A REVOLUTION IN PROTOTYPING, DESIGN, AND MANUFACTURING.

The Fourth Industrial Revolution

Just like the layer-by-layer approach of the technology itself, 3D printing has taken a while to build up to its full potential. It has now reached a technological and economic inflection point that is opening the door for the digital transformation of the global manufacturing industry.

3D printing has been around for more than 30 years. With the main techniques patented in the 1980s, it has taken some time to emerge as an economically viable commercial manufacturing process. Initially seen as “a solution looking for a problem to solve,” the technology continued to evolve through the 1990s, notably with the development of hardware and the rise of computer-aided design (CAD) software. “3-D printing” made its first appearance as an entry in Merriam-Webster’s Dictionary in 1992.

It all changed in 2009, when Fused Deposition Modeling (FDM) patents expired. The industry took off, technical development accelerated and the cost of equipment started falling. As the technology became more accessible, it also became more visible. Today, virtually everybody has heard of 3D printing and its potential, with education—as you would expect—in the vanguard of adopting these technologies.

What is additive manufacturing (AM)?

- AM describes technologies used to build 3D objects by adding material layer-upon-layer.
- AM systems typically comprise computers, 3D modeling CAD software, printing hardware and layering material.
- Rapid Prototyping (RP), 3D printing and Direct Digital Manufacturing (DDM) are all AM technologies.

The outlook: “think in 3D”

We are in the early days of the Fourth Industrial Revolution: a seismic shift from analog to digital. Additive manufacturing is already reshaping global manufacturing by reducing costs, localizing production, shortening supply chains, reinventing product design, creating new markets and enabling customization at wide scale. It is changing the way organizations think about how they conceive, design, produce and distribute products—with the promise of “democratizing” both design and manufacturing.

Research in 2018 by A.T. Kearney and HP[1] indicated that 3D printing could create 3-5 million new jobs in the next 10 years in the US alone. Demands for a new breed of engineers, designers and other skilled professionals able to “think in 3D” will therefore become increasingly urgent as the adoption of 3D printing accelerates. So, how will this new breed emerge?

3D printing could create 3-5 million new jobs in the next 10 years in the US alone.

Source: A.T. Kearney

The role of higher education

3D printing is genuinely transformational. As with other leaps forward in science, technology, industry and culture, universities will play a central role in driving this revolution by changing the culture of design for all manufacturing, including traditional techniques. Properly funding and equipping educational institutions to train the next generations of designers, engineers and other specialists on manufacturing-capable 3D printers will be key. As will encouraging research into newer and more advanced techniques.

> “Providing students access to Additive Manufacturing is becoming a critical part of an engineering education. It is not only a valuable tool to accelerate students’ prototyping and production in engineering design; it is also important that we expose these students to AM technology early so that they learn to design for AM, and not become stuck in the mindset of designing around traditional processes,” says Christopher B. Williams, Ph.D., Associate Professor, Department of Mechanical Engineering, Virginia Tech.

This is already happening for some. Dr. Brett Conner, Director, Advanced Manufacturing Research Center at Youngstown State University, says his institution is proud to offer its students and the wider university community: “access to world-class capabilities in additive manufacturing. We are committed to working with innovative leaders like HP as we continue to drive the premiere learning experience and ensure our graduates serve a productive role in the exciting transformation of manufacturing.”

However, obstacles remain. Many universities, colleges and schools have tested the water with printers which may not be designed to match their ambitions, resulting in artificially low expectations of quality, output, and reliability. Moreover, ensuring a smooth end-to-end design for additive manufacturing process remains an obstacle—especially where 3D modeling and CAD software design requirements are concerned.

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1. *3D Printing: Ensuring Manufacturing Leadership in the 21st Century*, 2018

Changing the culture of design

What does this mean in practice? Color is an example of how the latest 3D printing technology can shape the new design culture. Cheryl McLeod, HP's Global Head of Fusion Science, states lower cost full-color 3D printers: "make advanced technology available to universities to educate and train the next generation of digital designers and innovators." As a result, she says, "Educators and students will be able to design, produce and utilize true-life, color-enhanced 3D models, experimental prototypes, and educational tools—from concept to physical reality—right in the classroom, fostering a new environment of collaborative learning and innovation that has never before existed... hands-on, real-time creation by students is a dynamic cocktail for fueling pure innovation."[2]

> "The exciting mix of engineering, materials science, art and design, systems thinking, and entrepreneurialism is staggering in its potential," adds McLeod.

In these ways and more, the culture of design will inevitably change, led by universities and colleges.

How do we get there?

The future will see an increasing number of academic, industry, and government partnerships focused on additive manufacturing and 3D printing. It is hoped this will drive the education and adoption necessary to fuel the revolution in manufacturing.

Dion Weisler, President and CEO of HP Inc., has observed that as 3D printing matures "from its infancy to powerful adolescence capable of high volume quality production, it's increasingly critical that technological innovation be coupled with strategic and lasting partnerships across government, industry, and academia to ignite manufacturing's digital reinvention." He says this change requires global leaders prioritizing the creation of "new educational programs and incentives for comprehensive training in 3D design, engineering, and the associated skills... providing educators and institutions with the R&D funding they need to foster the growth of digital manufacturing capabilities and ecosystems worldwide."[3]

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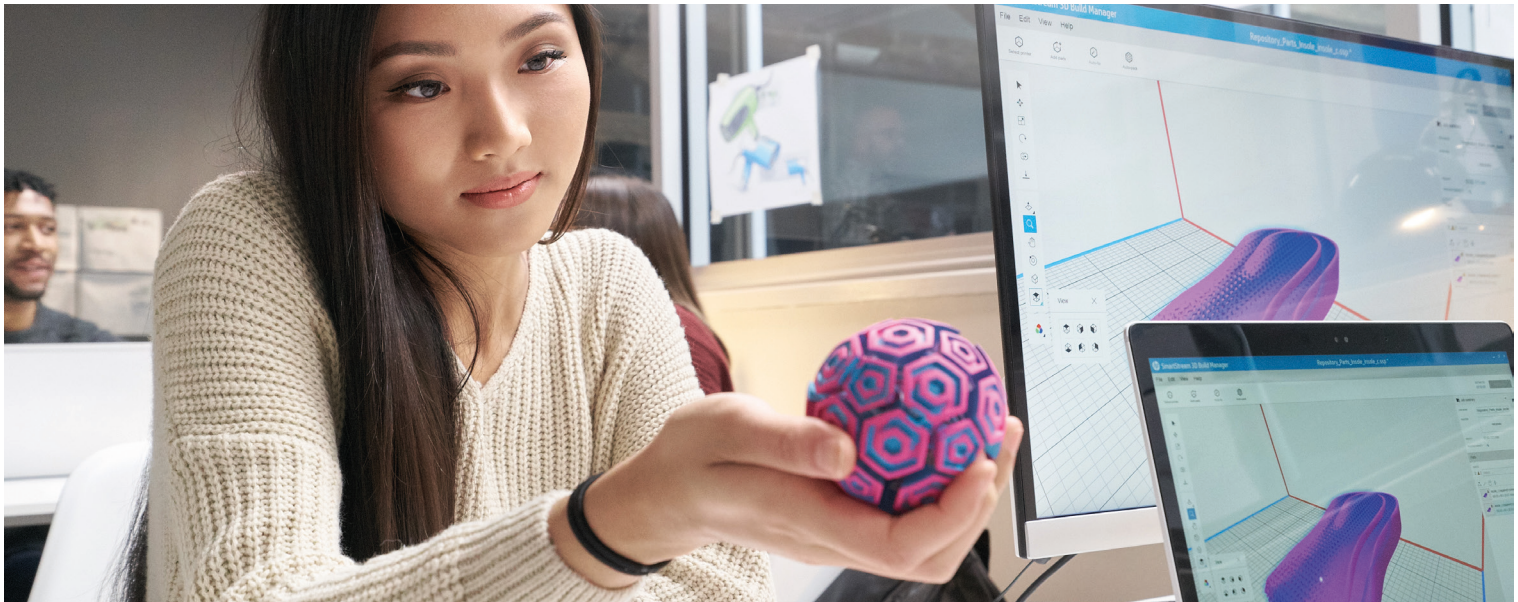
2. Flarrio emerging tech platform 2018, http://flarrio.com/color-communicates/
3. As quoted in Quartz, 24 January 2018, https://qz.com/1188144/hp-ceo-hpq-davos-how-governments-can-get-workers-ready-for-the-fourth-industrial-revolution/



Of course, HP already has a strong track record in 3D printing. A pioneer with its HP Multi Jet Fusion (HP MJF) technology (see box below), HP Jet Fusion 3D printing solutions are having a significant influence, shaking up the industry and helping reveal the potential of additive manufacturing. This includes increasing speed and productivity, with the ability to produce multiple parts in the same time as it usually takes to print a single part[4]—all within an open platform that enables development of lower cost materials and new applications. As Dr. Brett Conner of Youngstown State University states: "HP's ability to offer cutting-edge technology like its new full color 3D printers will enable industry, government and academia to imagine endless new applications that will have an impact on people around the world."

The rise of 3D printers in schools, colleges and universities appears unstoppable—even after some initial false starts with devices intended for consumer grade use, not product ready part development. Such technology has to be affordable as well as richly functional and reliable. At the same time, the number of Bachelor's and Master's degrees incorporating additive manufacturing and 3D printing are increasing.[5]

In this landscape, technology partners can play a key role in bringing 3D printing into university workshops and labs in the most effective ways, ensuring right-sized solutions with the capabilities to support educational institutions, and bringing additional expertise to support university departments and enhance the student experience. Indeed, working with trusted partners means the institutional focus will remain on teaching, learning, application and practical experience, rather than logistics and other non-academic issues.

HP MJF 3D printing technology

Breakthrough technology opening up possibilities for designers and engineers:

- Accelerate design cycles: create, test, iterate in hours.
- Jet Fusion 300/500 Series: the industry's first 3D printing tech for engineering-grade, functional, full color parts.
- Cost-effective 3D printers designed for universities and smaller product development teams.
- Prototype and produce using the same HP MJF technology platform.
- Microscopic voxel-level control and detail.

Reinvent design and manufacturing: explore new materials, products, markets and applications.

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4. Based on internal and third-party testing for HP Jet Fusion 580 and 540 3D Printers, printing time is a fraction of the time of the printing times of comparable plastic fused deposition modeling (FDM), stereolithography (SLA), and material jetting solutions from $20,000 USD to $120,000 USD on market as of June, 2017. Testing variables for the HP Jet Fusion 580 3D Printer: Part quantity: 1 full build chamber of parts from HP Jet Fusion 3D at 10% of packing density versus same number of parts on above-mentioned competitive devices; Part size: 30 cm^3; Layer thickness: .08 mm/0.003 inches. Competitor testing variables are comparable.

5. Chief Executive magazine, May 2017: https://chiefexecutive.net/universities-offering-degrees-additive-manufacturing/

Printing the future

Industry, academia and government are racing towards a 3D-printed future. As part of this, the technology has opened a world of possibilities for higher education: rethinking long-accepted ideas and challenging the status quo, reinventing design thinking, delivering new avenues for problem solving, and gaining the ability to explore a new world of practical applications based on incredible versatility in materials and approaches.

This is what the Fourth Industrial Revolution looks like, with university labs acting as a microcosm of the wider revolution under way, as a sandbox for innovation, and as incubators for the industry's new leaders.
The possibilities for students, academics and researchers seem limitless: from graphic design and CAD through innovative materials to defining entirely new design and manufacturing processes.

> "Multi Jet Fusion has such amazing potential. It has the ability to tap into entirely new design processes and print with unusual materials," says Dr. Shu Chang, Melbert B. Cary, Jr. Distinguished Professor in the School of Media Sciences, Rochester Institute of Technology College of Imaging Arts and Sciences.[6]

Learn more at: hp.com/go/3DPrint
Or have an HP 3D Printing expert contact you: hp.com/go/3DContactus

6. As quoted in The Garage – 3 April 2018, https://garage.ext.hp.com/us/en/news/hp-s-stephen-nigro-honored-for-his-three-decades-of-print-leader.html

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