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Make your own: the 3D printing revolution

Today you can make plant pots; in the future it could be phones, even houses. But should big business fear the 3D printing revolution?



The Makerbot Photo: MAKERBOT

By **Horatia Harrod**

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Brendan Dawes makes eggcups with his 3D printer. Enrico Dini wants to build igloos on the moon with his. Today we can print out custom-fitted teeth and titanium hip joints; tomorrow, we may be able to print out living tissue, to make new veins, new organs. With a 3D printer, someone who's useless at making things can produce unbelievably complicated and beautiful objects. A design created on your PC can turn a spool of plastic filament - heated, melted and guided into shapes by a computer-controlled printer head - into almost anything you desire. "Think of it as a China on your desktop," said a Google executive a few years ago.

In 1978, Dr Adrian Bowyer built his first computer. It took him every evening for a month, hand-soldering it together. Today, Bowyer's Nascom 1, a single circuit board covered with golden traces and impenetrable black boxes, is nailed to the wall of his study. New and different machines buzz and whirr on his desktop, filling the air with the faint smell of caramel. They are replicating rapid prototyping machines, RepRaps. Bowyer built these himself, too, but perhaps one day every home will have one, as every home has a computer.

People have been making things with 3D printers for more than 30 years.

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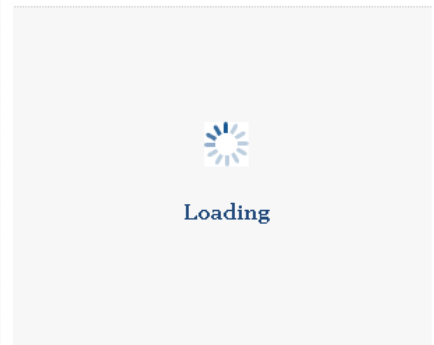
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At around the same time that Bowyer was tinkering with his Nascom, a man named Wyn Kelly Swinson patented a process called stereolithography. Imagine a vat filled with clear liquid. Just below the surface of the liquid is a flat plate. A blue light skitters back and forth on the plate: a laser beam, directed by a computer to follow a design, solidifying everything it touches. The plate moves down by a fraction of a millimetre, and the laser begins its dance again. Layer by layer, an object is built. "When the process is finished," says Bowyer, "the plate emerges from the liquid and it comes out like Venus from the half shell."

Swinson's basic idea – the dropping plate, the layered construction, the computer-aided design and control – has since spawned many magical machines. Perfect scale models can be made from hot wax shot out from tiny pipes attached to a printer head; electron beams can fire at lines of titanium powder, fusing them together, layer after layer; parts emerge from vats of plaster dust looking like finds from an archaeological dig.

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And then there's the RepRap and its descendants, the MakerBot and the Ultimaker and the Fab@Home. These machines don't look sophisticated – Meccano-like skeletons of metal rods held together by plastic nubbins – nor do the objects they produce look especially refined. They're made by a squirry icing method: plastic is squeezed out of a nozzle in incremental layers. There's no sleek casing, but these £1,000 machines have the same ability as their £100,000 kin to make objects grow from nothing.

Around these machines, as with any new technology, you find an excitable crowd of hobbyists and visionaries, industrialists and revolutionaries. Tuning into the hubbub tends to induce anxiety: is it really possible that before the decade is out, we'll be printing out iPhones in our printed-out homes? There are university researchers and garage tinkerers around the world who'll tell you yes, we're working on ways to print out electrical circuits or clear glass or concrete walls.

The farther reaches of 3D printing have a whiff of science-fiction about them. Enrico Dini is an exuberant Italian engineer who wants to build houses using a giant printer that creates organic, Gaudi-esque structures using a mixture of sand and binding agent. His company is based in London, "because I wanted to approach the private equity companies in the UK. Also I was in love, for a woman, but this is another story." The technical and logistical problems of Dini's D-Shape printer are immense – transporting vast quantities of sand, for one – and the financial ones even greater since the recession. Dini fears that big companies are already working on rival projects, waiting to enter the field at the right moment. "They have the capital to do 100 times better than me what I did," he says.

Such is Dini's passion for the technology that nothing will put a stopper on his ambitions. His latest project is to build a Foster and Partners-designed structure on the moon using a 3D printer working with binder and moon dust. The first deep vacuum trials were a success. (Last summer, an object – a spanner – was printed in zero gravity for the first time, being able to manufacture complex objects quickly, and with little

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time, being able to manufacture complex objects quietly, and with little human intervention, mean that 3D printing is an ideal outer-space technology.) "If I don't put my life on the table to demonstrate today that this is feasible," he says, "everything might become a flop." So he carries on.

Space igloos will always be more appealing than eggcups. But what's happening at the lower end of the 3D printing market is just as radical as what's going on at the top end, if for different reasons.

You might not know anyone with a 3D printer yet, but, says Neil Gershenfeld, head of the Center for Bits and Atoms at the Massachusetts Institute of Technology, "digital personal fabrication has been growing exponentially, and the ways these exponentials work is that there's a kind of barrier to perception. You may think nothing's happening and then suddenly there's a revolution." Brooklyn-based MakerBot has sold around 6,000 machines, to tech-savvy early adopters like the aforementioned eggcup maker, [Brendan Dawes](#). But we don't know how many 3D printers there are out there – some, like the RepRap, can make their own parts and reproduce themselves. Bowyer designed them to be "evolutionarily stable": RepRaps offer people goods so that people will build them, just as flowers offer bees nectar so that they'll carry their pollen.

Another problem with the perception of desktop 3D printers is that the things people are making at home right now don't look that exciting. Take the Thingiverse, a website where people upload photographs and design files of things they've designed and made themselves. There are plastic kittens. Plastic door stops. Plastic plant pots. Plastic toy planes. Plastic widgets and encoder wheels and screw isolators and servo wheels, individual parts to improve your printer but not much else.

But just when your inner cynic starts to kick in, because homemade plastic tchotchkes don't look much more appealing than ones made in Taiwan, someone will tell you a cautionary tale. Gershenfeld invokes the name of Ken Olsen. The head of a company called the Digital Equipment Corporation (DEC), in 1977 Olsen made a famous pronouncement: "There is no reason for any individual to have a computer in his home." As Gershenfeld says today, "Now DEC is bankrupt, and you have a computer at home." Underestimating the potential for new technologies to adapt, evolve and thrive can make you look stupid.

Once you've got over the fact that, yes, if people are given the chance to make anything they want, they'll make carrot holders, the Thingiverse shows us something important. What's extraordinary about the growth of 3D printing is how democratic it is. When people design things, they can easily share the digital files so that others can copy them. Once you've got the file you can tweak or customise it to suit you. "If your needs are the same as everyone else on the planet, you can just buy the same mass-produced product," says Gershenfeld. "But if you want a telephone with a wildly different shape, or custom train track, you can do that." Bowyer published the details of his first RepRap machine online to keep the technology free. He did so, he says, "for an uncharacteristically noble reason. It seemed to me that this was a very powerful technology, and if you try to create ownership over it, you divide the world into haves and have nots, and that's a way to make bad things happen."

There's a revolutionary flavour to this conversation. Are there industries, "haves", that ought to be watching their backs? "The people who should be threatened largely aren't," says Gershenfeld. "Because they consider these toys. By the time they are threatened, it'll be too late."

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these toys. By the time they are uncratched, it'll be too late.

At the Royal College of Art, you can see why the technology has the power to divide. Walking between the rooms of the Rapidform studio, the machines look anything but toylike. A huge titanium printer is covered in mathematical formulae – "It's a bit of a black art to operate it," says Nick Grace, the affable studio manager – and there is a smell, which I identify as soy sauce, but is in fact a melange of many noxious chemicals. (Compare with Adrian Bowyer's RepRaps, which run on a starch-based plastic called polylactic acid, and give off a sweet smell.)

Within the bland industrial casing of these machines are produced items of baroque strangeness and beauty, which can be seen in glass cases mounted on the corridor walls: a titanium face pouting angrily, a resin dog with antlers, a tiny, perfectly formed wax seashell. The latter two were created by scanning real objects, scaling them up or down, possibly adding antlers, and printing them out.

That's why the debate between traditional craftspeople and digital designers is getting lively. "Traditionally," says Grace, "the non-maker had to rely on another human being to help him out. Now they can do it all themselves. There's a lot of Luddite mentality attached to it, a lot of fear. Some people think that in order for something to be good it has to be difficult to achieve, and for someone to achieve something easily, it's just not fair."

Watch the creation of a scaled model of the Olympic stadium using rapid prototyping technology

When Grace shows me how to use some design software, I reconsider what he means by "easily". As I clumsily make holes in a 3D cube on the screen, I wonder how long it would take me to design something worth printing. According to James Russell, the College's Computer Aided Design Advisor, it wouldn't take more than a few weeks to master the technology. But, he admits, "Making the software more accessible to the masses is what needs to happen next." Or I could just copy something else.

At the beginning of last year an app called Trimensional was launched which allows you to scan objects with your iPhone. It's not accurate – the scans I made of my colleagues' faces would suggest that the *Telegraph* is staffed by troglodytes – but it only costs 69p, compared to the thousands you would pay for a decent desktop scanner.

The point is this: as scanners become cheaper, or scanning apps more refined, we will be able to create design files for all the objects we own or covet. Once you have the file, you can find a way to print it out, either at home, or at one of the printing bureaus that are opening thanks to enterprising start-ups like Sculpteo and Shapeways.

This seems like murky territory. But as it happens, design items in the UK are afforded very poor protection against copying. At best, designs can be registered for 25 years. They're treated as industrial products rather than artworks, which can be given copyright stretching to 70 years after the death of the creator. But even if our design protection is brought into line with the stronger laws which operate in the EU, what's to stop someone from copying, for example, a lamp they like in the privacy of their own home?

With each passing year more and more of our lives become digitalised: the music we listen to, the photographs we take, the films and television we watch, the things we read. There was a phrase Gershenfeld used that

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stuck with me, perhaps because it sounded so fantastically Star Trekian: "programming physical reality". Turning what's on the screen into what we have around us.

It's frightening, because it's new, and because some people – designers, craftspeople, manufacturers – could lose out because of it. But don't be too afraid. "For centuries we've been passing through these transitions," says Gershenfeld. "It takes us back to racing horses against steam trains. The trains won, but we still have horses."

This article also appeared in SEVEN magazine, free with the Sunday Telegraph. Follow SEVEN on Twitter @TelegraphSeven

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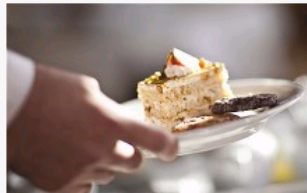
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