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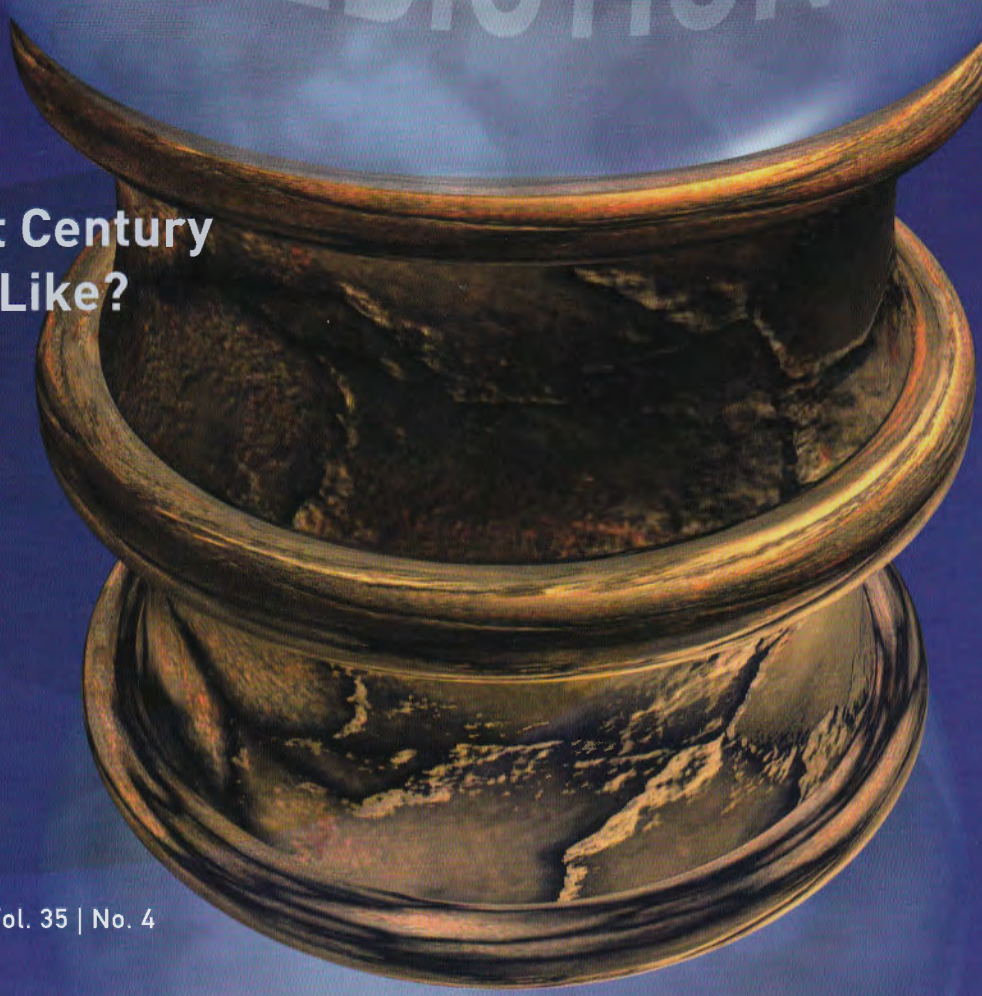

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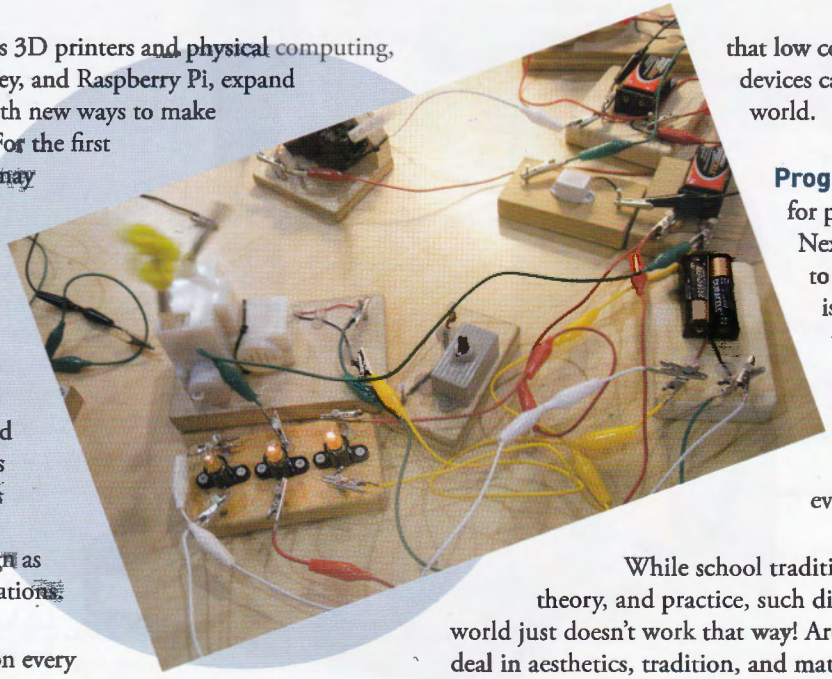
A Trend Worth Watching—
The Maker Movement

The Maker Movement is a technological and creative revolution underway around the world that celebrates using technology to make, repair, and customize the things we need. Hundreds of thousands of adults and children alike are frequenting Maker Faires, hackerspaces, and DIY (Do-It-Yourself) websites. A growing library of print literature inspires learners of all experiences to seize control of their world. Making brings engineering, design, and computer science to anyone who is willing to dive in and try something new. Fortunately for educators, this Maker Movement overlaps with the natural inclinations of children and the power of learning by doing. It also holds the keys to reanimating the best learner-centered teaching practices.

Digital fabrication devices such as 3D printers and physical computing, including Arduino, MaKey MaKey, and Raspberry Pi, expand a child's toy chest and toolbox with new ways to make things and new things to make. For the first time ever, childhood inventions may be printed, programmed, or animated with interactivity. Recycled materials can be brought back to life. Online communities serve as the hub of a digital learning commons, allowing people to share not just ideas, but the actual programs and designs that they have made. This ease of sharing lowers the barriers to entry as newcomers can easily use someone else's code and design as building blocks for their own creations.



Three game-changers should be on every school's radar:

Computer controlled fabrication devices—Over the past few years, devices that fabricate three-dimensional objects have become an affordable reality. These 3D printers can take a design file and output a physical object. Plastic filament is melted and deposited in intricate patterns that build layer by layer, much like a 2D printer prints lines of dots that, line by line, create a printed page. With 3D design and printing, the ability for students to design and create their own objects combines math, science, and craft.

Physical computing—New open source microcontrollers, sensors, and interfaces connect the physical world to the digital world in ways never before possible. Many schools are familiar with robotics, one aspect of physical computing, but a whole new world is opening up. Wearable computing—where circuits are made with conductive thread—makes textiles smart, flexible, and mobile. Plug and play devices that connect small microprocessors to the Internet, to each other, or to any number of sensors mean that low cost, easy to make computational devices can test, monitor, and explore the world.

Programming—There is a new call for programming in schools, from the Next Generation Science Standards to the White House. Programming is the key to controlling this new world of computational devices, and the range of programming languages has never been greater. Today's modern languages are designed for every purpose and every age.

While school traditionally separates art and science, theory, and practice, such divisions are artificial. The real world just doesn't work that way! Architects are artists. Craftsmen deal in aesthetics, tradition, and mathematical precision. Video game designers rely on computer science. Engineering and industrial design are inseparable. The finest scientists are often accomplished musicians. The maker community brings children, hobbyists, and professionals together in a glorious celebration of personal expression with a modern flare.

Lessons from the Maker Movement

"Doing" is what matters—Makers learn to make by making. Schools often forget this as they endlessly prepare students for something that is going to happen to them next week, next year, or in some future career. Students can and should be scientists, artists, engineers, and writers today. The affordable and accessible technology of the Maker Movement makes learning by doing a realistic approach for schools.

Openness—The Maker Movement is a child of the Internet but does not fetishize it. Makers worldwide share design, code, and ideas, but making occurs in real life. Makers share their expertise with a global audience. "We" are smarter than "me" should be a lesson for educators. Collaboration on projects of intense personal interest drives the need to share lessons learned, not external incentives like grades.

Give it a go—Back in the '80s, MacGyver could defuse a bomb with the chewing gum and paper clips he found in his pocket. Modern MacGyvers are driven to invent the solution to any problem by making things, and then making those things better. While perhaps "grit" or determination can be taught, the best way for students to become deeply invested in their work is for their work to be personally meaningful, supported by time and encouragement to overcome challenges.

Iterative design—Computers make designing new inventions risk-free and cheap. You can now tinker with designs, code, and make nearly perfect prototypes easily and quickly. This is a departure from linear design methodology that assumes that mistakes are expensive and need to be avoided. However, many educators are still clinging to old design models where students are provided recipes and prescriptive rubrics. This deprives students of the chance to take risks and learn how to navigate their way to the end of a project, facing unknown challenges and constraints just like engineers and scientists do in real life.

Aesthetics matter—Many Maker projects are indistinguishable from art. It's human to embellish, decorate, and to seek the beauty in life. In schools, there is a movement to add Arts to STEM subjects (STEAM). That's a good instinct, but if school hadn't artificially removed all traces of creativity and art from STEM subjects, we wouldn't need to talk about STEAM. Find ways to allow students to make projects with pride and unencumbered by categorization.

Mentoring defies ageism—As Sir Ken Robinson says, school is the only place in the world where we sort people by their date of manufacture. The Maker Movement honors learners of all ages and embraces the sharing of expertise. Young people like "Super Awesome Sylvia" (sylviashow.com), a young maker who broadcasts her project tips on her own web show, or Jody Hudy, who surprised President Obama with a marshmallow cannon at the White House, are valued alongside decades-older master tinkerers and inventors. Schools may create opportunities for mentoring and apprenticeship by connecting with the greater community. Access to expertise must not be limited to the classroom teacher.

The Maker Movement values the intensity of the learning experience with endless options and choices about what a person might find interesting or fall in love with.

Learning is intensely personal—The current buzz about "personalized learning" is more often than not a scheme to deliver content by computerized algorithm. Not only is it magical thinking to believe that computers can teach, it confuses learning with delivering content. Learning happens inside the individual. It can't be designed or delivered. Learning is personal—always. The Maker Movement values the intensity of the learning experience with endless options and choices about what a person might find interesting or fall in love with. Giving kids the opportunity to learn about what they love means they will love what they learn.

It IS about the technology—Some educators like to say that technology is "just a tool" that should fit seamlessly into classrooms. In contrast, the Maker Movement sees tools and technology as the essential elements for solving unsolvable problems. To Makers, a 3D printer is not for learning to make 3D objects, but is the raw material for solving problems, such as how to create inexpensive but custom-fit prosthetics for people anywhere in the world, or print a pizza for hungry astronauts. The Maker philosophy prepares kids to solve problems their teachers never anticipated with technology we can't yet imagine.

Ownership—One motto of the Maker Movement is "If you can't open it, you don't own it." Educators often talk about how learners should own their own learning, but if the learner doesn't have control, they can't own it. Teachers should consider that prepackaged experiences for students, even in the name of efficiency, are depriving students of owning their own learning.

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Our new book, *Invent To Learn: Making, Tinkering, and Engineering in the Classroom*, explores the Maker Movement and makes the educational case for bringing making, tinkering, and engineering to every classroom. The book combines theory, history, practical classroom tips, and countless resources to help K-12 schools make creativity, construction, and children the focus of education once again.

Common Core and the new Next Generation Science Standards emphasize critical thinking, creativity, and 21st Century skills. To achieve these goals requires taking a hard look at both what we teach and how we teach it. The Maker Movement offers lessons, tools, and technology to steer a new course to more relevant, engaging learning experiences for all students. CUE

Sylvia Libow Martinez and Gary Stager, PhD are the authors of a new book, Invent To Learn: Making, Tinkering, and Engineering in the Classroom *published by Constructing Modern Knowledge Press.*

Sylvia is currently president of the non-profit Generation YES organization, a maker, mom, video game designer, and electrical engineer.
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Gary is a veteran teacher-educator and speaker who has taught computationally enhanced making in the classroom for more than 30 years. Gary was presented with CUE's TILL Award in 2012.
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Additional Resources

BOOK – *Invent To Learn: Making, Tinkering, and Engineering in the Classroom*
Books, links, resources, and professional development for making in the classroom.
www.inventtolearn.com

VIDEO – Making in Education
Gary Stager's interview with Steve Hargadon at the 2012 San Mateo Maker Faire
youtu.be/RVJfba1TAhg

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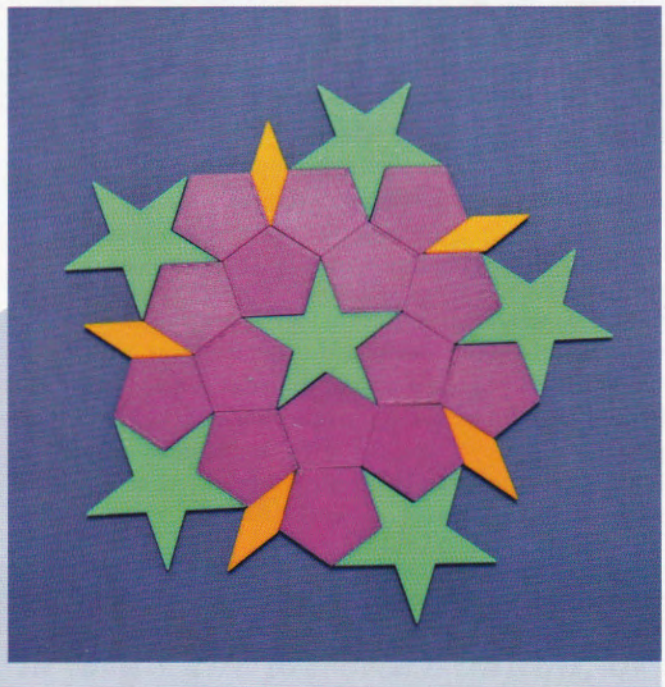

3D printer pieces for this pattern were made through the Knights of Knowledge Pentagram Project.

them out. Important learning takes place in both phases. We are, in fact, working on a book for teachers that shows, step-by-step, how to use free software tools to design and build educational products.

From where I sit, we are at the start of a technological revolution that will have a huge impact in our schools, as well as let you build some nifty 3D backpack tags after school! CUE

David Thornburg, PhD, has been involvd with educational technology since the 1970's and is still going strong. His work spans several countries and his insights have been shared at CUE conferences since the beginning. His recent work is centered on the Knights of Knowledge project (knights-of-knowledge.com) in conjunction with his wife, Norma, and colleague, Sara Armstrong. dthornburg@aol.com