WHAT'S THE Maker Movement AND WHY SHOULD I CARE?

WE'RE GLAD YOU ASKED. The coauthor of *Invent to Learn* explains how to start one in your schools and why "making" is the most powerful way for kids to learn.

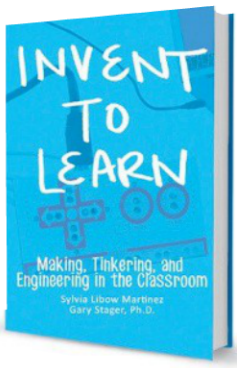
By Gary Stager

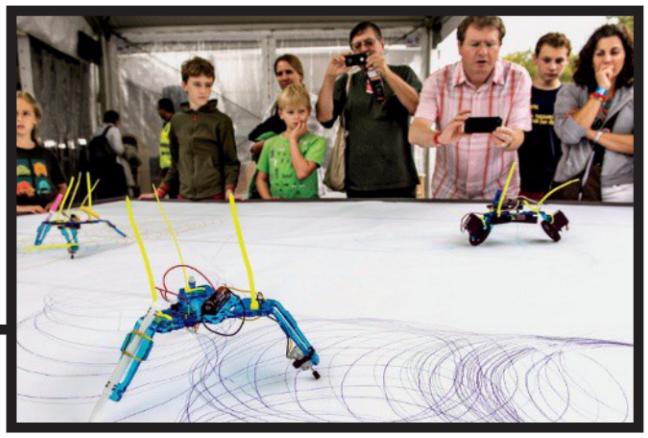
IF SOMETHING IS WORTH DOING, IT'S WORTH SKIPPING LUNCH for. That may not be the official motto of Tracy Rudzitis's students at The Computer School in New York City, but it might as well be. On any given day, 50 of the sixth through eighth graders gather during lunchtime in the school's "Maker Space" to design their own video games, build robots, mix squishy circuit dough on a hot plate, or sew a wearable computer.

Rudzitis is the digital media teacher at M.S. 245, The Computer School. When it's not lunchtime, she teaches programming, information literacy, and design to the 350-plus middle school students. While her lunchtime crew started informally, the growing maker movement has certainly helped attract more students, and push those already interested to take on more elaborate projects. "If we had a motto in Maker Space, it would be a combination of what two students said to me: 'Nothing is impossible,' and 'Everything you touch is an adventure,'" says Rudzitis.

She says her experiences constantly remind her that children are capable of powerful ideas. One student said the time spent in Maker Space "helps us understand what we are capable of."

The same type of excitement happens in Jim Tiffin's classes at The Harley School in Rochester, New York. His students





Attendees at the 2013 World Maker Faire in Queens, New York, watch artbots in action.

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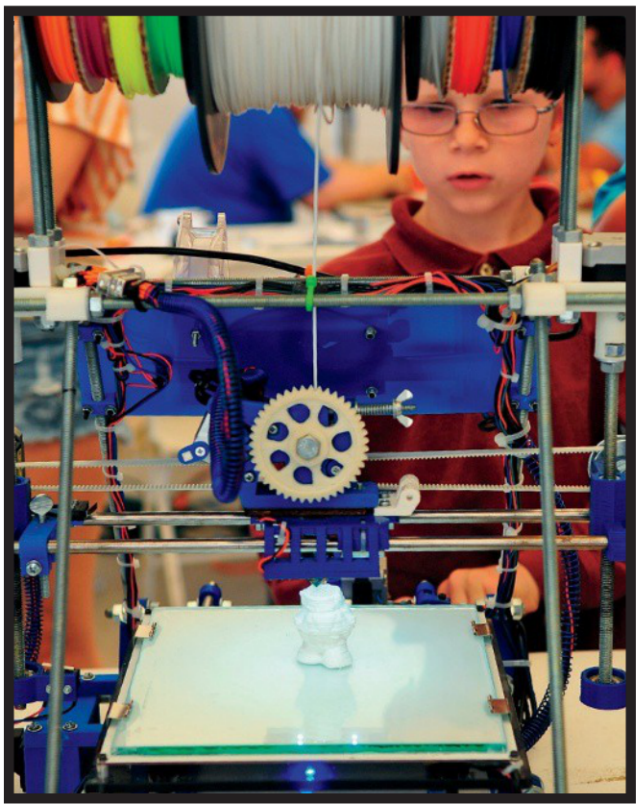
Maker Faires are billed as "the greatest show-and-tell on Earth" and expose students to creativity and innovation.



An 8-year-old boy (right) watches as a robot makes a plastic monkey at a Mini Maker Faire in Albuquerque.

build rockets, learn to use a 3D printer, and make movies during the space of a 12-week course. "It has had the most empowering effect on students of any of the courses that I've taught before," Tiffin says. "Students are taking the experiences from this class and using them in their other classes."

"For instance, students have designed and 3D-printed artifacts from the stories they've read in English as part of their work for that class—and not because their teacher told them to, but because it was the students' own idea," Tiffin adds.

"When I first saw the 3D printer and the things we could make, it seemed so complicated," says Richard, who is in sixth grade at Harley. "But wait, it's just shapes. Everything seems a little more simple now."

"After making one thing, I couldn't wait to make more," says Pieter, also in sixth grade. "After I built my first rocket, I was anxious to try out a new design to see if I could make it better."

Both of these classes exemplify the trend that is pushing its way into more schools—the maker movement. The shift to "making" represents the perfect storm of new technological materials, expanded opportunities, learning through first-hand experience, and the basic human impulse to create. It offers the potential to make classrooms more child-centered: relevant and more sensitive to each child's remarkable capacity for intensity. Making is predicated on the desire that we all have to exert agency over our lives, to solve our own problems. It recognizes that knowledge is a consequence of experience, and it seeks to democratize access to a vast range of experience and expertise so that each child can engage in authentic problem solving.

As an education technology innovator, I don't just advocate for tinkering, or making, because it's fun. The central thesis is that children should engage in making because it is a powerful way to learn.

Why Make?

EVEN IF YOU DON'T HAVE ACCESS TO EXPENSIVE (BUT increasingly affordable) hardware, every classroom can become a makerspace where kids and teachers learn together through direct experience with an assortment of high- and low-tech materials. The potential range, power, complexity, and beauty of projects have never been greater thanks to new tools, materials, and ingenuity.

You can begin with found materials: buttons, bottle caps, string, clay, construction paper, broken toys, Popsicle sticks, and tape (hint: Google "tapigami" or "duct tape projects"). Reusing materials is consistent with kids' passion for environmentalism and is an ideal of the maker movement.

If you can't yet get your head around the idea of designing a bicycle in the shape of a Matisse nude and e-mailing it to your holiday destination to be 3D printed and ridden upon arrival, consider the most important implications of the maker movement on education: Making dissolves the distinctions between domains such as arts, humanities, engineering, and science. More important, it obliterates the destructive cleavage between vocational and academic education. When the very same tools, techniques, and process skills are found and required in the physics lab, art studio, and auto shop, schools can and must stop sorting kids into winners and losers.

PHOTOS (LEFT TO RIGHT): SERGEI BACHLAKOV/XINHUA/LANDOV; ADOLPHE PIERRE-LOUIS/*ALBUQUERQUE JOURNAL*/ZUMAPRESS.COM

Wearable Computers? Yeah, You Can Make That

EDUCATORS SHOULD HONOR AND NURTURE MANY FORMS OF expression; students may demonstrate understanding of an assignment with a presentation, a written paper, a video, a shoe-box diorama, a programmable robot, or a Yugoslavian folk dance. The tools used are a whole lot less important than what is produced and the intellectual processes employed.

Three categories of game-changing technologies can help advance making today: fabrication, physical computing, and computer programming. Experiments can test how these new technologies mix with more ordinary materials and craft traditions to supercharge project-based learning.

Until recently, what you made on a computer could reside only on the screen or on paper. Now children can design physical objects with the computer. Some adults may be irrationally exuberant about 3D printing without regard for the fact that the real thinking is in the design of the object that's created by the machine.

Physical computing is the adding of interactivity and intelligence to everyday objects or materials, including paper, cloth, wood, or plastic. Hobbyists and professionals alike use popular open-source microcontrollers such as Arduino to create machines capable of interacting with the world. The Lilypad and Flora versions of Arduino are machine-washable microcontrollers that use circuits sewn with conductive thread to create wearable computers. Imagine a sweatshirt with directional signals on the back, a backpack that detects intruders, or a necklace that lights up when you approach your favorite class.

Conductive ink pens allow kids to draw circuits on paper and create interactive greeting cards. The MaKey MaKey turns a banana into a joystick or your stairs into an orchestra. Electronics, a field we have long taken for granted, returns to prominence as the maker movement lifts the lid on "invisible" systems so central to our lives.

What was considered science fiction a few years ago is now a Mother's Day gift and the stuff of childhood. We enhance creativity and enrich childhood when we add colors to the crayon box and offer a larger canvas on which to paint our future.

Computer programming not only creates a vocational path but also is the way in which one controls the other game-changing technologies. Fundamentally, being able to program grants a child agency over his or her increasingly technological world. It answers the question Seymour Papert began asking 45 years ago: Does the child program the computer, or the computer program the child?

Kid Power

MAKER FAIRES, WHERE ADULTS AND CHILDREN ARE GATHERING in ever-growing numbers, celebrate the inventor in all of us, but they also seem to be brewing an anti-school streak among some parents and children. "School is boring" has given way to "School is destroying my child. Look at what they are capable of doing! School is oblivious to my child's interests, talents, and expertise." I am not willing to give up on school, simply because that is where the kids are. We can and should make classrooms more like Maker Faires.

One of the most exciting aspects of the maker movement is how children are at the center of it. In an age short on apprenticeship experiences, adult makers are eager to share their expertise with kids. Not only that, but children are the heroes of the community, not because they are stage-managed show ponies, but due to their demonstrated competence. Twelve-year-old Super Awesome Sylvia has been producing Web videos—modestly called "Super Awesome Sylvia's Super-Awesome Maker Show"—with which she has inspired millions of views and countless learners of all ages to engage in personal engineering projects. Sixteen-year-old Joey Hudy uses the proceeds from the electronics kits he designs and manufactures to attend Maker Faires around the world. These kids and many more like them are revered, cherished, and celebrated by the community of makers. They love being in the company of adults who have expertise to share.

The twin ideals of high standards and progressive education are not mutually exclusive and may be unified by making, tinkering, and engineering. The Next Generation Science Standards recently published by the National Academies Press make explicit calls for computer science, engineering, and tinkering to be a part of every child's education. In fact, if one were to faithfully implement the NGSS, he or she would need to make structural changes to the learning environment that would put a smile on John Dewey's face.

In the future, science assessments will not gauge students' understanding of core ideas separately from their abilities to use the practices of science and engineering. They will be assessed together, showing that students not only "know" science concepts but also that they can use their understanding to investigate the natural world via the practices of inquiry or solve meaningful problems through engineering design. ■

GARY STAGER is a teacher educator, author, and speaker who works with schools and keynotes conferences around the world. inventtolearn.com

IF IT'S GOOD ENOUGH FOR MIT

We convinced you about the merits of making, right? Now how can you counter the skepticism you might face from parents and staff?

TRY THESE READY-MADE REPLIES.

When parents say:
This is just a fancy shop class. Our children need to focus on getting into college.

You can say:
The 21st century is going to see the integration of these tools into every college major and career choice. MIT recently announced it is adding a section to its admissions application for students to write about what they have made. Making demonstrates not only technical knowledge and creativity but also habits such as perseverance and resourcefulness. Surely, anxious parents want their children to attend schools like MIT. Engineering and art are interrelated; computer programming is mandatory for biologists, musicians, and historians.

When teachers say:
We should go slowly and proceed cautiously.

You can say:
We know that students learn better and invest themselves in learning when it's meaningful and interesting. Making puts the learner at the center of the educational process and creates opportunities. Makers are confident, competent, curious citizens in a new world of possibility. The time to start making this real is now. We need to have the courage to lead on behalf of the children we care about.