

What are you printing? Ambivalent emancipation by 3D printing

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Abstract

Purpose – The purposes of this paper are to study how entry-level 3D printers are currently being used in several shared machine shops (FabLabs, hackerspaces, etc.) and to examine the ambivalent emancipation often offered by 3D printing, when users prefer the fascinated passivity of replicating rather than the action of repairing. Based on a field study and on a large online survey, this paper offers to examine different practices with entry-level 3D printers, observed in several shared machine shops (FabLabs, hackerspaces, etc.). The recent evolution of additive manufacturing and the shift from high-end additive technologies to consumer's entry-level 3D printing is taken as an entry point. Indeed, digital fabrication has recently received extensive media coverage and the maker movement has become a trendy subject for numerous influential publications. In the makerspaces that were taken for this field survey, 3D printers were very often used for demonstration, provoking fascination and encouraging a passive attitude.

Design/methodology/approach – As part of the work for a PhD research on personal digital fabrication as practiced in FabLabs, hackerspaces and makerspaces, since 2012, a large-scale field survey at the heart of these workshops was carried out. Particular attention has been paid to the relationships established between the inhabitants of these places and their machines, observing the logic of developing projects and the reactions or techniques used to counter unforeseen obstacles – that shall be demonstrated to be an essential occurrence for these moments of production. From Paris to Amsterdam, Barcelona, Rome, Lyngen (Norway), San Francisco, New York, Boston, Tokyo, Kamakura (Japan) to Dakar, a means of observing at the heart of more than 30 makerspaces (FabLabs, hackerspaces) has been created, with the aim of looking beyond the speeches relayed by the media and to constitute an observatory of these places. The field observations are confirmed by a quantitative study, based on a survey submitted online to 170 users, coming from 30 different makerspaces in more than ten countries in the world and reached through social networks or mailing lists. This survey offers a rigorous insight on the uses of 3D printing and leads to the consideration of the types of attention applied to 3D printing and the part played by the "default" or "trivial" productions used for their demonstrations or performances.

Findings – Based on both the observations and the quantitative survey, it can be discussed how the question of so-called "user-friendliness" is challenged by practices of repairing, fixing and adjusting, more than that of replicating. Indeed, it is claimed that this offers a possible meaning for 3D printing practices. In the description and analysis of the behaviours with 3D printers, this leads to privilege the idea of "disengaging" and the notion of "acting" rather than simply passively using.

Originality/value – 3D printing is just one of the many options in the wide range available for personal digital fabrication. As a part of the same arsenal as laser cutters or numerical milling machines, 3D printing shares with these machines the possibility of creating objects from designs or models produced by a computer. These machines execute the instructions of operators whose practices – or behaviours – have yet to be qualified. These emerging technical situations pose a series of questions: who are those who use these 3D printers? What are they printing? What are the techniques, the gestures or the rituals imposed or offered by these machines?

Keywords Innovation, Rapid prototyping, Fabrication, Machine tools, 3D printing, Computer-aided manufacturing

Paper type Research paper

1. Introduction

Additive technology has existed for over 30 years; however, it is only in the past 10 years that 3D printers have been developed at prices that are more affordable to the general public. Most models can now be built at home for several hundred euros. As has been the case for artificial intelligence and the conquest of space, 3D printing, as an incarnation of

scientific progress, both unites people and divides opinions, with both sides supported by isolated cases and exceptions. The media oscillates between extremes; the domestic production of 3D printed guns provokes outcry, whereas the printing of low-cost made-to-measure cranial implants (Mazzoli *et al.*, 2009) feeds unrealistic expectations that also combine with hopes about the emancipation of consumers through self-manufacturing.

Public discourse often confuses the quality 3D printing available to the medical or aeronautic industry with the disappointing reality of fused deposition 3D printers that are

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Rapid Prototyping Journal
21/5 (2015) 572–581
© Emerald Group Publishing Limited [ISSN 1355-2546]
[DOI 10.1108/RPJ-09-2014-0128]

Received 23 September 2014
Revised 14 December 2014
21 January 2015
13 April 2015
Accepted 9 May 2015

available in FabLabs (Gershenfeld, 2005), hackerspaces, makerspaces and shared machine shops.

In this paper, a critical description of the 3D printing techniques available is presented by focusing on certain technical situations that result in different levels of emancipation, empowerment, commitment and behaviour. As part of this research, a field study in FabLabs, hackerspaces and makerspaces was conducted. Particular attention was paid to the relationships established between the people using these places and their machines. The logic of developing projects and the techniques used to counter unforeseen obstacles were observed. The research was conducted in Paris (France), Amsterdam (Netherlands), Barcelona (Spain), Rome (Italy), Lyngen (Norway), San Francisco (USA), New York (USA), Boston (USA), Tokyo (Japan), Kamakura (Japan) and Dakar (Senegal). A method for observing what happens in more than 30 of these makerspaces (FabLabs, hackerspaces) was developed to look beyond the simplified media coverage (Bosqué and Ricard, 2015). Previously, we described how a FabLab community forms its own identity and promotes certain principles and values of peer production (Kohtala and Bosqué, 2014). However, this work focuses on entry-level 3D printers, found in all of the FabLabs or hackerspaces visited.

These machines provoke very different practices in the communities where they are being used or built. 3D printing is one of the many options now available for personal digital fabrication. It belongs to the same family as laser cutters and numerical milling machines. Entry-level 3D printers share the possibility of creating objects from designs or models produced by a computer in common with these other methods. The machines execute instructions given by operators whose practices and behaviours have not been studied. These emerging technical situations pose a series of questions. Who are the people using these entry-level 3D printers? What are they printing? What techniques do the machines offer their users? What rituals do they impose on them?

After briefly discussing Rapid prototyping and the history of 3D printing techniques, the maker movement and the use of entry-level 3D printing by ordinary people will be discussed. The field observations are confirmed by a quantitative study, based on a survey submitted online to 170 users from 30 different makerspaces in more than ten countries. The survey shows how 3D printing is being used and highlights the attention given to 3D printing and the trivial production (Blikstein, 2013) often used to demonstrate their function. How user-friendliness is challenged by practices of repairing, fixing and adjusting, rather than of replicating, is discussed.

2. From high-end additive manufacturing to consumer 3D printing

Conventional production is characterised by subtractive manufacturing; material is removed from a larger block of material until the final product is formed. Over the past decade, companies have begun using additive manufacturing for production instead of for prototypes. An attractive aspect of additive manufacturing processes is that they do not produce excessive waste material. Parts or objects with complex forms not easily produced by subtractive

manufacturing methods can now be produced on mainstream production lines.

Rapid prototyping allows companies to “directly [generate] physical objects from graphical computer data” to build concept models and functional prototypes (Jacobs, 1992). The additive manufacturing process begins with the creation of a three-dimensional computer model, which is then sliced into thin layers by a computer program. The layers are then added to the machine piece by piece, with each slice built on to the previous one.

3D printing is part of a wider regime of emerging technologies. According to Gershenfeld (2005), it presents “the ability to turn data into things and things into data”, and widespread access to digital fabrication technologies “allow individuals to design and produce tangible objects on demand, wherever and whenever they need them”.

Despite the recent popularity of digital fabrication and 3D printing, additive manufacturing was first used for prototyping in the late 1980s. Thirty years into its development, it has now become a mainstream manufacturing process, and there has been an exponential rise in available systems, technologies, materials and applications.

Hopkinson *et al.* (2006) write that:

[...] the field of Rapid Manufacturing has grown in recent years and [that it] offers such significant potential that it must be considered as a discipline in its own right that is independent from its predecessors of Rapid prototyping and Rapid tooling. This new discipline, which eliminates tooling, has profound implications on many aspects of the design, manufacture and sale of new products.

Although additive manufacturing was initially used to make concept models in architecture or functional prototypes, “it has become possible today to obtain parts representative of mass production within a very short time” (Bernard and Fischer, 2002). Previous technologies could only produce parts for prototyping purposes, and were often not efficient enough for production. This is the case for stereolithography, fused deposition modelling and early selective laser sintering systems (Hopkinson *et al.*, 2006). However, it is now possible to produce full-strength polymer and metal objects by using the latest additive manufacturing technologies (Wohlers, 2009). Additive manufacturing is creating new possibilities for the aeronautical industry (Nathan, 2011; Freedman, 2011) and offering a broad range of potential applications for design (Hopkinson *et al.*, 2006).

Hopkinson *et al.* (2006) pose the following question: “What other technology can get an artist, a medical clinician, an engineer and an environmental champion excited in the same way?” The promises of additive manufacturing have been realised in customised health-care products, reduced environmental impact of manufacturing and a simplified supply chain that increases efficiency and responsiveness in demand fulfilment (Huang *et al.*, 2012).

3D printed materials can also be found on surgical tables (Winder and Bibb, 2005; Bibb *et al.*, 2010; Dalgarno *et al.*, 2006; Gibson *et al.*, 2006; Rengier *et al.*, 2010), in dentistry (Liu *et al.*, 2006; Zax, 2012), for biomedical engineering (Melchels *et al.*, 2010; Mazzoli, 2013) and on laboratory benches (Melchels *et al.*, 2012; Oxman *et al.*, 2011; Oxman, 2012).

In the field of education and culture, schools and public libraries are also adopting 3D printing (UK Department of

Education, 2013; Blikstein, 2013). Parallel to these developments, policymakers are interested in the promises of digital fabrication to help address various “grand societal challenges”, such as the lack of vocations in science, technology, engineering and mathematics (Lipson and Kurman, 2010), the reshoring of manufacturing jobs (Pisano and Shih, 2009) and sustainable development (Horizon 2020 Work Programme, 2013).

Additive manufacturing is often described as a world-changing innovation that will create profound sociotechnical change. Multiple objects can now be printed, including toys; car and aircraft parts; jewellery; fashion accessories; furniture; customised mobile phone covers; bionic arms; medical implants, such as dental crowns; and possibly artificial blood vessels (Moskvitch, 2011). The range of materials is increasing rapidly. Birtchnell and Urry (2013) state that:

Some future innovations are likely to include machines able to print mixed materials at the same time; the printing of active systems such as batteries, circuits, actuators and assembled machines; organic printing of stem cells, organisms and cultures; infrastructure printing of buildings, large structures and vehicles; and *in situ* printing inside the body, in space, in deep oceans or whilst in motion.

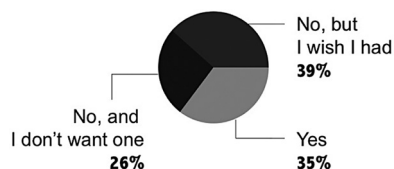
Understandably, these innovations have inspired many writers; a few examples would be Stephenson’s *The Diamond Age* (1995), McDonald’s *Brasyl* (2012), Stross’s *Rule 34* (2012) and Doctorow’s *Makers* (2009).

As a technology that is still in its infancy, these works contribute to collective speculation on future scenarios. *The Diamond Age* (1995) features a “matter compiler”, a machine that can produce all types of products and food at home, by using nanotechnology. The future of personal digital fabrication is very often linked to science fiction stories. In the first part of *Fabricated: The New World of 3D Printing*, a short essay called *Everything Is Becoming Science Fiction* (Lipson, 2011) describes a near future in which people can choose and print their customised toothbrushes or any daily object. Despite the promise of a near future where everyone prints whatever they need at home, 3D printing at home is not yet a reality. What is more, many of those who use 3D printers (26 per cent) do not even see the benefits of having such a machine available at home (Figure 1).

3. A promising future: Towards a new world of ordinary makers

An ordinary consumer can buy a 3D printer for less than a thousand euros, whereas high-end industrial printers can cost millions of euros. Over the past five years, the world of digital fabrication has received extensive media coverage and growing policy support. As a result, digital fabrication and 3D printing have made it to the cover of influential

Figure 1 Answers to the online survey question “Do you have a 3D printer at home? Would you like to have one?”



magazines such as *The Economist*, *Wired* and the *MIT Technology Review*.

Gershenfeld (2005) describes a future in which everyone has access to a personal fabricator, a machine capable of producing not only simple material objects but also other machines. This, he claims is “a curious sort of revolution, proclaimed more by its observers than its practitioners” (Gershenfeld, 2012). Gershenfeld says that:

[G]lowing articles about 3D printers read like the stories in the 1950s that proclaimed that microwave ovens were the future of cooking. Microwaves are convenient, but they didn’t replace the rest of the kitchen (Solon, 2013).

In other words, 3D printing will not, according to Gershenfeld, replace established subtractive manufacturing technologies, such as milling and cutting.

However, manufacturing on demand and customising objects can lead to potential cost savings and be competitive for many companies. Gershenfeld (2005) believes that the widespread access to digital fabrication technologies that “allow individuals to design and produce tangible objects on demand, wherever and whenever they need them” might make the biggest impact.

If large numbers of ordinary people were to start manufacturing their own unique objects at home, one might predict a worldwide proliferation of decentralised workshops or lightweight microproduction shops, each serving specific demands. According to the summary of the report “3D Printing – A Global Strategic Business Report” by Global Industry Analysts, the 3D printing market could reach approximately USD 3 billion by 2018 (Raby, 2012). A whole new system may emerge. If manufacturing were to be localised, it might lead to an “after the factory” (Fox, 2010) stage of development. The so-called “democratisation of manufacturing”, which has already been qualified as an industrial revolution (Anderson, 2012a, 2012b), might share some of the innovations found in music or film economies, where the Internet has given its users wider access to material and multiple downloading options (Rifkin, 2001). Similar developments for 3D printing would be based on the exchange of downloadable files of models and blueprints (Lipson, 2011).

In addition to the profound repercussions this technology might have (Mills, 2011) on the manufacturing industry (Mills, 2011), it might also unleash creativity and innovation at a level comparable to the personal computer revolution and the Internet. As Von Hippel (2005) points out:

User-centered innovation processes offer great advantages over the manufacturer-centric innovation development systems that have been the mainstay of commerce for hundreds of years. Users that innovate (Ecker, 2005) can develop exactly what they want, rather than relying on manufacturers to act as their (often very imperfect) agents. Moreover, individual users do not have to develop everything they need on their own: they can benefit from innovations developed and freely shared by others.

Although scientists and technologists investigate the potential of additive manufacturing, the media tends to focus on the diffusion of open-source 3D printing, FabLabs and the maker movement.

The practices of sharing and remixing are being renewed by access to the tools that turn digital models into tangible things, and the modification and circulation of digital files.

When these 3D printing technologies start to infiltrate basic individual practices on a large scale, new questions will be

posed. This led to studying the actual places where entry-level 3D printing is now being used: FabLabs, hackerspaces and makerspaces. An online survey was conducted in November 2014, and approximately 170 answers were received. It is confirmed that makerspaces are the places where entry-level manufacturing mostly takes place (Figure 2). In a multi-answer questionnaire, 64 per cent of the people who answered said that they usually went to the local makerspace to use a 3D printer, whereas 33 per cent claimed to use a 3D printer at home, 21 per cent at the office and 24 per cent at school or university.

The entry-level version of 3D printing is indeed one of the main tools of a growing social movement of tinkerers, activists and entrepreneurs. It can therefore be found in garages, FabLabs and hackerspaces (Anderson, 2012a, 2012b; Bowyer, 2011; Burns and Howison, 2001; Doctorow, 2013; Malone and Lipson, 2007; Rotman, 2013; Söderberg, 2013; Tochetti, 2012; Townsend *et al.*, 2011; Gershenfeld, 2012; Hatch, 2013).

4. The RepRap project: An ideal of autonomy, emancipation and empowerment in a distributed community of hobbyists

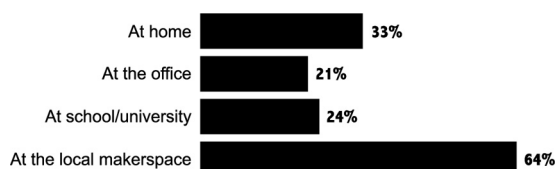
Open-source, home-built 3D printers are being developed by communities of hobbyists. The RepRap machines are far from standardised. As Soderberg puts it:

To get a machine to work reliably with consistent results is not a trivial task. [...] It requires knowledge about soldering, mechanics, electronics, and, on top of that, some programming skills (Soderberg, 2013).

RepRap can serve as an entry point to the debate on deskilling and user-friendliness.

The media has focused on several major aspects. First, 3D printers empower ordinary people technically and offer them a form of emancipation. Second, by distributing the means of production in local communities, the possibilities for autonomous production can also be expanded. A different vision of the classical centralised means of production engages with 3D printing in shared machine shops. Here, the question of emancipation and empowerment is crucial, and linked with opposition to passive habits of consumption and an ideal of self-commitment and autonomy (Morosov, 2014). This is the subject of numerous recent publications. In 2010, *The New York Times* declared it a “revolution” (Vance, 2010). *The Economist* (2011) published a special issue called “The printed world: Three-dimensional printing from digital designs will transform manufacturing and allow more people to start making things”, and a second article (*The Economist*, 2012) titled “Solid print: Making things with a 3D printer changes the rules of manufacturing”. These publications describe the process of converting data into tangible objects. The growing interest in 3D printing is a result of the improved quality of

Figure 2 Answers to the online survey question “Where do you 3D print?”



production. The machines are becoming more and more accessible for users. Although 3D printers on laboratory benches are used to print tissues and organs, open-source 3D printers, such as the RepRap printer, are designed to produce diverse things at very low cost. These machines make it possible for non-professionals to fabricate objects at home or in shared workshops. For example, the Fab@Home machine, designed by Hod Lipson and colleagues, was specifically designed for domestic use[1]. Lipson describes it as:

[...] a consumer-oriented fabber [short for digital fabrication], coupled with the networked educational and technical resources already available today, [that] empowers individuals with much of the innovative facility that would otherwise require an entire R&D laboratory. This could potentially lead to economic innovations such as neo-cottage industry manufacturing, an “eBay of designs” where individuals would be able to market unique product designs as digital instructions and material recipes for others to execute on their own fabbers, and millions of people inventing technology rather than merely consuming it.

3D printing might not only change our modes of production but could also alter the way daily products are bought and consumed. By changing our modes of consumption, entry-level 3D printing and decentralised production could lead to massive political and economic changes (Lipson and Kurman, 2010). Those machines are meant to be accessible to a wide audience. All of these beg the following question: Is 3D printing a disruptive technology, reinventing the way we work and create value?

Adrian Bowyer began developing an open-source, low-cost, self-replicating 3D printer called RepRap, an abbreviation for Replicating Rapid Prototyper, in 2005 in the Mechanical Engineering Department of the University of Bath. RepRap consists of an extruder, which heats a plastic filament to 210°C and lays each layer on top of the next one, creating the object step-by-step on a hot plate, on three axes, starting from the bottom. RepRap has a metal structure, which contains small plastic parts that are components that can only be replicated by another home-built 3D printer and are not sold. As of yet, the motors, the electronic parts and the extruder cannot be printed with another 3D printer. The electronics and the software are additional components. The first replicated machine was introduced in 2008, and described as the “son” of the very first RepRap, assembled with plastic parts printed with a RepRap of the same kind. The ideal of autonomy is embodied here, by the independence from industrial suppliers.

The development of these machines could lead to a decentralisation and a distribution of the means of production (Rifkin, 2001). In some cases, hobbyists could join professional markets. FabLabs, hackerspaces and makerspaces are fertile environments for the development of entry-level open-source 3D printers. They rely on physical and virtual networks of hobbyists, forming rhizomatic communities, where sharing and discussions about technical experimentations, based on the RepRap project, are valued. Without relying on hierarchy or subordination, RepRap users collaborate constructively, sharing similarities with the “bazar” described by Raymond (2001) as opposed to the “cathedral”. To document the progress of each possible version of the project, images, videos and tutorials are offered online (Gilloz, 2013), and real-life meetings are held, where the massive flow of online information is evaluated and discussed.

Online communities make up the virtual part of the activity in FabLabs and hackerspaces.

Bowyer (2006) calls the development of RepRap Darwinian Marxism:

So the RepRap project will allow the revolutionary ownership, by the proletariat, of the means of production. But it will do so without all that messy and dangerous revolution stuff, and even without all that messy and dangerous industrial stuff.

A form of evolutionism could indeed allow RepRap machines to be more accessible and enable the empowerment of makers and hackers. This might be the only way to get beyond the current fascination with these machines.

5. Beyond fascination and phatic objects

Hopkinson *et al.* (2006) state that:

The design freedoms afforded by Rapid Manufacturing are immense and the processes are capable of creating mind boggling geometries. Prior to the advent of these technologies, has mankind ever been in the situation where visualising and designing a product is actually harder than making it?

It goes without saying that we have only just begun to explore the freedom and possibilities of this technology.

The setup is always the same in the makerspaces that were visited. The printer is placed on a table, connected to a computer by a bundle of electronic cables, which is generally left bare. We hear mechanical scanning, a stuttering electronic sound interrupted by sequences of little organic noises. In the midst of the machine's noise is the hot plate, a thin metallic sheet on which everyone's attention is fixed, where the image that was displayed on the computer screen a few seconds before will soon appear. A plastic component darts across the plate, trailing a slender, melted filament that is immediately assimilated by the preceding layers. One layer has scarcely been laid when another level of the object appears. Something gradually emerges, its shape not immediately recognisable. A small box appears: "Remaining time: 21 minutes". Everybody's gaze is fixed on the minuscule layers formed by the material that is slowly building up on the small stage at the heart of the machine [Figure 3(a)]. 3D printers build things layer by layer, with no human intervention, and the printing process is still long. However, observing the printing process is a satisfying experience in itself; obtaining the final product almost feels like a bonus. Yet *something* must be printed. The fascinated audience wants proof of the machine's functionality. During a performance in front of an audience, 3D printers often produce useless objects that serve as pretexts for operating the machines [Figure 3(c and d)]. Usually, these samples are downloaded from the Internet. Known as "crapjects", a contraction of "crappy" and "objects", they are

printed to make up for a lack of inspiration; the idea that we can print anything petrifies people far more than it liberates them. These objects, created by default, should be referred to as *phatic objects* from the ancient Greek word *phanein* meaning "to show". They represent a ready-made lyophilised version of the possibilities of personal production. The Russian linguist Jakobson (1963) defined the phatic function of language as language for the sake of interaction. In the technical situation imposed by 3D printing, this means maintaining active contact between the operator and the printer. *Phatic objects* are objects that are printed with no real purpose, a sort of cheat sheet that hides a lack of ideas (Figure 4).

The following conversation is typical; someone is trying the 3D printer in the FabLab in Gennevilliers for the first time. It reveals the feelings of powerlessness people feel on their first contact with the machine:

- Is this the first time that you've used a 3D printer?
- Yes, I've never seen this before. It's crazy.
- So, what are you printing?
- That: it's a little bendy snake [. . .] (Figure 5).
- Did you make it?
- No, I downloaded it just now. I didn't know what to print, so I had to find something!

The survey results showed that the less people are familiar with the machine, the less likely they are to overcome their fascination with the production of *phatic objects* and have a more individual approach to it (Figure 4). In contrast, the people who describe themselves as "experts" mostly use 3D printing for prototypes to adjust settings or to print pieces for another 3D printer; "beginners" and "one-time" users tend to stick to a more spectacular approach. "Printing decorative objects" and "to see how it works" are the two most common answers in this category.

Another interesting aspect of the survey concerns the printing of "objects that you can use". Whereas beginners and first-time users claim that they are printing "decorative objects" and "objects that can be used", the more experienced users tend to call them "prototypes". This reveals an evolving relationship with what is being printed and the potential of the machine itself, which leads to the hypothesis that while new users are still in a stage of fascination, dreaming about the possibilities of the machine, more advanced users have become aware of the poor quality or non-relevance of the tool for a "real" production of day-to-day objects. This part of the survey raises questions of technical literacy and the limits of

Figure 3 (a) A group watches a FoldaRap 3D printer, FaLab in Gennevilliers, February 2013; (b) Group at Sculpteo exhibition stand and (c), (d) various fabricated objects, Maker Faire in Rome, October 2013



Figure 4 Answers to the online survey questions “How familiar are you with 3D printing?” and “What do you use 3D printing for?”

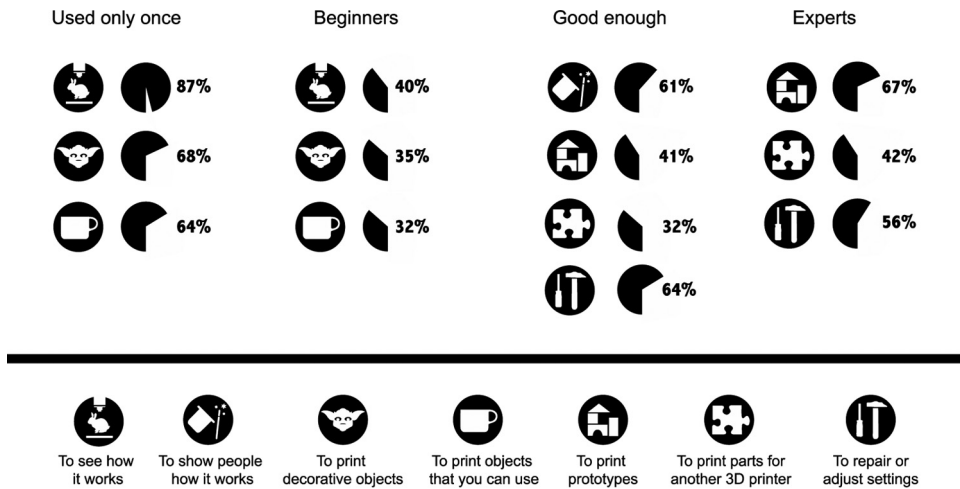
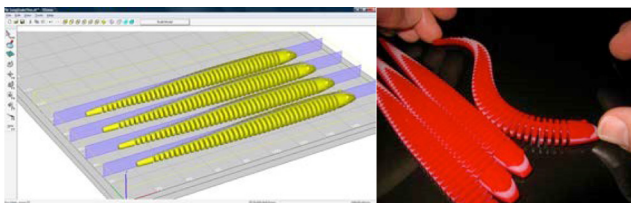


Figure 5 Little snake downloaded from Thingiverse



the creativity and imagination of people who are using the tool for the first time. Hopkinson *et al.* (2006) write that:

[...] as these technologies [become] more commonly used and their products [more often] seen by the general public, then the creativity that can make full use of the potential of the processes will be realised. As today’s computer literate children grow up they will be able to unleash their creativity in ways that had not been possible before [...] There will need to be considerable work in the development of such packages to suit the new generation of computer literate but non-engineering specialised designers of tomorrow.

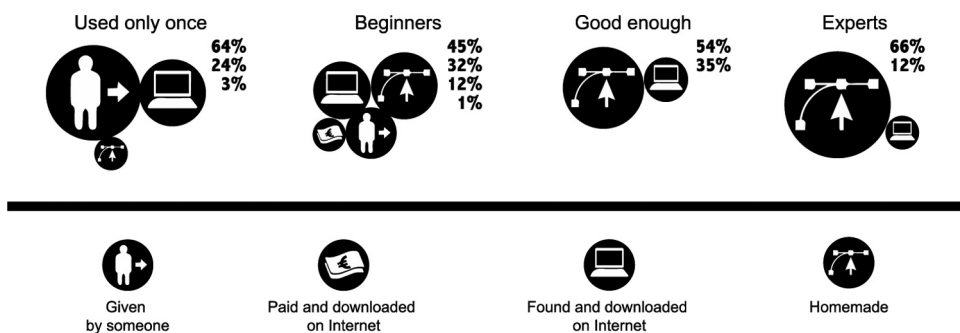
When people are asked whether they made their files themselves or not (Figure 6) or where their files come from, the answers make it even more relevant. Beginners and one-time users have an indirect relation to the model they are printing because their files are most often supplied by others or found on the Internet. Homemade files require more time,

and adaptation is not instinctively part of the background of newbies. However, homemade files seemed to be an option for some “beginners”, but were more common for those who considered themselves as “good enough” and “experts”. The survey also made clear that paying for files was almost never considered an option.

6. Repairing rather than replicating: Building the case against user-friendliness

Phatic objects, extruded one after another by 3D printers during demonstration sessions, are physical proof of the production capacities. During a study of personal digital fabrication in schools, Blikstein (2013) criticised certain teaching methods: “Because the machines can produce beautiful objects with very little effort, the teachers should avoid quick demonstration projects and push students in more complex directions”. Making keychains with a laser cutter was part of the first discovery sessions in Blikstein’s classes. “By the fourth session, I realised that something wasn’t right. The workshop had become a factory for producing keychains, and students refused to work on other projects”, he explains. By valuing the product rather than the process, the students simplified all the technical aspects and concentrated on the “trivial” objects that they could make independently. Blikstein calls this “keychain syndrome”.

Figure 6 Answers to the online survey question “Do you make your files yourself?”



The distribution of ready-made models calls into question the emancipation of the amateur by digital technology, as valued by the French sociologist Flichy (2011) as a modest acquisition of skills “driven by passion”. By Rancière’s (2008) definition, emancipation is a “blurring of the boundary between those who act and those who watch, between individuals and the members of a collective corpus”. As a means for denying the real acquisition and transmission of expertise, the distribution and the repeated production and replication of *phatic objects* extends a state of spectacle and, at the same time, it encodes the frozen expertise, hiding the space that should give rise to new ideas or new aims. When Adrian Bowyer began the open-source RepRap project in 2005, documenting the building of the project online to encourage its development by the viral distribution of its plans, he could not have imagined that, 10 years later, his model would have developed a genealogy of different machines based on very specific developments of one particular feature or another. One of the main principles of RepRap is that each printer can self-reproduce; the printer can print many of the parts needed to build another printer of the same kind. The RepRap (and the other generations of 3D printers based on its plans) is simultaneously replicable, modifiable, adjustable and repairable. In this sense, it is at the same time a machine that is both repairable and a tool for repair. The idea of repairs implies the possibility of improvement. This idea is crucial. Technology should help reveal our existence and express our creativity by allowing us to demonstrate it and test it. The machines that we use must help to determine active rather than passive behaviour.

Without doubt, there is an element of play here and a form of DIY, described by Levi-Strauss (1962) as a readjustment of the “residues of previous construction and destruction”.

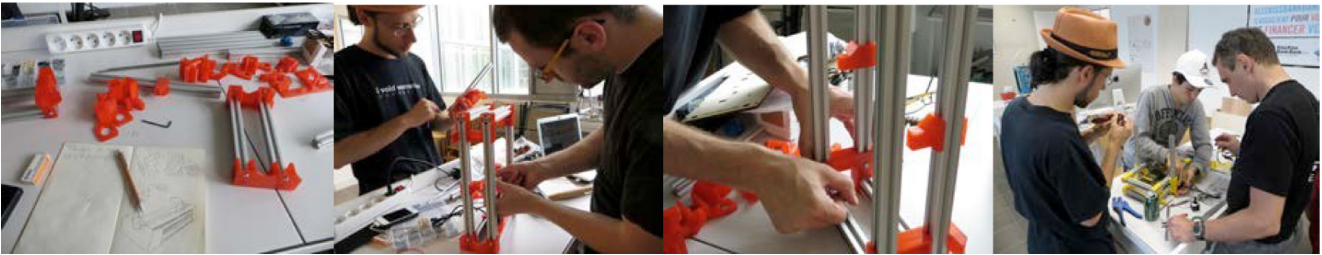
In this sense, the practices at stake reveal the ruses and tricks described by De Certeau (1980) that can produce without actually creating any profit. In his introduction to *The Practice of Everyday Life*, he describes the “poaching” of everyday people when they read, and the re-attributions that introduce a “different world (the reader’s) into the author’s place” and this “makes the text habitable, like a rented apartment”. From repairs to re-attribution, different manipulations make it possible to work around the passivity induced by the production of *phatic objects*.

There are several recurring situations because of the novelty of 3D printing. However, for use that is more active, several phases of behaviour were witnessed in 3D printing. After the initial fascination, which generally lasts for the first few minutes of the printing process, the patience of beginners is tested, whereas more experienced users impose patience on themselves in a systematic manner. When using 3D printers, people rarely leave the printer unattended; with traditional 2D printers, feeding the paper into the machine’s tray is sufficient. At The South End Technology Center in Boston, a sign says: “If you are using the 3D printer, you must be at the 3D printer”. In the FabLabs that were studied, it was noted that “launching” an impression does not mean sending it very far. The user stays by the machine for several minutes, often until the object has fully emerged.

This is because of various factors. Beyond the spectacle of the extruded thread, laid precisely on the previous layer,

experienced users know that a large part of their role consists of dealing with unforeseen events. Such random events may constitute a problem or simply serve as a source of satisfaction. Predicting such events is a large part of the preparation for printing. Problems may be of any sort, for example, from an error in the software settings or simply from specks of dust on the hot plate. These events counter the inaction of the operator watching the machine. Events require the intervention and expertise of the operator who balances and manages the disruptions. Therefore, not everything is prepared in advance. Despite the simplistic view of plug and play technologies where you press a button and wait, these machines require a form of translation on the part of the operators. Simondon (1958) states that, when placed in front of an “open machine”, the operator becomes a “permanent organiser, a living interpreter of machines, from one group to the other”. The signs from the machine may inform the user of an irregularity in the diameter of the thread or a short circuit that causes the printer head to slow. Errors may result in deformations of the model, unforeseen colours, imperfections, differences or accidents that can stop the machine. The distinction between behaving and acting illuminates the subject; animals behave, people act. We can only act within the margins for manoeuvre if not everything is decided in advance. If we cannot live without techniques, people can only truly act within these techniques by not following rules. The person monitoring the printer must think for themselves when seeking out or tracking the cause of the fault; loosen the thread, assess the nozzle diameter and gradually adjust the parameters for the printer head movement. In the keychain production example, by avoiding new projects, the students are reduced to following the logic of production and profit without deviation. In contrast, “acting” supposes that the operation of the machine is open, modifiable, interpretable and repairable. This means not systematically following the rules.

“We had the manual but we threw it away!” explained a young hacker from /tmp/lab in Vitry during a series of interviews conducted in December 2012. Hacking the technology allows innovation. In the hackerspaces that were studied, particularly in Noisebridge (San Francisco) and in some FabLabs, the machines were often exposed without any protection, such as housings or grills. As a result, the operator had direct access to the workings of the machine and could detect the slightest variation in the noises, which could increase the user’s personal investment in the technical activity. 3D printers such as the RepRap and its descendants are stripped down, left exposed to development and play. Accentuating the plasticity of the machine may become a subject for experimentation and testing (Figure 7). Going against the flow of users who limit themselves to the controls planned for the “actors” by the designers (Akrich, 1993) and fighting against the closed subject and the black box, the hackers, as they were studied by Turkle (1984), deliberately place themselves in situations on the edge of catastrophe. Beyond adjustments and independent projects, which encourage active participation, some operators seek to deliberately explore technical failures, which lead them to push the limits of their ingenuity.

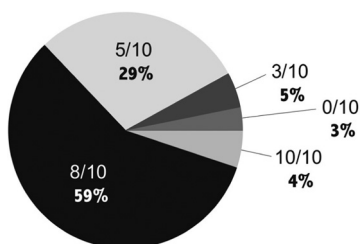
Figure 7 Assembling a 3D FoldaRap printer, FaLab in Gennevilliers, June 2013

The online survey revealed that around 37 per cent of the 170 respondents are not yet fully satisfied with the quality of what they print (Figure 8) and grade it between 0/10 and 5/10. Around 59 per cent rated the quality of their productions with 8/10, and only 4 per cent are fully satisfied with their experience. Users of the entry-level 3D printers seem to be waiting for, and expecting, technical improvements.

Conclusion

This article has provided an overview of the recent shift from high-end additive technologies to consumer entry-level 3D printing. A closed situation where consumer 3D printers are displayed in front of a small crowd of spectators was presented. By focusing on 3D printing, and taking RepRap as a typical example, a general picture of the limits and promises of the maker movement was obtained. To push people into acting rather than behaving, the curiosity of hackers and digital tinkerers must persevere, and users should be encouraged to have active attitudes towards the technology.

The exploration of areas of uncertainty in 3D printers, driven by an operational translator able to control its faults and random occurrences, was also examined. The level of emancipation was discussed from the lowest degree to the point where repairable technology can be used independently. The production of *phatic objects* stripped of purpose and the ground-breaking practice of assembly and disassembly was described, from replication to repairing and adjustment, and away from empty user-friendliness. These practices and situations mark the first steps towards technical and technological ambivalence of entry-level 3D printing as it is being gradually introduced to the general public. This may either take the form of a group of disciplined, anonymous users who are fascinated by the technology, or of operators, who are active participants in technical situations of their own

Figure 8 Responses to online survey question: "How would you evaluate the quality of what you have printed?", rated on a scale of 1 to 10

making. There is evidence that indicates that the latter group will win the battle. Indeed, let us hope so.

Note

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