THE 3-D REVOLUTION

A New Design Era Explodes on Campus

By BAY BROWN

Imagine sitting at home and printing out a Barbie for your child that actually looks like you—your curly tresses, your olive skin, and your freckles. As such mass customization becomes more accessible, both in terms of cost and ease of use, 3-D printers may become as ubiquitous as iPads in the not so distant future.

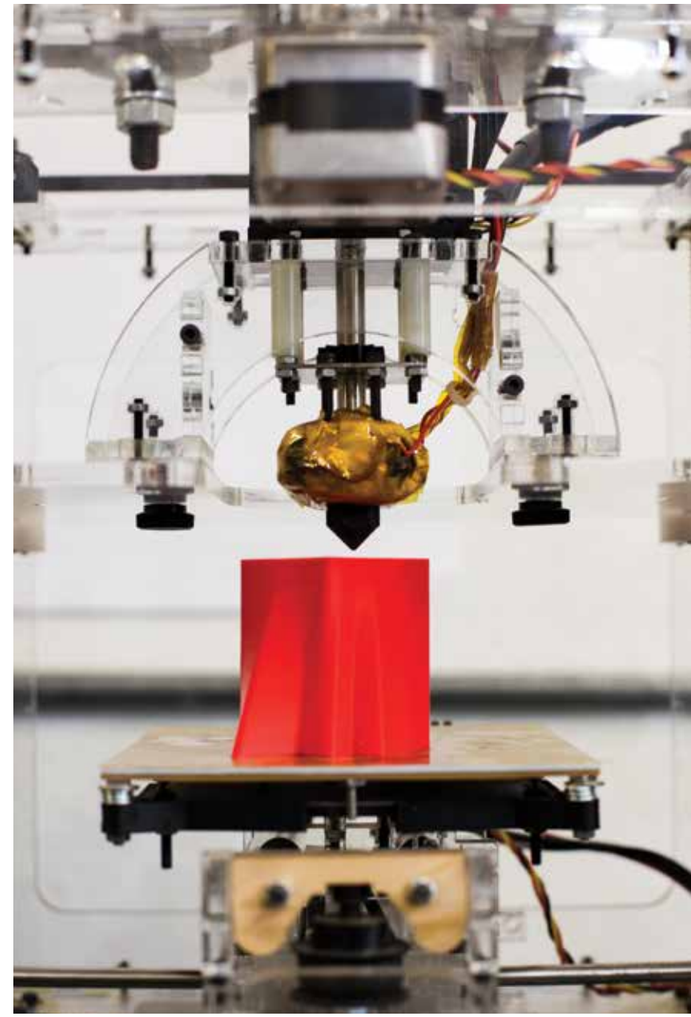
In his State of the Union address last February, President Barack Obama invoked 3-D printing as having "the potential to revolutionize the way we make almost everything." This official nod affirms that 3-D printing and related technologies like CNC (computer numerical control) milling and laser cutting have the capacity to fuel new jobs for American designers and techies.

Such technologies have the potential to launch a new industrial revolution, according to former *Wired* magazine editor Chris Anderson and author of the recent book *Makers: The New Industrial Revolution*. Through open-source design and 3-D printing, today's entrepreneurs are driving a resurgence in American manufacturing from their desktops, he argues. "This generation of 'makers' will help drive the next big wave in the global economy," Anderson writes.

Of course, these tools have special relevance to colleges of art, design, and architecture where these emergent makers are learning their crafts. At Pratt, those using 3-D-manufacturing methods believe that the Institute is uniquely positioned to be at the forefront of the revolution in a truly cross-disciplinary manner. While 3-D manufacturing may give the consumer access to mass customization, it gives designers even greater opportunities.

AN EVOLUTION TO EMBRACE

At Pratt, 3-D printing has been used for rapid prototyping in the Industrial Design Department for more than a decade, but recent technological advances have increased the machines' quality while decreasing their cost. Not long ago price tags for 3-D printers were in the $400,000 range, making them within reach only for government agencies and established companies. Now, Brooklyn-based MakerBot is selling its small-scale 3-D printer, the Replicator 2, for $2,199—a price that doesn't require a NASA-size budget.



Pratt Provost Peter Barna, currently the Institute's chief academic officer but formerly chair of the Industrial Design program, sees growing demand for 3-D output on campus as a natural evolution that should be embraced. Accordingly, Barna sees expanding campus production facilities as a top priority. He is also enthusiastic about the potential to partner with commercial venues that operate on a cooperative subscription basis. Such operators can provide cost-effective access to large-scale equipment that can make entire chairs or architectural window-wall systems, for example, in one piece.

(Top) Pratt's Digital Futures Lab in the School of Architecture made its own "Frankenbot" 3-D printer from a MakerBot kit; (left) Mark Parsons oversees the production facilities in Higgins Hall.

"It is remarkable how digital technology has evolved and now can be linked to the physical," says Barna, alluding to skeptics who have seen the digital realm as divorced from the physical. "Before, digital technology was seen as a virtual, parallel universe. The ability to have 3-D digital output creates a fortuitous bridge between those two worlds."

With regard to concerns over the impact of 3-D technologies on teaching the foundation of design, he compares it to the initial reception of applications like AutoCad, PhotoShop, and Illustrator and their early impact on drawing and drafting.

3-D PRIMER

At Pratt, the most commonly used 3-D technologies for digital output include 3-D printing, CNC milling, and laser cutting. All of these machines work with computer-aided-design (CAD) drawings created using a 3-D software application like Solidworks or Rhino. These CAD files depict the object to be manufactured cross-sectioned into thousands of layers.

3-D PRINTING

3-D printing is an additive process, wherein an object is created one layer at a time. Taking liquid, powder, or sheet material as a building material, 3-D printing commonly constructs plastic and metal parts. Once used just for rapid prototyping, printers now can create finished products.

CNC MILLING

Computer numerical control (CNC) milling is a subtractive process of using a rotary bit that goes back and forth, and up and down, three-dimensionally cutting material—typically wood, foam, and metal—away from a base. The CNC-milling process engraves objects and creates relief effects.

LASER CUTTING

Laser cutting is also a subtractive process, wherein a high-power laser cuts materials including wood, paper, fabric, plastic, and Plexiglas®. The material then either melts, burns, vaporizes, or is blown away with compressed air, leaving an edge with a high-quality surface finish.

"These technologies allow designers to fail often—and quickly—during the design process. It allows them to test quickly and move on to a more refined solution," he says, describing advances in 3-D production.

At Pratt, few believe that do-it-yourselfers and their printers are threatening trained designers. The Institute teaches a mastery of art and design—the theoretical understanding, ability to conceptualize, and celebration of individuality—that sets its graduates apart.

A STRADIVARIUS FOR THE MASSES

For Mark Parsons, director of production and technology in the School of Architecture, access to 3-D production blurs the line between students' intentions and the actual realization of their ideas.

"Students are learning the relationship between designing on a computer and making at full scale," says Parsons.

"In a world that is historically about the narrowing of professional fields through job specialization, we now see an unexpected shift—the 'designer' and the 'craftsman' can now be the same person," Parsons added.

Among other responsibilities, Parsons runs the School of Architecture's production facilities. It's home to four laser cutters, two 3-D printers, and two CNC-milling machines—equipment the school has acquired over the past eight years. Most of the "print jobs" are architectural models or furniture, but some are pushing the envelope, creating things like a suit of armor, and, in one case, a working violin.

"I have played violin since I was three years old," says Oliver Allaux (B.Arch. '13). "I have wanted to make one for some time." Allaux, who took the course Methods and Materials with Parsons, is in the final stages of crafting a full-size violin using a CNC miller, laser cutter, and 3-D printer, as well as the traditional wood and metal shops.

Allaux found two-dimensional plans on the Internet for a violin modeled after the Stradivarius. Then he transferred the design into the software program, Rhino, and created the templates. Next he used a CNC miller to cut out the large pieces of wood that compose the body of the violin. Finally, using a large-scale 3-D printer—that runs approximately $100,000—the smaller parts were formed out of plastic silicate powder. The entire production took about two days.

Allaux plans to make three slightly different violins, each with a small adjustment in form to experiment with sound. He acknowledges that his process may be considered somewhat illegitimate by traditionalists.

"Violin makers would be upset because historically this sort of woodworking is taught by a master to a student," he says. "With my process, a machine is ripping through sacred wood." While Allaux has great respect for ancient methods—he hopes to tour luthier workshops in Europe soon—he is intent on pushing the boundaries of conventional craftsmanship by introducing modern construction methods.

(Top) Oliver Allaux's violin in the process of being assembled; (right) Allaux with his violin

WEARABLE TECHNOLOGY

3-D manufacturing is also finding its way into the Fine Arts Department. Professor Patricia Madeja, who coordinates the jewelry program, is launching a new course in fall 2013 called Digital Tools for Object Making. Open to students across the Institute, the course will teach how to use 3-D printing to create jewelry, sculpture, art objects, and molds that are part of the larger fabrication process.

Pratt's Digital Output Lab, which serves students Institute-wide, will be getting new equipment, upgrading electrical for the entire building, and expanding its floor space in part to accommodate the growing need in the Fine Arts Department. According to lab supervisor Paul Petruccelli, the Institute will be installing four MakerBot Replicator 2X 3-D printers and a large-capacity 3-D printer that builds in wax, which will be geared toward

those students taking the new course Digital Tools. The 3-D printer will create an object in wax, and, in turn, the student will use the traditional lost-material-casting method, wherein the mold is encased in a plaster medium with a tube leading into it. The wax will then evaporate and molten metal is poured into the space.

"It is absolutely essential that our students gain 3-D production skills since this is where the industry is going," says Madeja.

Pratt alumna Erica Schwartz (M.I.D. '07) exemplifies this trend. Schwartz creates jewelry out of laser-cut bamboo and 3-D-printed steel and nylon. She uses commercial 3-D printing services like Ponoko and Shapeways that manufacture projects on their high-end printers overseen by a team of engineers.

"There is no need for me to own the machines. That's part of the beauty of the technologies," says Schwartz. "If I owned one machine, I'd be invested in one production method. This way I can use them all."

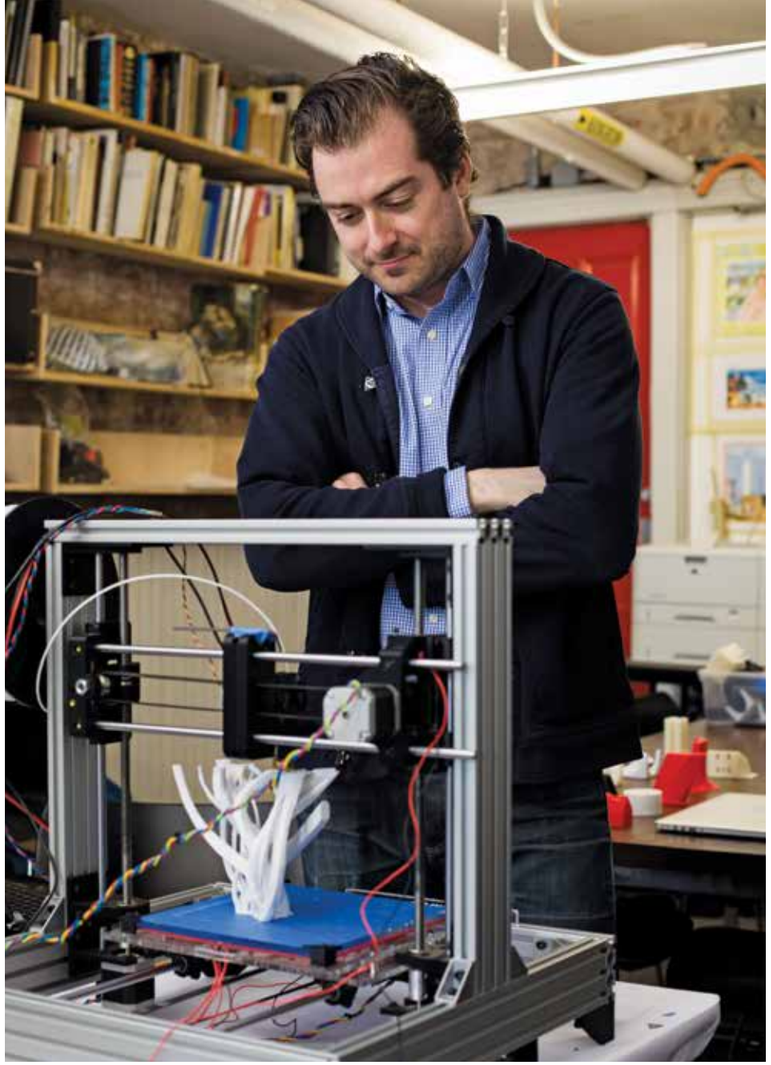
Schwartz says that the more affordable machines geared toward consumers are still producing rather unfinished products. "The products I get from places like Shapeways are more finished, there are many more material options, and it means I don't have to spend my time learning how to operate a machine."

EXPANDING THE NOTION OF CRAFT

To the other extreme, Richard Sarrach, adjunct assistant professor and director of the Digital Futures Lab within the School of Architecture, follows the credo of history's most famous carpenter: Give a man a fish and he will eat for a day, teach a man to fish and he will eat for a lifetime.

Rather than students queuing to use the school's large-scale printers or investing in more affordable off-the-shelf MakerBots, Sarrach is on a mission to teach students not only how to operate these machines, but how to build their own 3-D printers. The rationale is that it is cheaper than purchasing a MakerBot, you actually learn how the printer works, and you can build your own replacement parts for the printer as they wear out, which happens frequently.

According to Sarrach, building a MakerBot-like 3-D printer is fairly straightforward. Most of the assembly is done with a simple Allen wrench. Through open-source technology, the designs are readily available online, as are all the components. He says that a student could build a printer in about two days.



In the Digital Futures Lab, Sarrach and colleagues have two 3-D printers they have built. Affectionately dubbed the "Frankenbot," the first was made from a MakerBot kit but has many upgrades to enhance its performance. (MakerBot recently stopped selling kits in favor of preassembled complete 3-D printers.) Nearby is the "BKMM," or the "Brooklyn Magic Machine," which they made from scratch and which has more than double the output capacity of the Frankenbot.

Sarrach's team took Frankenbot to MakerBot's offices in downtown Brooklyn to show the engineers what they had created. "I think they were impressed," recalled Sarrach. "They were looking at it and then repeatedly kept leaving the room to bring more staff in to see it."

While the cost per cubic inch for big printers, like those made by Stratus or 3-D Systems, is $8-$12, the Frankenbot can print for only 20 cents, says Sarrach. "Using a printer no longer has a cost barrier. For a final model, with the big printers it costs $300-$400. You can't afford to do tests on those printers," says Sarrach. "These machines also have substantial wait times. You can gain access to the tool sooner if you have your own."

One can buy a MakerBot for $2,000 or make his or her own for $1,000, according to Sarrach, though he concedes the process is not for everyone. "For those who aren't mechanical, they should probably buy a MakerBot."

Sarrach noted that some are critical of these technologies because they think they are anti-craft. "Plastic can have beautiful qualities, varied texture, and striations. The craft is in the planning, not so directly in the hand," says Sarrach.

Sarrach certainly has a kindred spirit in Pratt Provost Barna. "Design was never only about eye–hand coordination," says Barna, "Design is a way of thinking about problems."

Clockwise from left to right: A necklace designed by Anthony Tammaro, who will be teaching jewelry students how to use the Institute's new 3-D wax printer; Richard Sarrach and his team built the "Brooklyn Magic Machine" 3-D printer from scratch; in the Industrial Design Department, the traditional hands-on approach is just one way students are taught about craft- and form-making today; a piece by Erica Schwartz (M.I.D. '07), who designs jewelry that is 3-D printed in metal and plastic.