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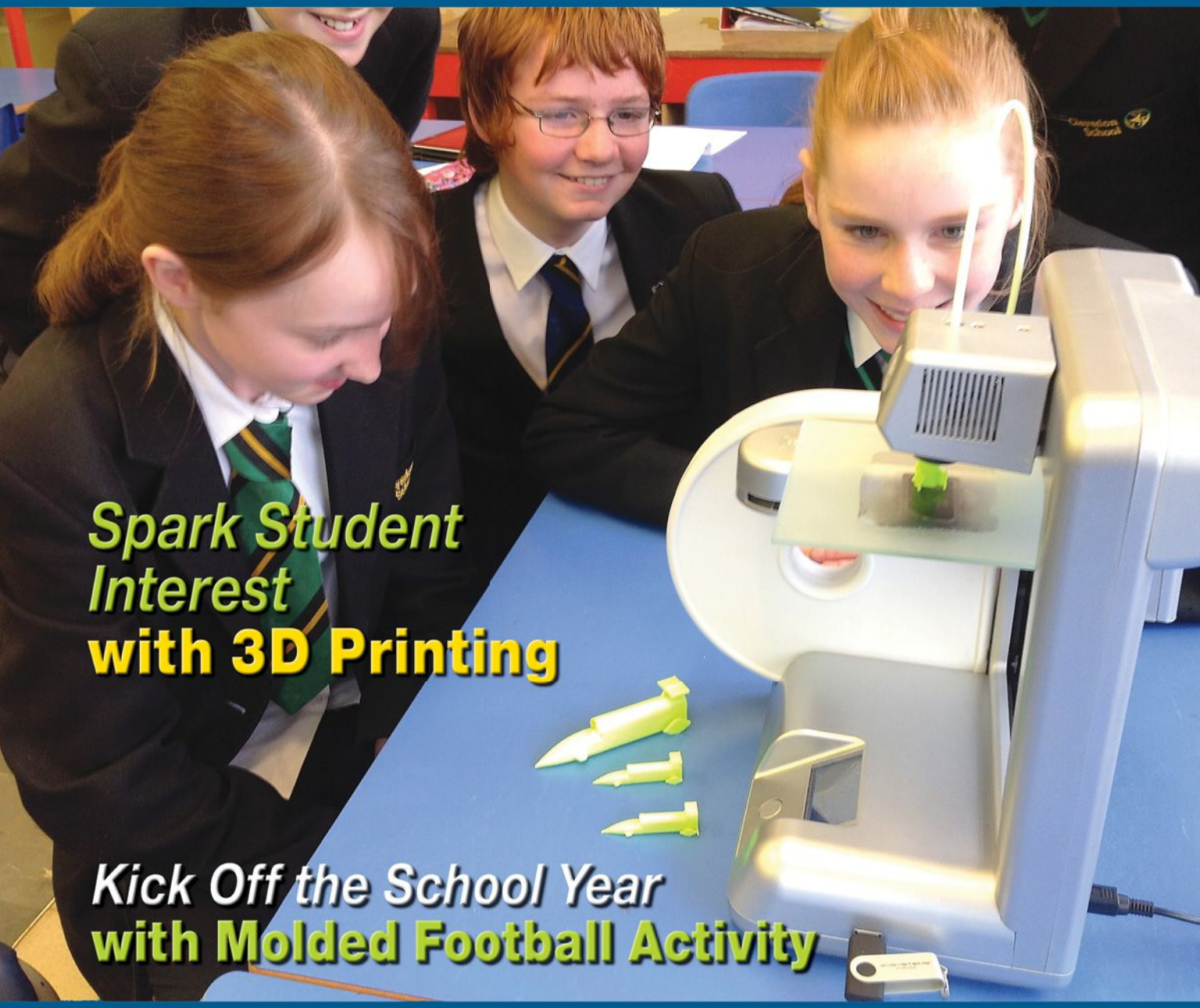

Spark Student Interest with 3D Printing

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Turning Students into Engineers with 3D Printing

By Steve Murray
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3D (three-dimensional) printing has been used by industry for decades as a rapid prototyping tool. Engineers rely on rapid prototyping to study new product designs, to find their flaws, and to improve their features. 3D printing in schools hasn't been around as long, but it's used for many of the same reasons. The technology has proven itself in the classroom as a fun, real world way to teach science, technology, engineering, and math (STEM) skills, to develop creativity, and to encourage teamwork.

As printer prices fall, and as the machines and their software become easier to use, teachers are finding that they can offer 3D printing experiences to students as early as elementary school.

How 3D Printers Work

Fused deposition modeling (FDM) 3D printers work like inkjet printers, with a few important additions. The biggest distinction is that they contain plastic instead of ink. The machines use ABS plastic, like that found in LEGOs, as well as PLA plastic. The material is softened and deposited with a computer-controlled cartridge onto a firm surface, where it quickly cools and hardens.

Another distinction is layering. While an inkjet printer produces a flat page with text and images, a 3D printer must make an object that has both vertical and horizontal shape. Consequently, a 3D printer goes over the surface repeatedly, leaving new layers of plastic each time, until a final form is completed.

Besides FDM, additional additive processes are available, which differ in the way layers are deposited and the materials that can be used. Methods that soften or melt materials to form the layers include selective laser melting (SLM), direct metal laser sintering (DMLS), and selective laser sintering (SLS). Other methods cure liquid materials using different technologies, such as stereolithography (SLA). In laminated object manufacturing (LOM), thin layers are cut to shape and joined together (e.g., paper, polymer, metal).

Many 3D printers use two cartridges to produce more complex objects. The second cartridge contains a material that gives structural support to the primary form as it is being built, and the support material is removed when the job is completed. This process can yield very complex and delicate objects with interlocking, movable parts.

The objects that 3D printers make are designed with CAD (computer-aided design) software programs. Most modern CAD programs have good interfaces that can be used by both novices and experts, and many programs are free. 3D printers can work with any program that exports an STL (Standard Tessellation Language, a common CAD format) file.

Printers for school use are typically small enough to fit on a tabletop and can be carried by one or two people (handy features for schools that share a printing resource).

The Cube 3D printer along with several items made using it

How They're Used

Classroom and lab printing projects require all the steps used in real-world engineering. Students first analyze what they want to build, design a product to match their requirements, and evaluate the result.

Steve Murray is an engineer and science writer, San Diego, CA.

Project difficulty can be tailored to a student's abilities and interests, so 3D printing can be used for all ages. Products can be selected from predefined models, downloaded from the Internet, or created from scratch. Younger students can build printable objects by simply drawing them with graphical software while older students can build more complex designs with mathematical equations.

Working in project groups will add communication and teamwork skills to the learning mix. Group members can contribute based on their individual strengths and feel that they're part of a team contributing to a common goal.

Some teachers have used 3D printing to fabricate models and visual aids for their chemistry, math, and biology courses. In the process, they have discovered that while the visual models add to the clarity of the lessons, they also draw students into the printing technology that created them.

In both education and real-world settings, 3D printing is also flourishing in areas like art, fashion, jewelry design, lighting, music, and architecture.

Three school experiences, below, will show the value and effectiveness of 3D printing for all grade levels.

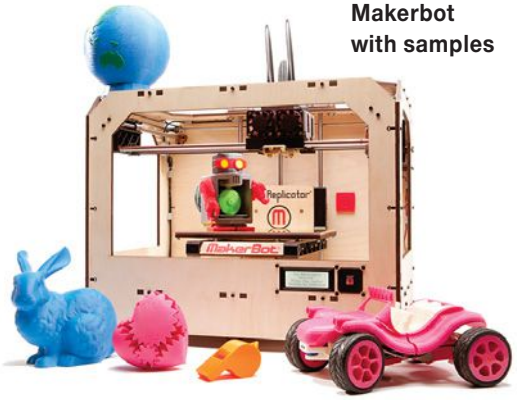
Harnessing Natural Enthusiasm

Although the fun of 3D printing may first capture the attention of elementary school students, the technology quickly leads to more ambitious classroom exploration. Kris Swanson, Planetarium Resource Teacher at Poinciana Elementary STEM Magnet School in Boynton Beach, FL, has seen the excitement. "The kids are simply mesmerized by the process—watching a thread of plastic turn into a thing, especially when that thing is something that they designed."

Swanson uses 3D printing to help students visualize the world. "One of the challenges of teaching engineering and design to elementary-aged students is getting from an abstract idea or even a 2-dimensional drawing to an actual object in the real world," he said. "My challenge is to help them make their ideas real. 3D printing is a powerful tool to help do that."

He purchased a MakerBot Replicator 3D printer in 2011 with a STEM grant, and members of his after-school engineering club served as guinea pigs to figure out how to use the machine.

Poinciana Mad Panda Maker Club



Makerbot with samples

One of his biggest challenges was determining which CAD software was most appropriate for his 8- to 10-year-old students. He settled on Tinkercad, a free program with an easy-to-use interface, and found a Tinkercad tutorial to guide his students through their first printing project of making nameplates for their cubbies. After that, some of the girls moved on to designing jewelry, while the boys gravitated more towards spacecraft.

"This year, we just got experience with the printer," he explained. "Next, my plan is to integrate the printer into 4th- and 5th-grade geometry units and to complete some engineering projects with them."

Building Toward High School

3D printing has been used in middle schools to give students a technical foundation to take advantage of opportunities they'll encounter in high school.

Peter Grimm, an industrial technology teacher at Southview Middle School in Edina, MN, focuses his students' energies with design competitions. One of his first projects was a challenge to improve the usability of automobile cup holders, and the winners were rewarded by having their design printed.

The response of his students has convinced him of the value of 3D printing for teaching physical concepts. "Giving students the ability to hold a functional model of their design work makes engineering real," he said. "It is one thing to create a solution using 3D software. It's quite another experience to actually manipulate the mechanism you designed. ►

"Having an actual prototype helps students understand many things: proportion, fit and clearance, the visual elements and mechanical function of the design, and many other aspects that aren't as easily understood when solely viewing a model on a computer."

Southview Middle School purchased its first printer by combining a contribution from the Edina Education Fund with proceeds from private fundraising. Southview shares the printer with another middle school to make the best use of the resource.

Grimm has also found an unexpected, but welcome, benefit of the technology. "3D printing has elevated the excitement level in the classroom—and it has been a great promotional tool for our program," he said. "We bring it to fundraisers and get lots of 'oohs' and 'aahs' from potential donors. It also makes the rounds at teacher conferences. Keeping enrollment strong in design and engineering courses is always a consideration."

Training for College and Beyond

STEM skills are particularly important in high school, as students prepare for college and careers, so 3D printers are more commonly found in high school classrooms.

Bryce McLean, chair of the Applied Technology Department at Coronado High School in Colorado Springs, CO, uses 3D printing to augment his engineering courses. "We can give kids the ability to get a tangible item in their hands," said McLean, "which accelerates the learning process much more than just looking at a design on a computer screen or a piece of paper." McLean only prints one or two of the best designs in each class, which pushes every student to do their best work.

McLean obtained his first printer with the help of Project Lead the Way (PLTW), which provides STEM curriculum guidance and resources to middle and high schools. He follows the PLTW curriculum and introduces students to engineering topics early. Freshmen and sophomores take introductory courses that eventually culminate in a senior capstone course.

"In our Aerospace Engineering class," said McLean, "students design an airfoil and place it in a wind tunnel to test various aerodynamic characteristics. I turn the project into a contest and print a 3D model of what is considered to be the most efficient design in the class. The students really get into it."

McLean also supervises the school Robotics 2996 Club, where he uses the printer to make pulleys for robots, and nose cones and fins for rockets.

Like other teachers who have used the technology, McLean appreciates the "wow" factor of 3D printers. "People come by to look at the tool and that sparks their interest," he said. "Once they see it, they get hooked."

And, for anyone who might not be impressed with the new tool? "I actually show the kids a video, describing old machine shop techniques, to give them an appreciation for how far the technology has come."

Summary

Every time 3D printing is used in the classroom, teachers gain experience and instructional techniques improve. Many teachers are sharing their knowledge via blogs and websites, and some 3D printing manufacturers offer lesson plans and online user communities to help teachers develop course content.

There's plenty of help to get started.

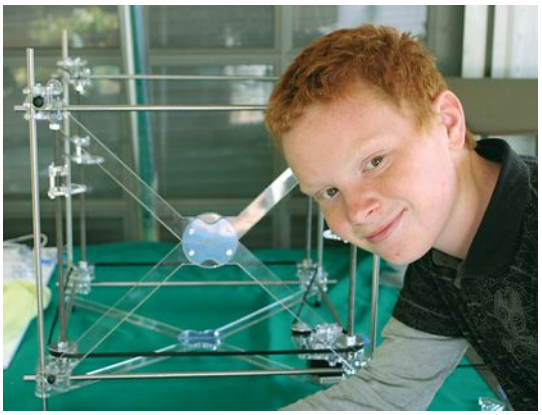
Student pulls his finished product from a printer.

As Kris Swanson, of Poinciana Elementary School, said, "This is the dawn of a technology that will be commonplace by the time my students become adults. Learning how to design and create objects in this way can only be helpful to them, not only in what they are learning now but what they need to be able to do in the future."

Sources of Additional Information

- A series of school and college case studies about 3D printing can be found at www.stratasys.com/Resources/Case-Studies.aspx under the Educational category.
- 3D printing lesson plans for grades 3 through 12 are available at http://curriculum.makerbot.com/index.html on the Lesson Plans link.
- Project Lead the Way (www.pltw.org) does a lot to support 3D printing in the classroom. Click on the Getting Started link.
- Make Magazine (http://makezine.com) offers plenty of student-friendly 3D printing activities and ideas, and is just one of many online information sources on the subject.
- www.3dsystems.com/solutions/education
- http://3dprintineducation.wordpress.com
- www.classroom3dprinters.com

Enthusiastic Student Introduces Peers to 3D Printing



Riley and Rapman

SOMETIMES, innovation is driven from the bottom-up. Riley Lewis, a Discovery Charter Middle School student in San Jose, CA, didn't wait for his teachers to start a 3D printing program, but charged out on his own to introduce the technology to his friends. In only three years, Riley's initiative has helped to establish 3D printing in several Bay Area schools and has turned students, teachers, and parents into printing enthusiasts.

Riley's path to 3D printing started in 2010 when he learned how to use a sophisticated CAD software program to help complete his entry in an engineering design competition. News of his talent reached 3D Systems, a printer manufacturing company, which donated a Rapman 3.1 printer kit to his middle school to see what he could do with it.

Riley assembled the printer over the summer of 2011 with help from his dad, David Lewis, and his best friend, Vernon Bussler. Working out of the family garage, the small team learned how to use the Rapman, printing designs and gaining experience.

In the fall, David Lewis got permission from Riley's school to start an elective class in 3D printing. Students as young as 11 years old signed up, designing things in class and printing them in Riley's garage after school and on weekends.

Riley also found time during the school year to give 3D printing demonstrations to GATE program students in Santa Cruz, and 3D Systems invited him to a series of spring break events to spread the word about what 3D printing could do.

Riley and his team

More recently, 3D Systems donated another Rapman and two Cube printers to Riley's middle school.

Riley is now attending high school at University Preparatory Academy in San Jose and has set up a 3D printing program there for his high school classmates. This doesn't mean that he has forgotten his middle school roots, though—he continues to help out with the 3D printing class at Discovery Charter.

Riley's influence in 3D printing education could soon play on a larger stage. At a 3D printing event at San Mateo College, Riley was asked to talk about his achievements with the Department of Education Undersecretary for Innovation and President Obama's Special Assistant on Domestic Policy for Education.

Riley has shown what individual passion and perseverance can accomplish in spreading STEM education.