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 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 firsthand 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.

This book doesn't just advocate for tinkering or making because it's fun, although that would be sufficient. The central thesis is that children should engage in tinkering and making because they are powerful ways to learn.

Our new book, *Invent To Learn - Making, Tinkering, and Engineering in the Classroom*, co-written with Sylvia Martinez, is the first book to capture the energy, tools, innovation, and creativity of the rapidly expanding maker movement as a vehicle for school reform. The book places the maker movement in a historical and theoretical context, recognizing that we stand on the shoulders of giants. It explains the technological game-changers and describes their use in today's classrooms. Chapters on learning, teaching, shaping the learning environment, leadership, advocacy, and hundreds of resources are intended to turn every classroom into a makerspace and every educator a maker. We even provide a chapter filled with a list of responses you might offer to those questioning the value of making, tinkering, or engineering in the classroom.

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, breadth, power, complexity, and beauty of projects have never been greater thanks to the amazing new tools, materials, ingenuity, and playfulness you will encounter in this book."

"The best way to activate your classroom is for your students to make something. This might an amazing high-tech invention or it might take the form of costumes for a historical reenactment, homemade math manipulatives, a new curtain for the local auditorium, toys, a pet habitat, a messy science experiment, or a zillion other things. Best of all, you don't need expensive hardware, or to start by mastering a programming language. You can begin with found materials: buttons, bottle caps, string, clay, construction paper, broken toys, popsicle sticks, or tape (hint: Google "tapigami" or "duck 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.

Wearable Computers? Yeah, You Can Make That

For too long, schools have undervalued learning with one's hands. Modernity, as exemplified by the maker movement requires us to value learning with the head, heart, and hands equally. Eleanor Duckworth reminds us, "If materials are slim, the only questions likely to be posed are the teacher's."

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?

Teaching making re-skills and re-empowers teachers who have been fighting a battle to maintain agency over their practice.

"Education policy often confuses teaching and learning. Learning is not the direct result of having been taught. If you have spent any time working with learners, you know that you can't simply talk at them, or do something to them, and expect that they have learned anything. A robot can deliver curriculum; great teachers provide much more."

"In spite of research that shows that experiential classrooms and long-term projects are effective in teaching higher-order thinking skills and deep content knowledge, such pedagogical methods are not widespread. This may be a result of the current focus on standardized testing and the acceptance of teaching to the test as never before."

"Understanding is the result of existing knowledge accommodating and explaining new experiences. If we focus on a handful of powerful ideas and create experiences where students naturally need to stretch their understanding, students learn more. The role of the teacher is to create and facilitate these powerful, productive contexts for learning."

"One simple way to do this is to make your teaching mantra, "Less Us, More Them." Piaget suggests that it is not the role of the teacher to correct a child from the outside, but to create conditions in which the

student corrects himself. Whenever you are about to intervene on behalf of a teachable moment, pause and ask yourself, "Is there a way I can shift more agency to the learner?"

Less Us, More Them doesn't exempt teachers from the learning process, or minimize the importance of their expertise within the learning environment. This raises expectations and standards in our classrooms by granting more responsibility to the learner. In this environment, it is natural to expect kids to look up unfamiliar words, proofread, and contribute resources for class discussion without prodding from the teacher."

"In addition to the current political climate, the kind of teaching required by making must be learned and practiced. Studies show that teachers have concerns about their own ability to provide the required scaffolding for students that can't be found in the back of the textbook."

Community Of Practice

"Maker classrooms are active classrooms. In active classrooms one will find engaged students, often working on multiple projects simultaneously, and teachers unafraid of relinquishing their authoritarian role. Collaboration between students is flexible and teachers experience a seamless metamorphosis between mentor, student, colleague, expert, and personal shopper, all in service of their learners."

One model for classrooms might be Maker Faire. There are three major Maker Faires in the USA each year and hundreds of Mini Maker Faires springing up in communities across the globe. "The Greatest Show and Tell on Earth" is a celebration of invention, ingenuity and creativity where learners of all ages come together to share their skill, passion, talent, and expertise in formal and informal settings. The San Mateo Maker Faire this past May had over 150,000 attendees. That is ten or fifteen times the size of the largest edtech conference and demonstrates a growing hunger for experiences too often being driven from schools. Are your schools aware of the learning tsunami outside of school? Why can't every classroom be like Maker Faire?

"The role of the teacher is to create the conditions for invention rather than provide ready-made knowledge." —Seymour Papert

"It is incumbent upon educators to cherish the gifts that children bring to us, even if just an absence of fear, and help them build upon those gifts, to go farther than they could have gone on their own."

"Children deserve rich experiences across the widest range of disciplines available. The good news is that in the maker community, artistic projects and craftsmanship are highly valued. Music composition is often required in programming a computer game or making your robot dance. Oral presentation skills are necessary for pitching your invention or in narrating your film. Artistic skills, creativity, and curiosity are in high-demand by any project, no matter how technical."

"All too often, we are enchanted by the technical merit of a project and forget the importance of relevance, meaning, and sufficient evidence of understanding. Adults are often quick to celebrate students' success with technology and neglect to consider the overall impact of student project work."

Makers eagerly share what they know and do with others at Maker Faires and in thriving online sites like makezine.com and instructables.com. Maker teachers maintain a Twitter chat with the hashtag, #makered. There is a shared sense of responsibility among makers to empower others.

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.

Often parents are torn between their respect for the institution of school and their intuition that something is not working for their child. Be clear while making your case that although your plans may not look exactly like traditional school, you are not abandoning high standards or a quest for learning. The argument for making, tinkering, and engineering should not be as an "alternative" way to learn, but what modern learning really looks like.

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. Middle schooler Schuyler St. Leger is known for his viral hit, "Why I Love My 3D printer" and is a featured attraction at the annual Autodesk University, Quin Etnyre leads a company that designs new sensors and runs his own makerspace where he shares his knowledge with the community and was recently featured in Popular Science at the age of twelve. 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.

"Kid makers possess a skill set and self-efficacy that will serve them well in school, as long as they are engaged in interesting activities worthy of their capacity for intensity. Despite the swirling politics and external pressures on schools, the maker movement may offer teachers cause for optimism. The stuff of making is super cool and gives those teachers so inclined another chance to reanimate progressive education. If your administrator likes to buy shiny new things, then there are plenty of things to buy that actually amplify the potential of children. Silicon Valley billionaires are endorsing the non-profit, Code.org, which advocates for kids to learn computer programming. The Association for Computing Machinery is advocating for computer science to be a curriculum staple from kindergarten to twelfth grade and the brand new Next Generation Science Standards by the National Academies of Science makes explicit calls for meaningful assessment, interdisciplinary knowledge, inquiry, and engineering.

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.