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Anticipated environmental sustainability of personal fabrication

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ABSTRACT

Distributed manufacturing is rapidly proliferating to citizen level via the use of digital fabrication equipment, especially in dedicated “makerspaces”. The sustainability benefits of citizens' personal fabrication are commonly endorsed. However, to assess how these maker practitioners actually deal with environmental issues, these practitioners and their practices need to be studied. Moreover research on the environmental issues in personal fabrication is nascent despite the common perception that the digital technologies can become disruptive. The present paper is the first to report on how practitioners assess the environmental sustainability of future practices in this rapidly changing field. It does so through an envisioning workshop with leading-edge makers. The findings show that these makers are well able to envision the future of their field. Roughly 25% of the issues covered had clear environmental implications. Within these, issues of energy use, recycling, reusing and reducing materials were covered widely by environmentally-oriented participants. In contrast, issues related to emerging technologies, materials and practices were covered by other participants, but their environmental implications remained unaddressed. The authors concluded there is a gap between different maker subcultures in their sustainability orientations and competences. Further research on the environmental aspects of real-life maker practices and personal fabrication technologies now could help avert negative impacts later, as the maker phenomenon spreads. This knowledge should also be directed to developing targeted environmental guidelines and solutions for personal fabrication users, which are currently lacking. Potential also lies in seeking to enhance dialogue between pro-environmental and new-technology-oriented practitioners through shared spaces, workshops and conferences.

1. Introduction

Certain groups of end-users, often called “makers”, are increasingly involved in the design and production of their own products (Raasch and von Hippel, 2012; Anderson, 2012). This transition is enabled by greater access to digital manufacturing technologies at home, through services or in dedicated spaces (i.e. “makerspaces”). Such access is regarded by many as a disruptive alternative to mass production and consumption through material “peer production” (Benkler, 2006; Bauwens et al., 2012) or “personal fabrication” (Gershenfeld, 2005). There are potential environmental benefits, and harms, to distributing production in this way, but these have been little studied to date (Kohtala, in press).

If these personal fabrication practices diffuse into wider society, it is important to clarify the direct environmental impacts of technologies and materials, but also their indirect effects on society and consumption patterns. For instance, the “maker movement” is often promoted as more environmentally benign than mass production, by enhancing skills to build and repair, answering one's own needs as opposed to “satisficing” through passive consumption, and distributing production within local networks as opposed to long, large-volume supply chains (Diegel et al., 2010; Niinimäki and Hassi, 2011; van Abel et al., 2011). How maker practitioners organise their activities may provide a leverage point for more sustainable practices, depending on the makers' own knowledge of environmental impacts and how they enact sustainability-oriented values.

These hypotheses about the current and future sustainability of making are, however, currently based on limited scientific evidence, and maker practitioners tackle these questions of environmental sustainability based on their professional skills. This raises the question of maker practitioners' knowledge: how wide and

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deep is their own awareness of the environmental implications of making, and do they operationalise it in their current practices as well as planning for future activities?

The authors have earlier investigated these topics through long-term ethnographic research, examining the daily practices of setting up new makerspaces and organising and conducting making activities. This appears helpful in discerning the gaps between actors' pro-environmental attitudes and their concrete practices (e.g. Kohtala and Bosqué, 2014). However, making is a rapidly changing phenomenon where environmental implications may change and evolve as new technologies and interests emerge. The research question in the present paper is therefore:

What issues do competent maker practitioners foresee in the environmental sustainability of near future makerspaces?

To assess this, a workshop was organised with leading-edge practitioners in Finland. It was designed carefully so the practitioners were working on a real project, but also to offer a clear view on if and how they would consider issues related to the environmental sustainability of makerspaces in 2020. The year 2020 was a target date close enough for the practitioners to voice reasoned propositions about, but also far enough in the future to push them to envision likely future developments in this rapidly changing field and indicate any related environmental effects. The reasoning behind the workshop structure and its context is explained in section 3, as well as the methods for analysing the results. The findings and their implications are summarised in sections 4–6. Section 2 provides more background on the maker movement and personal fabrication, with special emphasis on shared makerspaces and the knowledge on sustainability issues to date.

2. Background

Although “making” builds on a tradition of handicraft and “DIY” (do-it-yourself), it today also includes (and more commonly refers to) use of digital tools in hands-on fabrication of material artefacts, including electronics and physical computing experiments, stickers and marketing items for small businesses, furniture and items for the home or body, and prototypes of all kinds. Shared makerspaces are workshops with low-cost digital fabrication equipment, typically milling machines for making circuits or casting moulds (using wood, silicon, wax and plaster); vinyl cutters; desktop 3D printers (typically using ABS and PLA plastics); laser cutters (for usually plywood, cardboard and acrylic); and often electronics workstations for microprocessor programming and project prototyping.[1] Product designs (often shared digitally) are realised by the users themselves and, due to their digital form, can be designed together with peers in other locations.

Makerspaces include fab labs, which are workshops in MIT Center for Bits and Atom's network (Gershenfeld, 2005); hacklabs or hackerspaces for exploring electronics (Maxigas, 2012); commercial machine shops offering paid access to members; and a variety of other spaces that may be independent or associated with a library or museum, typically having less of the heaviest equipment such as large CNC machines (Troxler, 2011). The number of makerspaces worldwide is growing rapidly: to date there are over 450 fab labs and 1000 active hackerspaces (FabLabs, 2015; HackerspaceWiki, 2015), listings that do not account for independent spaces. There is currently scant research on who uses makerspaces and how exactly (e.g. Ghalim, 2013; Maldini, 2013), but the practitioner view is that there is considerable variation, from students in university fab labs to entrepreneurs to hobbyists who dominate hackerspace-type facilities (e.g. Eychenne, 2012; Toombs et al., 2014).

Reports on the sustainability of personal fabrication are emerging as the phenomenon spreads, often appearing as grey literature (De Decker, 2014; Olson, 2013). The few empirical studies that exist mainly focus on additive manufacturing, relevant to some digital fabrication equipment, such as studies on energy consumption and Life Cycle Analyses (e.g. Baumers et al., 2013; Faludi et al., 2015). When compared to mass production processes, digital manufacturing has the potential to reduce material, waste and energy, at least for small batches (ATKINS Project, 2007), and may mitigate negative impacts connected to supply chains (Huang et al., 2013). However toxicity of especially additive manufacturing materials remains a concern (Drizo and Pegna, 2006; Short et al., 2015), as well as the high energy consumption of digital fabrication.

In addition new DIY strands are exploring areas such as citizen science and urban agriculture, activities conducted in their own communities and spaces or included in the repertoire of already established makerspaces (Tocchetti, 2012). The environmental and human impacts of Do-It-Yourself Biology (“DIYbio”, “biohacking” or “DIY-pharma”) (Delfanti, 2013) are as yet unknown, but these practices are increasing in uptake and variety.

These environmental issues are summarised in Fig. 1. Given all these uncertainties, affecting how personal fabrication develops from early on appears preferable to simply having to face whatever negative impacts materialise later.

3. Data and methods

The data for this study were drawn from a collaborative design experiment where thirteen leading Finnish maker experts were recruited to elaborate the future of makerspaces for the year 2020. The stakes of the workshop were real: the host was Helsinki library services, who will build a public makerspace for its flagship city centre library that will open its doors in 2018, as well as a small-scale pilot space that opened a few months after the workshop. The local maker communities would be among the prime users of such facilities.

The workshop was designed to combine elements from lead user workshops (Herstatt and von Hippel, 1992; Churchill et al., 2009) and participatory design (Greenbaum and Kyng, 1991; Bødker et al., 2004; Hyysalo et al., 2014). Both the library personnel and the researchers sought practical information about future makerspaces but also raised discussion on sustainability, which was then highlighted in further analysis.

Similar futuring exercises have been conducted using, for example, participatory backcasting (Mont et al., 2014). Stakeholder collaboration was also seen as integral to learning and transition in urban transformation processes (McCormick et al., 2013). Furthermore peer-to-peer making practices are among the “grassroots innovations” that are rarely included in foresight exercises and innovation programmes but would have much to contribute (Smith et al., 2014; Hyysalo et al., 2013a,b, 2014).

The desired participants were identified by first listing the relevant maker communities, sectors and fields of expertise that would provide a diverse set of perspectives on the present and future of personal fabrication and makerspaces. The sectors, commercial, academic, third sector and local authorities, were further sub-divided into fields such as ICT, engineering, digital fabrication, “hacking”, “crafts” and “support organisations”. Both organisations and individuals were identified in the authors' contact networks (having been embedded in the Finnish maker scene for several years), in discussion with the library personnel and through snowball sampling. This resulted in a list of 32 individuals, many of

[1] For MIT's recommended Fab Lab inventory list, see Fab Foundation (2015).