A Shift To More Authentic Learning

HOW 3D PRINTING DELIVERS REAL-WORLD DESIGN AND PRODUCTION CHALLENGES TO STUDENTS IN THE CLASSROOM

By Stratasys

A Shift To More Authentic Learning

HOW 3D PRINTING DELIVERS REAL-WORLD DESIGN AND PRODUCTION CHALLENGES TO STUDENTS IN THE CLASSROOM

A broad shift is taking place in American education to encourage more authentic learning: the kind of learning that helps students prepare for life after school.

Authentic learning has multiple labels: project-based, problembased, inquiry learning. But at its heart, a student is given a genuine problem to solve that requires mimicking the work of professionals. Working toward an answer calls for the student to show creativity, collaboration and communication and to gain a deep understanding of both the problem and its possible solutions.

The results, say those who have experience in this type of educational model, far surpass the impact of a typical classroom test. Done well, the learning takes on a self-directed aspect that helps to build student autonomy.

The idea of authentic learning has wide support. A November 2013[1] survey by Achieve, an education reform organization, found that a majority of American voters considered high school graduates unprepared to meet the expectations they'll face as they take their next steps after high school. The same survey reported that an even higher percentage of voters believe that the Common Core State Standards Initiative will transfer the perceived emphasis off "teaching to the test" and on to real-world skills, such as critical thinking and problem-solving.

It's little wonder, then, that 3D printing is turning out to be an effective technology for the classroom where students are undertaking realworld learning experiences, since it inspires invention, design and engineering. A recent NMC Horizon Project Technology Outlook for STEM+ Education2 states, "One of the most significant aspects of 3D printing for teaching and learning is that it enables more authentic exploration of objects that may not be readily available to schools."

While the practices supporting authentic learning can be started among very young children, it's more impactful for students in middle school and beyond. At that stage in their learning development, they often need a bigger charge to get excited about the concepts of design and engineering. They need to see their ideas come to form, and that's exactly what a 3D printer can deliver.

As the following examples demonstrate, the use of a 3D printer gives students the ability to hold

A Shift To More Authentic Learning

HOW 3D PRINTING DELIVERS REAL-WORLD DESIGN AND PRODUCTION CHALLENGES TO STUDENTS IN THE CLASSROOM

the output of their work. That simple act can turn the disciplines they're learning — design and prototyping — into something real and authentic.

EXPOSURE TO THE IMPACT OF DESIGN

A group of STEM pioneers opened up STARBASE Minnesota in 1993 to help fourth- through sixth-grade students in Minneapolis and St. Paul get a new take on math and science. This program was one of more than 70 all over the country funded primarily by the Department of Defense[3] with the same goal: to give students the chance to see how those subjects help plan a mission to Mars, which includes building and launching model rockets. The curriculum is aligned with national and state standards.

Up until 2007, the kids could design models of rocket components on computers, but all they were left with was an ordinary twodimensional printout of their design. Then the DoD stepped in and supplied STARBASE sites with Dimension® 3D Printers.

The site in Minnesota, co-sponsored by the Minnesota National Guard, puts fourth- through sixth-graders through a five-day, 20-hour

After analyzing part performance, STARBASE participants can redesign their rockets using a 3D printer.

experience. First, says instructor Christina Johnson, the kids "learn about the science behind the fins and test different rocket parts throughout the week using the wind tunnel and air rockets." Next they use CAD software to design their own rocket fins, which are printed on a Dimension 3D Printer and attached to rockets on the final day of the program. Then the students get to head outside for the launch.

After launching their rockets, the students collect data about where the rockets land and discuss the results to conclude how fin design affects a rocket's path — just as real engineers would.

A Shift To More Authentic Learning

HOW 3D PRINTING DELIVERS REAL-WORLD DESIGN AND PRODUCTION CHALLENGES TO STUDENTS IN THE CLASSROOM

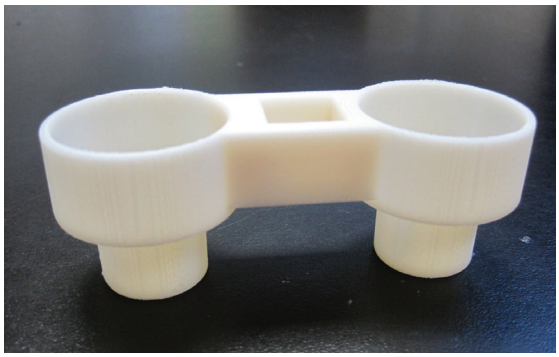
But the excitement about the process doesn't stop with the students. "It's amazing the impact of having the Dimension 3D Printer in the classroom," Johnson says. "We knew the kids would love this exercise; but what's been most surprising is to see how excited the instructors and other faculty get when they see rocket parts come to life in the Dimension 3D Printer."

Besides the student work, the 3D printer has also come in handy when equipment in the STARBASE lab doesn't work the way it's supposed to. For example, a faulty rocket launcher needed a part replaced, and the instructors were able to make repairs without having to wait on a supplier to come through.

A teacher whose class attended the program in another city observed, "STARBASE teaches science and math in ways that we wish we had the time, resources and expertise to do in the regular classroom. It's experiential, exploratory learning with a direct tie to the standards."

MAKING ENGINEERING REAL FOR STUDENTS

Peter Grimm, an industrial technology teacher at Southview Middle School in Edina, Minn., pursued



Students at Southview Middle School competed to design and 3D print improved cup holders.

funding for his district's first 3D printer, which the school shares with another middle school in the district.

Grimm had used Dimension 3D Printers at a previous school. There, he had teamed up with Project Lead the Way (PLTW)[4], a national organization that provides STEM programs to schools, including professional development, curriculum and partnerships with the private sector.

He continued that partnership at Southview, and because he was familiar with the "cost, ease of use and durability," of the Dimension 3D Printer, he felt the the uPrint® 3D Printer would be the right fit for the new programs he planned to implement.

Now the use of 3D printing has become part of STEM classes in seventh and eighth grade,

A Shift To More Authentic Learning

HOW 3D PRINTING DELIVERS REAL-WORLD DESIGN AND PRODUCTION CHALLENGES TO STUDENTS IN THE CLASSROOM

including “Design & Modeling” and “Automation & Robotics” for seventh graders, and “Flight & Space” and “Magic of Electrons” for eighth graders.

The uPrint, says Grimm, “has really helped bring kids into the engineering lab ... They’re able to see their CAD drawings become three-dimensional working models. It quickly brings designs that only existed in the students’ minds to life.”

In one project Grimm challenged his pre-engineering students to come up with a solution to a universal problem: ill-fitting car cupholders. Those who came up with the best designs received the honor of having their designs printed.

The uPrint 3D Printer has also become a useful promotional tool in the district, Grimm notes. “There are a number of engineers in this community. I think it’s exciting for them to see their children get their hands on this kind of technology.” At the same time, when the 3D printer is brought to fundraisers, it generates “lots of ‘oohs’ and ‘ahhs’ from potential donors,” he adds. “The enthusiasm it generates is priceless.”

APPLIED ENGINEERING FOR AERONAUTICS

Project Lead the Way has introduced similar STEM courses into Colorado schools. In fact, as of 2012, the state boasted 76 middle schools and high schools that use at least some portion of PLTW curriculum. One of those schools is Coronado High School in Colorado Springs, where Bryce McLean, an industrial arts teacher and chair of the Applied Technology Department, teaches engineering basics classes. McLean also teaches manufacturing fabrication and aerospace engineering (particularly relevant since the city is the site of the U.S. Air Force Academy, a university that educates future Air Force leaders).

McLean has found that having the Dimension 3D Printer on-site integrates smoothly with his

Students in Colorado Springs can quickly test part functionality, such as this car.

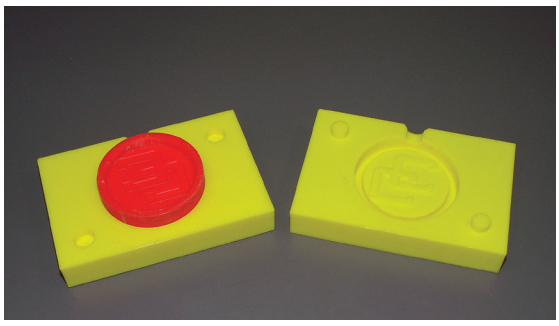
A Shift To More Authentic Learning

HOW 3D PRINTING DELIVERS REAL-WORLD DESIGN AND PRODUCTION CHALLENGES TO STUDENTS IN THE CLASSROOM

curriculum. As an example, in his aerospace engineering course, students design an airfoil and place it into a wind tunnel to test various aerodynamic characteristics, he says. “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.”

He adds, “The 3D printer allows us to more consistently match the student’s design specifications and generate a model that is to their exact standards.” To help them appreciate just how far the fields of engineering and manufacturing have advanced, he shows them a video that describes old machine shop techniques.

McLean and other teachers participating in the PLTW program often bring in speakers from local businesses to share their engineering experiences and give a reality-based perspective on the skills that are useful for success in the field. The presence of high-end equipment, including the 3D printer, impresses them, he says.



Project Lead The Way partnered with Coronado High School to bring 3D printing to STEM courses. This image shows a student-designed mold that was 3D printed.

THE COMPLETE WORK EXPERIENCE LIFECYCLE

Chico High School may be the ultimate example of how 3D printing in the classroom can help students gain hands-on experience in the entire lifecycle of production development. The California school received its first 3D printer in 2008 when Department Chair for Industrial Technology Mike Bruggeman acquired a Dimension 3D Printer. He was primarily looking for a way to expose tudents to an industry-caliber machine capable of producing custom prototypes.

That quickly evolved during a Regional Occupational Program event when two former students offered Bruggeman a design challenge. The former students ran Kleen Kanteen, a local company that produces an internationally popular series of ecofriendly stainless steel water bottles. Their products were made in China, but the language barrier was preventing the two sides from resolving design issues related to the lids.

A Shift To More Authentic Learning

HOW 3D PRINTING DELIVERS REAL-WORLD DESIGN AND PRODUCTION CHALLENGES TO STUDENTS IN THE CLASSROOM

Student Dillon Silverman and instructor Mike Bruggeman setting up their classroom's Stratasys 3D printer.

Bruggeman put his engineering design students on the job of coming up with which the students then 3D printed. Those lid designs were sent to China, where they served as prototypes for the final production pieces.

Since then, the students in Bruggeman's classes have not only done more work with Kleen Kanteen, but they've taken on a number of other design clients:

- **Westside Research** – This automotive cargo management product design and manufacturing company currently has student-designed products in production.
- **TLCD Architecture** – This California architecture firm turned to the school for help in creating a proposed bus transit facility.
- **Woodzee** – The creators of sunglasses made of wood and other sustainable materials asked students to help design new styles.

From its modest beginnings, the program has added industry-grade software to its labs for students to train on, including SolidWorks, AutoCAD, Revit and Mastercam. It has also added an additional 3D printer to keep up with demand.

Bruggeman says that all of the students who go through the program he's designed have gone onto college — and not just to study engineering, but also computer science, computer graphics, construction management, interior design and architecture.

A student-designed prototype.

A Shift To More Authentic Learning

HOW 3D PRINTING DELIVERS REAL-WORLD DESIGN AND PRODUCTION CHALLENGES TO STUDENTS IN THE CLASSROOM

THE SPARK OF THE AUTHENTIC EXPERIENCE

The NMC Horizon Report calls the addition of a 3D printer into the classroom a groundbreaking trend that has "largely been fueled by the 'Maker' movement, which consists of artists, technology enthusiasts and others who share a passion for creating."

This movement, the report explains, addresses the sorts of STEM skills that many educators and policymakers consider most important to productivity in the 21st century.

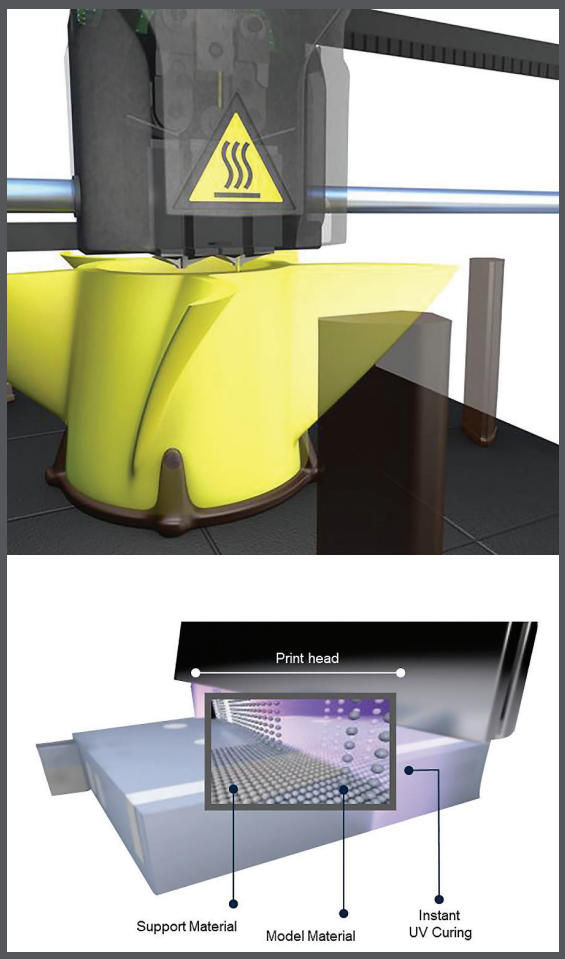
The real-world exposure gained by students and others in similar programs with access to the processes involved in 3D printing helps them make the connection between their coursework and the STEM fields they're heading into. That authentic experience can spark the learner's imagination, encourage them to persist in the face of setback, and gain confidence as problem-solvers, while helping them think, design and build. Those are disciplines we want for every student.

[1] *http://www.achieve.org/publications/voter-perceptions-common-core-state-standards-tests*
[2] *http://www.nmc.org/pdf/2013-technology-outlook-for-STEM-education.pdf*
[3] *http://dodstarbase.org/*
[4] *https://www.pltw.org/*

HOW 3D PRINTERS WORK

A 3D printer builds a model, prototype or object from a digital file one layer at a time. The student uses a computer-aided design (CAD) tool, such as the free Tinkercad or professional level SolidWorks or AutoCAD — or any kind of program that can output an STL file — to model what he or she wants to produce. Standard Tessellation Language (STL) is a common format that defines the details of every surface of the object to be printed. That STL output goes through a "slicing" process to tell the printer what each layer will consist of. When the printing begins, a flexible material, usually a form of plastic, is heated up and sent through an extruder that sprays a thin layer of the material onto a platform. Layer by layer, the object is built from the bottom up.

Different kinds of 3D printers follow variations on this process. For example, the Connex™ line of Stratasys[wvz] 3D Printers can print multiple materials and colors at the same time — each being sprayed from a separate extruder — creating ultrarealistic prototypes. Another distinguishing feature of 3D printers is their level of reliability. Some users like to "fuss" with the inner-workings of the printer to keep it operating as part of the "maker" process. Others seek high reliability so they can apply their time to other aspects of the design process, such as teaching their students how to correct any shortcomings that their prototypes reveal.



Illustrations of how FDM (top) and PolyJet (bottom) technology work.

info@stratasys.com

STRATASYS.COM

HEADQUARTERS
7665 Commerce Way, Eden Prairie, MN 55344
+1 888 480 3548 (US Toll Free)
+1 952 937 3000 (Intl)
+1 952 937 0070 (Fax)

2 Holtzman St., Science Park, PO Box 2496
Rehovot 76124, Israel
+972 74 745-4000
+972 74 745-5000 (Fax)

stratasys®

THE **3D PRINTING SOLUTIONS** COMPANY

For more information about Stratasys systems, materials and applications, call 888.480.3548 or visit www.stratasys.com