3D Printing Technologies: Social Perspectives

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Deborah Lupton, News & Media Research Centre, Faculty of Arts & Design, University of Canberra

Introduction

Three-dimensional (3D) printing is a process of fabricating objects using computer-aided design software and hardware that responds to instructions from the software. In this working paper, I provide an overview of 3D printing technologies, including their current and proposed uses. It has been suggested that these technologies offer a way of contributing to the reduction of environmental pollution by reducing the need for transporting goods and minimising waste and energy use in production and may lead to third industrial revolution, including in developing countries. The technologies have also been heralded as promoting open knowledge sharing and creative coding and as potentially contributing to participatory design opportunities and the democratisation of invention, as well as education and cultural heritage. The paper addresses the social, cultural, political and ethical issues concerning 3D printing and outlines directions for future sociological research on these technologies.

An overview of 3D printing technologies

Three-dimensional (3D) printing is a process of fabricating objects using computer-aided design software and hardware that responds to instructions from the software. It involves the use of materials such as plastics, powders, ceramics, metals and organic matter such as tissue cells or foodstuffs propelled through jets that extrude substances in layers to form objects. 3D printing is technically referred to as additive manufacturing or rapid prototyping. It has been used in industry since the 1980s, but it is only in the last few years, with the development of smaller and less expensive hardware targeted at mainstream consumer use, that the potential for 3D printing technologies to be taken up in other social domains has been explored.

Much excitement has been expressed in recent times about the possibilities of 3D printing technologies. Many popular and industry accounts of 3D printing, for example in 3D industry blogs and news reports, have represented the technology as potentially revolutionary and 'disruptive'. The World Economic Forum's list of the top emerging technologies of 2016 included additive manufacturing (Meyerson, 2015). It has been suggested that these technologies offer a way of contributing to the reduction of environmental pollution by

reducing the need for transporting goods and minimising waste and energy use in production (Birtchnell and Urry, 2012; 2016) and may lead to a third industrial revolution (Palavicino, Konrad, Bowman, Dijkstra, Fautz, Guivant, Konrad and Woll, 2015; Petrick and Simpson, 2013), including in developing countries (Birtchnell and Hoyle, 2014).

The creative and educational possibilities of consumer and domestic 3D printer technology use have also received attention. In maker and other creative pursuits, using the technologies to manufacture their own objects as part of craft, do-it-yourself, fan, hacker or hobbyist cultures has been represented as providing people with the opportunity to generate artefacts outside traditional institutional and commercial structures (Ratto and Ree, 2012; Fordyce, Heemsbergen, Mignone and Nansen, 2015; Palavicino et al., 2015). The technologies have been heralded as promoting open knowledge sharing and creative coding and as potentially contributing to participatory design opportunities and the democratisation of invention (Fleischmann, Hielscher and Merritt, 2016; Eisenberg, 2013).

The opportunity for 3D printed objects to engage the senses other than the visual has excited the interest of educators. 3D-fabricated objects are material culture artefacts, inviting multi-sensory responses that potentially can engage people more intensely in understanding and learning about the artefacts (Ratto and Ree, 2012; Lupton, 2015; 2016; Neumüller, Reichinger, Rist and Kern, 2014; Eisenberg, 2013). 3D printing also has implications for how people respond to and make sense of their personal data. Many digital technologies collect information about the people who use them. In most cases, these personal data can be viewed in the form of two-dimensional materialisations such as graphs or metrics displayed on a digital device screen. If 3D printing technologies are used, however, personal data can be materialised into physical objects that can be touched, held, displayed and even smelt, tasted and eaten.

Many of these claims remain speculative, outlining future possibilities rather than current uses. However, there are several areas in which 3D printing technologies have begun to take hold. Websites such as Thingiverse encourage the sharing of computer files for 3D printing enthusiasts. The possibilities for commodity generation by 3D printers were explored in the RepRap open-source printer project. This low cost 3D printer was designed to be able to generate most of the parts to make more RepRaps in a potentially unending loop of self-reproduction that challenged conventional assumptions about production, distribution networks and consumption (Söderberg, 2014).

3D printing technologies are currently used in the food industry, including fabricating food for people with chewing and swallowing difficulties and as part of novelty, decorative and gourmet food offerings (Lupton and Turner, 2016). 3D printing is used in medicine and dentistry to produce customised prosthetics and implants, and to generate bio-matter for purposes such as skin grafts (Lupton, 2015). 3D printing technologies are also used for marketing and leisure purposes: for example, providing replica figures of people that are used as mementos of events like graduations, sporting events and weddings (Lupton, 2016). Not only can these replicas be viewed, they can be handled, passed around and displayed decoratively, involving haptic as well as visual interactions. 3D fabricated objects that are anatomical replicas of whole or parts of people's bodies are used in medical and patient education and for planning surgery (Lupton, 2015). 3D printing is employed by archaeologists,

2

cultural heritage practitioners and museums to fabricate replacements for ancient artefacts and create virtual experiences or mementos for visitors (Kidd, 2015; Neumüller et al., 2014). Some schools and universities have adopted 3D printing as a new way of learning about and experimenting with digital technologies and creating objects (Fordyce et al., 2015; Eisenberg, 2013; Nemorin and Selwyn, 2016).

A sociological perspective on 3D printing

Given the wide array of objects that can be manufactured by 3D printing and the diversity of the contexts in which they can be made and used, there are many social, cultural and political implications of 3D printing technologies. In what remains a nascent sociology of 3D printing, these have yet to be fully identified. Sociologists have addressed the potential changes in manufacturing, transport and the supply chains of goods that 3D printing may generate (Birtchnell and Urry, 2012; Birtchnell and Hoyle, 2014). There are broader social and economic issues relating to 3D printing that are also relevant to the use of other digital technologies, including those concerning ownership of intellectual property and copyright and the creation and sharing of software and digital data. The income streams and business models of many industries have been transformed by the entry of digital technologies, from journalism to the music industry. 3D printing technologies offer similar challenges in terms of how products are monetised in the face of the impetus for consumers to take greater control in creating and sharing goods, including digital content.

Some researchers have also begun to discuss 3D printing technologies' socio-legal aspects. There is concern that 3D printing could be used in illegal ways: in the manufacture of weapons such as guns, for example, or in the flouting of copyright laws (Daly, 2016). Part of the discourses of creativity surrounding 3D printing discussions is the notion that the technologies allow people to engage in pursuits that are outside traditional forms of regulation and state control (Daly, 2016). In some cases, there are also concerns about the safety of products manufactured using 3D printing and how this should be monitored and regulated, including goods such as medical devices, human or animal tissue and foodstuffs (Daly, 2016; Tran, 2016; 2015).

Another focus of social research into 3D printing directs attention at the implications for people's engagements with their personal data. Designers and HCI researchers have experimented with using 3D printing to transform personal data into physical objects – or what are often termed 'data physicalisations' in the language of HCI (Jansen, Dragicevic, Isenberg, Alexander, Karnik, Kildal, Subramanian and Hornbæk, 2015). They have observed the extent to which the opportunity to handle, touch and display these objects help people to make sense of data in more multifaceted ways and to engage more emotionally with their data. A research team has adopted this approach in a project investigating whether printing out objects from physical exercise data tracked by digital devices will encourage people to be more active (Khot, Hjorth and Mueller, 2014). Other researchers have tried printing out chocolate artefacts as rewards for physical exercise, so that people can smell, taste and consume as well as view and touch these materialisations of their personal data and feel rewarded for their efforts (Khot, Pennings and Mueller, 2015). Nissen and Bowers (2015) have experimented with encouraging people to engage in 'data making' by producing 'data-things'

from their own data. Nissen and Bowers refer to such activities as 'participatory data translation'. They are intended to be communal rather than individualistic modes of generating and materialising data that invite reflection on how this information is created and who has the opportunity to use it.

Few researchers have investigated how people are taking up 3D printing technologies or their products as part of their everyday lives. There is some speculation already that these technologies' potential for domestic use has been over-stated. Consumers thus far appear reluctant to embrace home 3D printing, as representatives of one of the major developers of these machines, MakerBot, conceded in late 2016 (Cranz, 2016). A project by Shewbridge and colleagues (Shewbridge, Hurst and Kane, 2014) used a pretend 3D printer to investigate people's ideas about how 3D printers could potentially be used in the home. Their participants suggested that they could be used to fabricate common household, utilitarian or for craft uses or spare parts for broken objects and replacements for unique artefacts. This research did not address actual use of the real printing technologies, however. Studies on how people are engaging with 3D printers outside the home have identified a range of issues that have hampered uptake and challenged assumptions about the creative potential of these technologies and how easy they are to use. Hudson and colleagues (Hudson, Alcock and Chilana, 2016) researched how casual 3D printer users fared when trying to fabricate objects at public print centres. Their interviews found that these casual makers often struggle to successfully use these technologies. They are deeply dependent on the print centre operators to help them in the process, but these operators are not always well equipped to do so.

One of the few sociological enquiries into the experiences of 3D printing was undertaken by Nemorin and Selwyn (Nemorin, 2016; Nemorin and Selwyn, 2016) in the context of an Australian secondary school. Their ethnographic research identified the affective dimensions of this experience in the context of the school setting and existing pedagogical structures, including lack of engagement and the sheer hard work, tedium and frustrations in attempting to make the technology work as desired. My own study with Bethaney Turner (2016) similarly found that consumers reacted to the idea of 3D printed food with emotional responses, being fascinated by the possibilities but also struggling to comprehend how such an 'unnatural' process as digital fabrication could generate edible, appealing and nutritious food.

Future research directions

The research I have here reviewed represents just the beginning of a new line of digital sociological enquiry. There are many dimensions of 3D printing to explore, including such features as the ways in which these technologies are portrayed in popular culture and how they are taken up by members of the public across diverse social domains, as well as the wider implications for industry and the economy. Aspects such as 3D printing technologies' social, cultural, economic and political impact on education and the workplace, on consumption and leisure cultures including tourism, museums, exercise, gaming, fandom and food remain to be investigated. Their legal and ethical implications, their contribution to social relations, notions of embodiment, sensory experiences and knowledges and to people's understandings of personal data are some intriguing possibilities for further investigation.

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