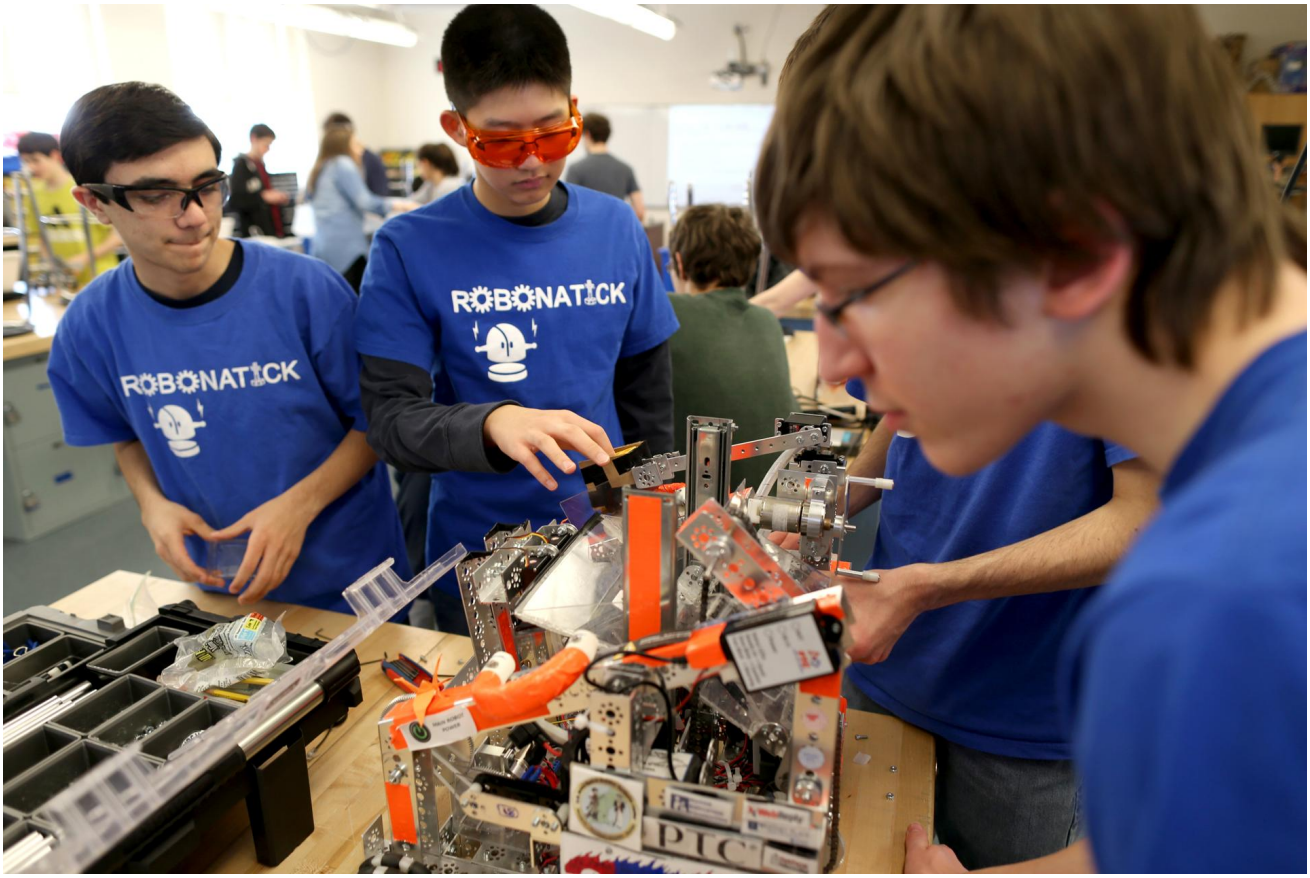
One such program, Science From Scientists, was founded by Erika Ebbel Angle in 2002 (back then she was Erika Ebbel; she married iRobot cofounder and CEO Colin Angle in 2010). The program, she says, has helped increase science scores on the standardized MCAS tests by 20 percent overall in schools that use it, and by 34 percent in schools that fell below state averages before the program came in. Colin Angle, who says he struggled in remedial math until a fifth-grade teacher helped him tap his potential, says programs introducing real-life work in classrooms can "materially change aptitudes and attitudes toward science." His company also has a program called iRobot STEM, where all employees are granted two paid days to go into schools, take robots, and educate students about real-life opportunities in the field. About 50 percent of them did this last year; the company is hoping for 60 percent this year. "We have a massive challenge graduating enough kids with interest in STEM education and STEM careers," says iRobot's Angle. "Solving this problem is huge."

Faith in the power of robotics to inspire students — from the basics of algorithmic thinking to the engineering behind building machines that do really cool stuff — is part of the Boston area's postsecondary academic culture, too. That's one of the ideas behind Lifelong Kindergarten, the research group run by Mitchel Resnick within MIT's Media Lab.

Researchers at the lab in the 1980s and '90s, funded by Lego and other sources, including the National Science Foundation, created the system of programmable bricks that inspired such products as Lego Mindstorms. A professor for 22 years, Resnick says that humans learn better when they're making things and that hands-on work teaches skills like project design, collaborating, and executing ideas. He thinks schools stop this process too quickly after kindergarten. "The education system tends to shift, and you spend a lot more time filling out work sheets at your desk or listening to a lecture," he says. Resnick thinks robotics can help make learning more fun and science less daunting.

Parents from the community — including one Eliot parent, Israel Ruiz, who also happens to be the executive vice president of MIT and an engineer by training — are also big believers in the vision. "Tangible techie things for kids are useful," he says. "They experiment, they manipulate things, they interact together."

Plus, robots are cool. "People just love robots," says Laurie Leshin, the president of Worcester Polytechnic Institute and geochemist who is a member of the Mars Rover team, one of the most high-profile real-life robotics projects yet. Leshin says robotics has the potential to galvanize science learning. "Second- and third-graders get this stuff inherently," she says. "By the time they get to middle and high school, life has beaten out of them some of that interest, and I think robots are a way to get that back." The university runs teacher training programs in conjunction with its summer camps for area kids, bringing teachers in to learn alongside the students — a program Leshin says the school would like to expand.



JONATHAN WIGGS/GLOBE STAFF/FILE

"People just love robots," says Laurie Leshin, the president of Worcester Polytechnic Institute. Here, a Natick High School team competes in a March robotics tournament.

A LACK OF TEACHERS and funds to hire them remain major obstacles. The Eliot School funded its program through government grants (with help for supplies from donations, including from the Boston Foundation), and was able to add time this year to the school day — allowing it to add robotics without cutting music, say, or language instruction — because it is an "innovation" school, a designation the community, including teachers, decided to take on.

And even at private Shady Hill, where teachers and administrators don't have to worry about teaching to Common Core or being judged on MCAS scores, time had to be taken from other areas of study in order to add robotics to the school day. For some students, it was introduced in what the school calls "flex week," one week a year where teachers experiment with new ideas. There's also an after-school Lego robotics club. So how can most public schools squeeze robotics into their busy days and tight budgets?

One public school with a well-established program is Cambridge Rindge and Latin High. It offers electives, and students can "major" in engineering, focusing on three yearlong engineering courses. Last year, 10 students graduated having worked through the engineering program, versus an average of six or eight per year over the previous decade.

The school tries to be smart in how it draws students to its robotics and engineering offerings. "We don't say, 'How'd you like to learn C++?' " says Michael V. Ananis, executive director of the Rindge School of Technical Arts, a department within the school. "You'll never see kids say, 'Oh, I want to learn how to do AutoCAD 3!' We say, 'How'd you like to create more healthy food? How about designing heart valves for infants with birth defects?' "

Principal Damon Smith says the school wants more students in these classes, and in 2015-16 may boost requirements for technical course work for the entire school population. "We're trying to teach 21st-century skills, for the emerging work spaces and globalization. We need to help kids develop skill sets and design and thinking for things we can't see," Smith says.

The last and maybe biggest challenge, as schools try to start programs, is teachers. Tufts's Chris Rogers, a professor of mechanical engineering and co-director of its Center for Engineering Education and Outreach, says the school has offered a variety of courses for teachers in robotics and engineering subjects since 1996 and has seen a surge of interest in recent years. He says these fields have to be taught differently from most school subjects. For one, the questions students and classes take on rarely have a right answer; they have multiple right answers. Robotics involves plenty of failure, and teachers and students must learn to work through that as part of the process.

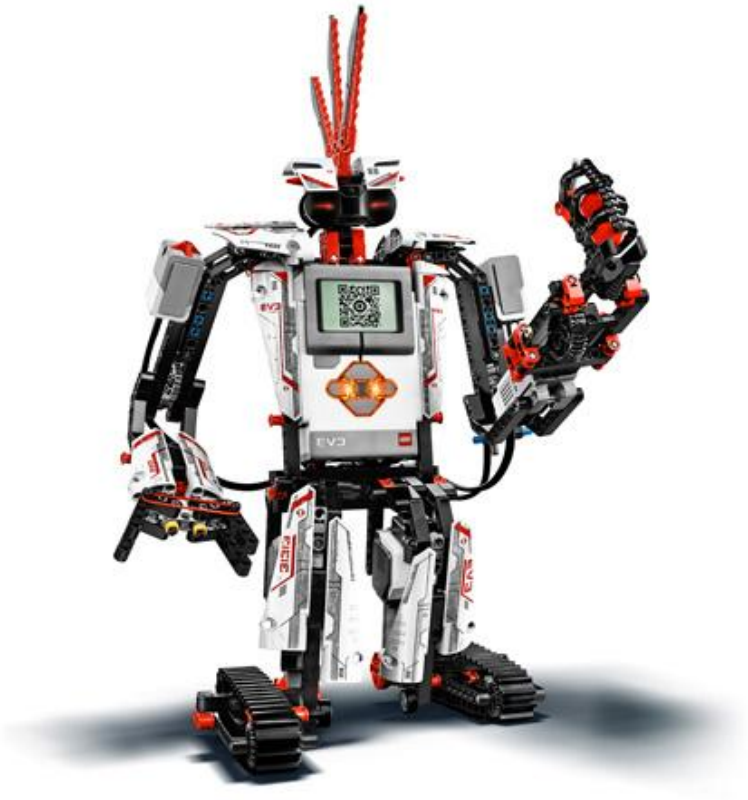
MIT's Resnick agrees that this is the subject's big caveat: The creative thinking, problem solving, and collaboration skills it can engender don't just happen because somebody at the front of a classroom opens a robotics kit. Rogers, meanwhile, said his center is looking at ways to create communities to provide additional support for teachers.

Adding robotics to the curriculum is hard "unless you have a person who has expertise and is motivated," says Alexander Mathews, principal at Boston's public Sarah Greenwood K-8 School, which offers dual language education in Spanish and English and is one of a handful of elementary schools in Boston with a robotics program. Even so, Mathews thinks robotics will become more widespread, and for practical reasons. "Engineering is what people do when they go to work — in a real way, not a phony way. They work on teams to solve a problem in a creative and innovative way using the skills that they have."

Sitting in Walker Griffith's office in the Eliot Upper School, the school's robotics teacher, Huijing Wu, pulls out her iPhone and shows off a video of a project she did during a summer teacher workshop. The video shows a Ferris wheel made of Legos spinning around. Wu talks about the program she wrote to make it spin, and how, using sensors, the Ferris wheel stops, waits, and moves, so its imaginary riders can exit. As a parent, it's hard not to want to see your children learning to do this kind of project. The question is whether it can become universal.

MEET THE CLASSROOM ROBOTS OF 2014

Lego's Mindstorms EV3 lets youngsters build and command robots that can talk and walk.



Lego also makes a WeDo Construction Set that includes a motor and motion sensors.

Bee-Bots, created by Terrapin Software in Cambridge, are programmable by even very young children.

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