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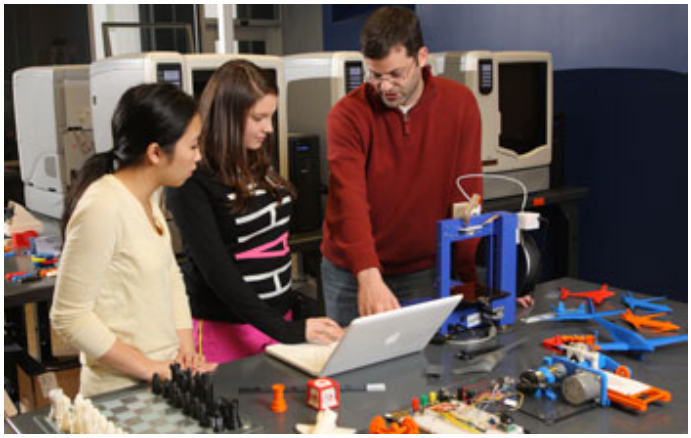
FABRICATING THE FUTURE: 3-D PRINTING MOLDS NEW K-12 STEM MODEL

Unique lab school uses engineering design to teach scientific concepts



Graduate student Jake Cohen discusses 3-D printing with students at the UVA FabLab.
Credit and Larger Version

A Buford Middle School student watches a 3-D printer at work.
Credit and Larger Version

Buford Middle School students measure the output of a speaker they made with a 3-D printer.
Credit and Larger Version

A 3-D printer and its finished product made from ABS plastic are shown.
Credit and Larger Version

Glen Bull is using 3-D printing systems to change the way teachers present science concepts.
Credit and Larger Version

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Driven by design software, 3-D printers churn out made-to-order objects on a desktop. A myriad of materials from polymers to metal alloys enable virtually anyone to manufacture almost anything they can imagine, including glow-in-the-dark pens, Lego-like building blocks, cogs and gears, electrical circuits and jewelry. Advanced applications produce living tissue for replacement organs in the body, intricate engine designs and parts for spacecraft during deep space missions.

The commercial success of these printers is also fueling their use as educational tools. Visionaries like Glen Bull, a professor of instructional technology at the University of Virginia's (UVA) Curry School of Education, are using 3-D printing systems to change the way teachers present science concepts and, in turn, how students learn and retain the material. Bull's collaborative efforts with numerous academic, industrial, state and local partners have led to a major education initiative in the Commonwealth of Virginia. "Glen's work is absolutely transformative," says Robert Pianta, dean of the Curry School.

Retooling technology for education

Bull's desire to use 3-D printers in the classroom started when he read Neil Gershenfeld's 2005 book "Fab: The Coming Revolution on Your Desktop." In his book, Gershenfeld, a professor at the Massachusetts Institute of Technology, describes how personal computers combined with 3-D printers will allow users to make almost any object they desire.

Intrigued, Bull looked for ways to create a printing system that schools could afford. At the time, 3-D printing technology cost between $150,000 and $250,000 and was mainly used by industry. His search ended when he reached out to Hod Lipson, a mechanical and aerospace engineering professor at Cornell University. Lipson and his students at Cornell's Creative Machines Lab were refining a tabletop 3-D printer that looked like an inkjet printer encased in Plexiglas. They built the printer with parts purchased online and made the blueprints available free of charge. "We wanted to make something that was accessible so anybody could build and use it," says Lipson.

With a few tweaks, Lipson and Bull transformed the printing system into one that could be assembled in less than a day for less than $1,000 in parts. Bull then compiled a suite of affordable personal fabrication tools that included the printer, design software and computer-controlled die cutters that use card stock to create objects. These items were at the heart of the proposal Bull wrote in 2010 seeking funding through the National Science Foundation's **Innovative Technology Experiences for Students and Teachers** (ITEST) program.

The **grant** Bull received through ITEST funded the FabLab Classroom, a program that provides fourth- and fifth-grade students and teachers in Virginia and Texas with 3-D printers, software and lesson plans to teach science concepts using engineering prototypes. Based on the pilot program's success and the commercial availability of inexpensive 3-D printers, Bull and his colleagues considered creating a laboratory school to integrate engineering design into the science curriculum. The school, run by the university and the Commonwealth of Virginia, would also serve as an experimental platform for science teacher training.

"The next-generation science standards call for making science and engineering equal, but there are no science teachers today trained to teach science and engineering and, even more importantly, there are no professors of science education prepared to train teachers to teach science and engineering," says Bull. "We wanted to change this."

Access for all

Just two years after the FabLab Classroom pilot project, its compelling results and the plan for the lab school captured the attention and financial support of the Commonwealth of Virginia, the Charlottesville City school system, the Albemarle County school system, the U.S. Department of Education, and several industry and foundation partners. In 2012 with about $6 million, Bull established the nation's first Laboratory School for Advanced Manufacturing.

The lab school will include an engineering laboratory in Charlottesville's Buford Middle School and a 6,000 square foot laboratory at Charlottesville High School. The school district committed $1 million to create the middle-school lab and $2 million for the high-school lab,

which will replicate every piece of equipment in the university's FabLab. Both labs will connect to the university's FabLab through a videolink, enabling collaboration between students, teachers and university researchers. Construction on the middle-school lab is scheduled to start this June, with completion by the end of August. The high-school lab will come online in 2014. The lab school's curriculum will tie into state and common core standards.

"Changes in technology change what's possible. This project has moved incredibly fast, but it will level the playing field and enable all students to learn about these concepts," says Bull. Accessibility is one of the fundamental aspects of the project. All those involved--from the school superintendent to the principal and teachers--are committed to ensuring that every student, regardless of ability, is eligible to enroll in the FabLab at both the middle- and high-school levels. "There is an entire generation of students we're losing and I believe this is a hook to re-engage students," says Charlottesville City Schools Superintendent Rosa Atkins.

In addition to new facilities, the lab school includes intensive teacher development. Teachers will spend the summer working collaboratively with researchers and students in UVA's Mechanical Engineering Department creating lessons and learning how to use the printers and other digital fabrication technologies. In the fall the teachers will teach in the morning and then spend their afternoons at the university continuing to refine their use of the technology. Three websites developed for the ITEST grant will assist teachers with lesson plan development, tracking in-class activities and providing resources for student teachers.

"The key piece of this project is the teacher training," says Buford's principal Eric Johnson. "This is new territory. We're changing how we teach science and math. Even with professional development, the process is eye-opening and sometimes overwhelming."

One of the unique aspects of the curriculum development process is the integration of undergraduate engineering students into the professional development process. Teachers will be assigned a group of first-year engineering students who will work as a team with the teacher designing prototypes for the 3-D printer that illustrate scientific concepts. These groups will remain on the project for their entire undergraduate career. "This is an important step for mechanical engineering because it is a way to interest students and increase diversity within the field," explains Hossein Haj-Hariri, chair of the university's Mechanical Engineering and Aerospace Department and a collaborator on the project.

An on ramp for the future

The lab school will also serve as an "on ramp" for the Commonwealth's larger advanced manufacturing initiative. A study done by The Boston Consulting Group suggests that over the next 20 years, advanced manufacturing could create 15,000 to 20,000 new jobs in the Commonwealth. Filling these positions, however, will require redesigning the K through 12 curriculum.

"We have to realign our courses with modern technology," says Haj-

Hariri. "We can't use a 1950s curriculum and we can't make this a 21st century version of shop. We want to get the E in STEM but our goal remains teaching science concepts. Engineering creates the context for us to introduce students to those concepts in a way they actually will understand and retain."

The Lab School "is truly preparing kids for the future," says Libbey Kitten, science coordinator for the Charlottesville City schools. Adds Kristen Crawford, an eighth-grade teacher who will be teaching in the Lab School, "this will lead our kids to be better problem-solvers and collaborators. We're developing all kids for success."

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Related Institutions/Organizations
Cornell University
University of Virginia
University of North Texas
University of Virginia Main Campus

Locations
Virginia

Related Programs
Innovative Technology Experiences for Students and Teachers

Related Awards
#1030865 Strategies: The FabLab Classroom: Preparing Students for the Next Industrial Revolution

Years Research Conducted
2010 - 2013

Total Grants
$1,199,998

Related Agencies
U.S. Department of Education