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Social Innovation, Democracy and Makerspaces

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Social Innovation, Democracy and Makerspaces

Adrian Smith[1]

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Abstract

Social innovation requires a transformation in innovation practices. These transformations should be democratic. At least that is the argument in this paper. Makerspaces are studied as potential sites for democratising innovation activity. Makerspaces are community-based workshops where people access the tools, skills and collaborators to design and make almost anything they wish. The tools available include technologies for digital design and fabrication, and which permit collaboration between participants in different workshops via online platforms and social networks. Makerspaces are also networked spaces for reflection and debate over design and making in society. But they are many other things too, including a place for personal recreation, entrepreneurship, and education - features of increasing interest to institutions. Makerspaces are pulled and pushed in different directions. An open innovation agenda seeks to insert makerspace creativity into global manufacturing circuits under business as usual. Others see in makerspaces an inchoate infrastructure for a commons-based, sustainable and redistributed manufacturing economy. Activists anticipate more democratic relations in material culture and political economy. Makerspaces are thus socially innovative and not socially innovative at the same time: a site of struggle over issues of profound social significance, and hence an example of innovation democracy in action.

Key words: Social innovation; democracy; makerspaces; digital fabrication; commons; critical theory; technology

1: Introduction

The dominant image (and practice) of innovation focuses upon rent-seeking, technology-based firms working with research institutes and investors, aided by a policy environment that facilitates systemic interaction between these institutions in the pursuit of economic growth (Martin, 2016; OECD, 2010). Yet innovation can and does arise in other settings, and can involve unusual combinations of people and technologies in pursuit of different goals. The global undercurrent of grassroots innovation for sustainable development is an example (Smith, Fressoli, Abrol, Arond, & Ely, 2017). The social innovation agenda is another example (Moulaert, MacCallum, Mehmood, & Hamdouch, 2013). Beneath the dominant image, innovation actually comes in a plurality of specific forms and arises in a diversity of spaces for a variety of purposes.

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Generally speaking, innovation is the capacity of people to exploit a new idea or method successfully and thereby realise a desired material and social effect. Innovation can involve the development of novel technologies, processes, organisations, and services (Freeman, 1991). The consequences of this innovative activity – intended and unintended - can entrain incremental, radical or transformational changes in social life.

Social innovation is often defined broadly, to mean novel developments in social practices and organization whose principal motivation is improving human welfare directly (as opposed to welfare improvements arising as a secondary consequence of innovations motivated by profit seeking) (van der Have & Rubalcaba, 2016). Social innovations can rely on technologies and other artefacts, such as ICTs for coordination, and indeed lead to novel adaptations and developments in technology. The social innovation agenda aims to redirect innovation capacity towards goals of social development. Does this agenda make sense? Historical experience suggests interventions for social development work best and endure longest when they build upon processes of citizen participation, open deliberation and sensitive community development (Fals-Borda & Rahman, 1991; Rist, 2011; World Commission on Environment and Development, 1987). Participation, openness and community are not characteristics typically associated with innovation (Chesbrough, 2006; von Hippel, 2005). Historically, innovators have rarely included citizens directly; at least, not until marketing their product to customers, or transferring the technology to recipients of aid (Chilvers & Kearnes, 2016; Rahnema & Bawtree, 1991). Innovation as conventionally conceived is ill-equipped for social development.

So, the social innovation challenge is more complicated and challenging than 'simply' redirecting conventional innovation capabilities to social goals. Social innovation implies reinventing innovation itself: transforming dominant concepts and practices so that participation, deliberation and community become central. As the next section will make apparent, these transformational aspirations provide an opportunity to recognize and reflect upon the inherently normative and hence political characteristics of innovation. One response is to seek a more democratic innovation. At least, that is the argument motivating this paper.

The paper goes on to introduce makerspaces as a site of activity relevant to transformational social innovation. Makerspaces are community-based workshops where people can access tools and skills for designing and making things, and where participation, community and reflection towards technology-based practices is valued and encouraged. It is a combination that makes makerspaces relevant to the themes introduced above: makerspaces lower barriers and open spaces for novel forms of socially innovative activity. Admittedly, much makerspace participation is motivated by personal projects and doing cool things. Activities frequently involve people experimenting and exploring technologies in playful ways. There are nevertheless some activities in makerspaces interested in their social possibilities. And institutions for social and economic development are also beginning to take a serious interest. Moreover, the capabilities and dispositions cultivated even through personal projects may nevertheless generate awareness of social implications, and can be carried through to other areas of social life and attain wider significance for social development. So, the hypothesis tested here is that makerspace activity can facilitate participation, openness and community in ways absent in conventional innovation systems and relevant for innovation democracy. As will become apparent in the analysis, there is evidence for this, but also evidence of contradictions and limitations in makerspaces that provide critical lessons instructive for social innovation.

The next section turns to theory in the politics of innovation in order to situate social innovation alongside a concern for democracy, and which it is argued must be a normative commitment underpinning the transformation of innovation. Section three introduces makerspaces and describes their development. That experience is discussed in section four in light of the concerns motivating the paper. Section five draws conclusions from the makerspace experience for social innovation more generally.

2: Social innovation and innovation democracy

The term social innovation joins a bewildering lexicon of adjectives and adverbs[2] signifying different aspirations for innovation in society. Alongside social innovation, for example, sit ideas for inclusive innovation, frugal innovation, sustainable innovation, citizen innovation, informal innovation and grassroots innovation. Historically too, there have been aspirations for appropriate technology, intermediate technology, liberatory technology, alternative technology, and social technology (Bookchin, 1967; Dagnino, 2009; Schumacher, 1973; Smith, Fressoli, & Thomas, 2013). Some of these older terms had considerable mobilizing power in their day, just as social innovation does today. Appropriate technology, for example, mobilized support and investments for dedicated centres, courses, programmes and businesses (Kaplinsky, 2011).[3] All these terms signify attempts to break from dominant innovation practices, usually because any human welfare benefits of the latter are considered to be eclipsed by inextricably harmful social consequences, such exacerbated inequalities, disrupted livelihoods, degraded environments, and heightened war and oppression.

The philosopher of technology Andrew Feenberg writes that, '[t]echnology is power in many societies, a greater power in many domains than the political system itself' (Feenberg, 1999: 131). The design, development and control of technologies can be key in determining patterns of social development. We can think of the influence of innovations over urban growth; or the kinds of energy systems powering societies; or the production and consumption of food; or forms and scales of manufacturing, and the kinds of labour required; the way we inhabit households; how we move about; and so on, and so forth. So, for example, the car, and all the attendant infrastructure for personalised automobility, shapes the way cities develop and interconnect, with implications for how and where many of us work, live, shop and play, as well as becoming a cultural symbol for those ways of living and a focus for reproducing political and economic privileges. These intimately interconnected social and technological developments beg questions concerning their consequences for peoples' lives and the kinds of society enabled and embodied through our technologies. However, we need to take care here to avoid becoming technologically deterministic. These technologies do not simply appear and then impact upon society. Technologies and their consequences result from a multitude of social choices and social forces that shape the way a new technique – be it physical, material,

[2] Adjectives if we think of innovation as a noun, and adverbs if we think of innovation as a verb. Innovation is simultaneously noun and verb and refers to both things and actions.

[3] A 1979 survey by the OECD Development Centre identified 388 organisations from 79 countries active in appropriate technology (Jequier, 1979). The Centre listed over 1000 organisations in 90 countries in 1984 (Jequier & Blanc, 1984). Just Faaland, President of the Centre, wrote how appropriate technology 'was no longer the preserve of small marginal groups but had become a major pre-occupation of national science and technology policy institutions, governmental research centres and private industrial firms' (Jequier & Blanc, 1984; quoted in Smith, Fressoli, & Thomas, 2013). Today, the European Union has policy programmes for social innovation, as do national governments, including Colombia and other countries in Latin America.

biological or computational - is understood, developed, appropriated and used. Ultimately, technologies are socially constructed (Bijker & Law, 1992).

If, as Andrew Feenberg claims, the social development of technologies constitutes societies in ways akin to legislation in the political system, then who writes the rules for innovation systems? Feenberg argues the overriding interest shaping and directing innovation is the accumulation imperative in capitalism. Put critically, firms become interested in inclusive innovation for the purposes of opening markets at the 'bottom of the pyramid', and entrepreneurial states promote sustainable innovation because they want profitable 'green tech' sectors within their political economies. Social innovation, according to this perspective, opens to private enterprising opportunity the perennial aspiration for social wellbeing. Such criticism is too sweeping. But there is no denying that dominant visions, values and interests in society encroach upon alternative innovation agendas and activities (Smith, 2007). And, since innovation is socially constructed, these moves can also be contested and pushed back by groups whose values and priorities differ (Hard, 1993). There is nothing automatic about automation, for example, nor is there anything neutral about low carbon technologies - both bear the imprint of their developers and the culture giving rise to their use.

These negotiations and struggles in innovation do not occur amongst equals (Herrera, 1971). A highly uneven terrain structures who has a say, and which values dominate (Mokyr, 1990). The terrain is shaped through the forms of knowledge privileged in society, the terms of access to capital, the availability of infrastructure for prototyping, the ability to influence the forces that shape markets, the cultural channels forming aesthetic sensibilities, the education institutions that socialize and train us, and so forth. Transformative innovations do not fit smoothly into these cultural and social contours - otherwise the activity would conform to those conditions and hence could hardly qualify as transformative. The transformational potential of innovations, and hence the work needed to disrupt the status quo, will vary depending upon how radical are the adaptive changes required in the social terrain in order to accommodate and capitalize upon the innovation.

Taking Feenberg's analogy with political systems further, might innovation systems similarly be susceptible to democratic struggles? Innovation is always open to debate, as genetic modification, nuclear energy, automobility, fossil fuels, large-scale dams, industrial agriculture, automation, and so on and so forth all illustrate (Rip, 1986). Techniques exist for public participation in these controversies and that try to help policymakers adjudicate or smooth scientific and technology development (Chilvers & Kearnes, 2016). The tendency is nevertheless to approach innovation as if it were apolitical. Methods for public participation are implemented too often as technical exercises seeking appraisal, consent and market facilitation. Moreover, their use is patchy and far from routine. Only rarely are methods used to open up innovation systems for accountability, critique, or creative political scrutiny.

Can the processes be opened further to more direct democratic participation and deliberation within innovation systems themselves? Arguably, the longstanding proliferation of terms like appropriate, social, inclusive, and grassroots expresses that democratizing aspiration. It is tempting to define each term and develop typologies more sharply. Yet the most important thing to recognize is the underlying normative values and therefore the politics inherent to innovation (Herrera, 1973; Smith & Arora, 2015). One way of permitting improved expression, contestation and deliberation over visions, values and outcomes is for innovation itself to become more democratic (Stirling, 2014). A democratic aspiration for social innovation could

be, theoretically: improving in any way, access by the least powerful people, to the capacities for challenging power in innovation (Smith & Stirling, 2016).

Arguably, democratic capabilities are able to open innovation up to scrutiny, debate and shaping by values of social justice and environmental sustainability. The key issue here, from a democratic point of view, is to interrogate the conditions that, 'create a separation of technology and sociality that makes us feel determined by a technology as if it were an "outside" factor' (Jordan, 2015: 46). Democracy is crucial in this, because it brings the social back into technology (Sclove, 1995). A concern for democracy helps subject the social choices involved in innovation to more effective public deliberation (Vessuri, 2003).

With these theoretical points in mind, we can think of makerspaces as a potentially radical social innovation that is redistributing access and power in innovation in society. Makerspaces are making it easier for more groups to access versatile design and fabrication technologies. As a result, a greater diversity of knowledges and values can be brought into workshop activities and projects can contribute to new kinds of material culture in societies. So, are we witnessing a new space opening up for negotiating innovation? Given the uneven terrain into which makerspaces are emerging, and the contestations involved in innovation, there will inevitably be uncertainty, ambiguity and ambivalence over the outcomes. What kinds of social innovation might makerspaces give rise to, or not; how might makerspaces be involved in democratizing innovation, and what might be their potential and their limitations?

3: Makerspaces: tools, skills, community, reflection

Makerspaces are not beacons of innovation democracy. But makerspaces do present a site where participation, deliberation and new communities in technology development are opening up. Therefore, they may be instructive for innovation democracy and transformative social innovation. Makerspaces are community-based workshops that enable people to access technologies and cultivate skills for design and fabrication, and to make things for themselves or with others in self-directed projects. As such, makerspaces are opening up design, prototyping and innovation to wider, non-professional participation. And as we shall see, in doing this makerspaces enable people to form communities capable of reflecting upon the social significance of their activity (Davies, 2017).

The evidence and analysis presented in this paper was built up through a combination of literature review (Hielscher & Smith, 2014), research projects, visits, consulting work, and presentations and discussion at research events (e.g. organisation of a conference session at 4S/EASST in 2016) and practitioner events (e.g. with the Maker Assembly in the UK). Interviews, visits and discussions were undertaken with organisers at twenty-six makerspaces in the Netherlands, Chile, Spain, UK, Argentina, Colombia, Germany, Denmark, Finland, and India. In three cases, visits included participation in making activity, but in all other cases interaction was limited to discussion and observation. Each makerspace represents nothing but itself. Taken together however, and acknowledging that coverage is patchy, these methods nevertheless bring into dialogue a diversity of makerspace types, histories, experiences and purposes appropriate to the research aims in this paper.

Evidence was additionally gathered through participant observation at gatherings of workshop organisers and participants. These have included the Fab10 international gathering of FabLabs in Barcelona in 2014, EMF Wave in London in 2013, Maker Assembly in London in 2016, three mini MakerFaires in Brighton, and a meeting of members of the FabLab Latin America

network in Buenos Aires in 2015. Online fora, videos, and platforms were also consulted in the research.

Workshop events were organised by the author that brought together makers and researchers with the aim to discuss, reflect and create insights into developments in makerspaces. These were held at the Living Knowledge network meeting in Copenhagen, at the Machines Room makerspace in London, and at the Science Museum in London.

The empirical material gathered, which consists of interview transcripts, documents, literature review, activity flipcharts, presentations, observational notes from makerspaces, and making experience, has been organised, interpreted and analysed in order to answer the hypothesis motivating this paper: how makerspaces may or may not facilitate participation, openness and community in (social) innovation.

3.1 Makerspace definitions

Typically, a makerspace is equipped with small-scale versions of highly versatile, digitally-enabled design and fabrication tools developed originally for rapid prototyping in industry, as well as providing more traditional hand tools associated with various crafts. So, for example, your local makerspace in Madrid, Medellín or Manilla might be equipped with 3D printers, a large router, a laser cutter, milling machines, drills, lathes, microelectronics stations, sewing machines, traditional hand tools, and even, in some cases, a bio-hacking lab. Participants in these spaces learn by doing and swap skills with one another. Some makerspaces also run training courses for members and the wider public.

Some makerspaces call themselves hackerspaces, and connect to a tradition of workshops that goes back to hacker communities and autonomous movements in the 1990s and earlier (Maxigas, 2012). A more formalized network of workshops adopts the label FabLabs. FabLabs span out of a community outreach programme at the Massachusetts Institute of Technology in the USA in the 2000s (Gershenfeld, 2005). FabLabs emulated the spirit of informal ‘skunk works’ in universities, where students and staff played with ‘cool’ technology projects outside their institutional duties. FabLabs took this activity off campus, to communities in the USA and internationally. The idea soon took on a life of its own as groups and institutions began opening FabLabs independently of MIT, including grassroots workshops (Troxler, 2014). There are other kinds of makerspace too, such as Tech Shops in the USA, and which are subscription-oriented workshops where users have to join as members, but which are owned by enterprises. Co-working space owners can sometimes similarly provide prototyping facilities to residents. Other workshops call themselves makerspaces and remain member-based though non-profit, and like hackerspaces and many FabLabs will have open days and a community-orientation. The milieu of community-based shared-machine workshops is complicated and dynamic. In this paper ‘makerspace’ is used as an umbrella term to include the other labelled workshops – which will annoy some hackers and some fabbers – but which is adopted here for convenience. The discussion below recognizes the diversity of purposes within community-based shared-machine workshops, and which the various labels signify.

Since the turn of the century there has been rapid growth in makerspaces globally. In February 2017, the fablabs.io website listed 1092 FabLabs in 116 countries, while the hackerspaces.org website listed 1336 active hackerspaces in 43 countries. Whilst there is local variation between all these makerspaces, there are also strong family resemblances. At heart, all of them share a commitment to ‘tools for people’. Makerspaces also constitute particularly visible and focal

nodes for a wider ‘maker movement’ of amateur users, freelance designers, social entrepreneurs, and technology activists involved in design and fabrication (Davies, 2017). Makerspace networks provide a platform for people to experiment with increasingly accessible digital design and fabrication technologies (Cardoso, 2010).

3.2: Makerspace possibilities

Two features differentiate makerspace activity from earlier waves of ‘tools for people’, such as movements for appropriate technology and socially useful production (Smith, 2014; Smith et al., 2017). First, participants can themselves make new technologies from the tools available, as evident in various open hardware networks. The ability of participants to build (cf. use) environmental sensor networks, say, or 3D printer tools, and so on, indicate technological capabilities that are incredibly versatile, recombinant and adaptable towards local circumstances. Second, digital features in the tools opens the possibility for wider collaboration and communication between groups at a distance, by sharing and coordinating globally across social media platforms. Influenced by free/libre cultures in software, open collaboration is a significant ethical commitment in makerspaces, even amounting to a political programme for more radical hackerpaces (Walter-Herrman & Büching, 2013).

Sharing the same tools and networking digitally means that, in principle, a prototype designed in one makerspaces can be made, adapted and improved in any other makerspace anywhere. FabLabs in particular are supposed to carry a specified suite of technologies precisely for that purpose. There exist, for example, networked collaborations in the development of low cost prosthetics, citizen environmental monitoring networks, civic furniture for reclaiming public places, housing initiatives, and many others. Sometimes these are self-organised through makerspace initiative, but on other occasions they have been initiated and/or sponsored by institutions.

Participants in makersapces collaborate freely in the design and fabrication of an impressive variety of objects, from environmental and energy monitoring equipment, to furniture; from human prosthetics, to sports equipment; from bicycles, to eco-houses; from wind turbines, to beehives; and all sort of things in between. Whilst many participants are involved for the personal fulfilment of making things, and sharing that enjoyment with others, some participants use makerspaces to pursue entrepreneurial activities, educational projects and socially-oriented innovation. In collaborating in these activities and documenting them openly, a platform infrastructure for knowledge and skills is emerging. Designs, instructions, and guides are shared over platforms like Instructables (supported by industrial CAD firm Autodesk – see later). At the same time, other social media sites provide a forum for discussing the meaning and social significance of this activity, such as the discussion lists on hackerspaces.org, and to what extent makerspaces contribute variously to new material cultures, manufacturing practices, and political economies in design, prototyping and making.

Online fora are an important source of advice, instruction and discussion in acquiring design and making capabilities. Videos posted online permit instruction in some of the more tacit and embodied forms of knowledge (Wood, Rust, & Horne, 2009); whilst residual requirements to learn and practice alongside more proficient makers is facilitated through physical proximity in the local workshop space. So, people learn from one another by working side-by-side, as well as consulting online. The most organised training programme is run by the Fab Academy, which has developed since 2009 under the Fab Foundation at MIT through course fees and industrial sponsorship. Participants attend a local FabLab and learn with participants at other

FabLabs globally through online courses, meet-ups, and shared projects, and that involve use of the local FabLab. Alumni have opened FabLabs in turn, and advocate for the community. Beyond the formalities of FabLabs, members of other kinds of makerspaces habitually visit other workshops – there is a culture of dropping into the local makerspace when visiting another town (hackerspaces even had a passport system at one point) - and there are national and international festivals where people gather to swap skills and share enthusiasms.

Platforms, events and meet ups also provide mutual help in opening, running and maintaining a makerspace. Chaos Computer Club conferences in Germany and similar events in the Netherlands were of formative importance in Europe, for example. A design guide for creating hackerspaces emerged from this milieu and was posted online by hackers in Germany in 2007, and which in turn inspired hackerspaces to open in the USA, and thence globally. Discussion lists debate a plethora of issues and share technical insights. Events include debates about the social significance and potential of makerspaces, and videos of presentations are posted online, such as makerassembly.org in the UK.

Outreach activities are another way that knowledge, enthusiasm and reflection about the possibilities of participatory design and fabrication is propagated. Outreach can involve open days or stalls organised by makerspaces at public events, such as science fairs and Maker Faires. Or collaborations with other organisations involve makerspaces in running themed workshops and problem-solving hackathons.

Unsurprisingly, given the dynamism and possibilities that makerspaces offer, they are attracting mounting institutional attention. Schools, universities, and other education and training institutions have become interested. Makerspaces opening in universities and in schools are used as a way for more open-ended, hands-on and collaborative learning experiences in technology, design, and prototyping. Public authorities have also become interested in makerspaces, and municipalities in Barcelona, São Paulo and elsewhere have opened public workshops in their cities. The Chinese government is opening makerspaces as part of its policy for mass innovation, and Iceland too has instigated a national programme. Public workshops are seen as contributing to a 21st century infrastructure for citizens analogous to libraries in an earlier era (Smith, 2015). Indeed, makerspaces are opening in libraries too (Hyysalo et al., 2014). The intent is that these public facilities - with courses, events and workshops for families, start-ups, and social innovation - will equip citizens with the knowledge and skills to benefit from the 'fourth industrial revolution'. Museums and art galleries have also become interested in the way workshops present new ways to explore material culture.

In other cases, public agencies with remits to promote innovation and local economic development are investing in makerspace potential for design, prototyping and manufacturing capacities and skills. Exchanges and events have been funded by bodies like the British Council that connect makers with manufacturing centres like Shenzhen, and with a view to helping entrepreneurial makers step up into production. Farsighted firms have similarly become interested in the creative and innovative possibilities of makerspaces – with some companies opening in-house facilities and inviting visiting residencies (e.g. Autodesk's Pier 9 in San Fransisco), whilst others donate versions of their computer-aided design packages to makerspaces, particularly through the FabLab network, or school-supported makerspaces. Technology providers, such as some 3D printing businesses, are exploring how community-based platforms can be tapped into as both a source of innovative design ideas, and a market for their business services (e.g. MakerBot supports the Thingiverse platform and Autodesk are

behind Instructables). Firms are adopting increasingly open innovation approaches towards makerspaces, and which simultaneously serve to familiarize maker clients with their commercial packages and technologies.

More generally, makerspaces have been swept into the swirl of interest in globally-connected place-based innovation spaces for people to meet, collaborate, and be creative together in ostensibly horizontal, open and challenge-led ways (e.g. Living Labs). It is a wave propelled by a celebration of entrepreneurship and individual initiative, whilst often inattentive to any associated downsides, such as new forms of exploitation and precariousness (see later). Inevitably, institutional designs and agendas towards makerspaces bring particular interests into play. Makerspaces risk being reduced to instruments for education, entrepreneurship and the cultivation of citizens conforming to the technological visions of public authorities. Countering this reduction in social innovation potential are partnerships organized explicitly for the purposes of social innovation and political action. Hackathons are initiated, for example, that select a social issue and invite participants to come and prototype solutions. The touring events associated with the Innovación Ciudadana network is an example. Institutional attention can clearly unlock more resources and confer a legitimizing status upon makerspaces but the associated agendas can also complicate matters. Some hackerspaces in particular are resistant to institutional encroachment.

3.3: Makerspace criticisms

Institutional developments in makerspaces have been a cause for reflection. Whilst some participants welcome the resources such attention brings, others are critical. Criticism derives from an issue pertinent to social innovations generally, which is the balance of power between, on the one hand, innovative activities pressing for transformations of institutions (e.g. into more socially just forms of institution), and on the other hand, existing institutions co-opting and diminishing the innovation to suit their current agendas.

One focus for criticism has been a perceived tendency for makerspaces, and institutional attention, to fixate on producing objects; and to naively see intractably complex and power-ridden social challenges as susceptible to prototyping and design solutions (Fonseca, 2015). It is a criticism also levelled at earlier movements like appropriate technology, and relevant to social innovation more widely today (Smith et al., 2013). The critical point to bear in mind is not that prototyping is invalidated, but rather to consider how prototyping has to be situated alongside strategies for transforming wider social structures into forms more conducive to the wide-scale development of the socially innovative prototype. Attention-grabbing initiatives like Open Source Ecology or POC21 (Proof of Concept), that develop objects of symbolic and practical significance for future sustainable societies, take a pragmatic approach and work with the opportunities available to them within these wider structural challenges (Smith et al., 2017). It is moot point, however, just how far crowd-funding, say, for the entrepreneurial development of, for example, open hardware solar power systems and recirculating water showers, addresses the root causes of energy and water unsustainability. Nevertheless, socially innovative approaches using open design and collaborative fabrication are demonstrated, and which can have a significance beyond the object to hand and inform wider-scale changes in social practice and structure (Smith et al., 2017). Moreover, socially useful products are created. And yet, it remains the case that the limits to social development based in innovation alone are also revealed.

Recognising these limits is another useful product of makerspace activity. Addressing any limitations can help pinpoint, say, the regulatory standards and market forces needed before wide-scale development and adoption of prototypes can be induced. In other words, in going against the grain, prototyping can perform an agit prop role and produce critical knowledge that is itself socially useful (Agre, 1997; Cooley, 1987). Sharper criticisms arise when prototyping initiatives lose sight of these structural challenges (Hertz, 2012a; Morozov, 2014; Ratto & Boler, 2014). However, responsibilities for social development cannot be loaded onto design and prototyping in makerspaces alone, and care has to be taken not to disempower laudable initiatives with unwarranted expectations (cf Cohen, 2016). Prototyping object solutions helpfully makes very visible and practical the challenges of institutional reforms and structural change. Strategies for mobilizing alliances and advancing political programmes for structural change might be built around such emblematic social innovation – but which require repertoires of social action beyond innovation.

Another focus for criticism is growth in marketing to makerspaces and the 'maker movement' (Dougherty, 2012). Most significant here has been the launch of Make magazine in 2005, and the growth in popularity of Maker Faires globally. The latter began in the Bay Area of the USA in 2006, spread across the country, and have since grown internationally. Since 2014, 14 official Maker Faires have been held in cities including Rome, Oslo, Shenzhen, and Tokyo, but also 119 independently-produced 'mini' Maker Faires internationally. Promoted originally by IT media firm O'Reilly, and now a subsidiary business called Maker Media, the 'maker movement' brand sells kits, tools, and events to makers. Cast in this light, makerspaces become showrooms for suppliers of all sorts of consumer tools, materials, kits and activity that amounts to little more than a new form of consumerism (Cohen, 2016; Fonseca, 2015; Hertz, 2012b).

Disappointed by such marketing are those makers, social innovators and activists with ideas and aspirations for makerspaces to constitute a post-consumerist site for sustainable production and consumption (Schor, 2010; Thorpe, 2012). These activists look to makerspaces as becoming a convivial space for fixing, hacking, and remanufacturing, and pioneering a sustainable and frugal material culture (Kohtala, 2016). Makerspaces are conceived as sites for disrupting existing institutions of production and consumption, and for creating the critical knowledge and alliances for those broader changes. Running against this social development aspiration, the marketisaton of makerspaces risks instead contributing to the proliferation of personalized manufacture and intensified consumption. The self-production of apparently frivolous artefacts - like the 3D-printed plastic Yoda heads and other 'crapjects' notoriously cluttering the shelves and recycling bins of makerspaces – may induct participants into additive manufacture, but does little to raise awareness about sustainability. Hacker concerns for technological sovereignty and the right and ability for citizens to open up and control technology is partly facilitated by such activity, which starts with where many people are at now in consumer societies, but trying to move participants towards sustainable development questions remains challenging in the face of makerspace marketisation. Much depends upon how makerspaces are organized and oriented. 'Remakeries' are opening, for example, where a sustainable development ethos is central, and ideas, designs and practices for upcycling, remanufacture, fixing and repair are demonstrated and promoted as defining the space and participation.

Criticism extends further to those makerspace organisations receiving sponsorship and assistance from corporations and government agencies with dubious records of social responsibility. To the chagrin of some makers, the Fab Foundation welcomed assistance from Exxon, and Make magazine partnered with DARPA, both in order to expand makerspaces into

schools and education. In the eyes of critics, such associations ought to be anathema to hacking, making and fixing because the partnerships legitimize the unsustainable and violent application of technological ingenuity (Finley, 2012). Hacker visions and values for autonomous social innovation and critical involvement in open technology is instead co-opted by an agenda to educate, train and entertain people, and where the fear is that it reinforces compliance with conventional innovation agendas. Responses to this criticism point to the mainstreaming of makerspaces and the wider reach facilitated by these partnerships, but gloss over the asymmetric power relations between 'partners'. In terms of innovation democracy, the critical question becomes the conditions under which makerspace participants can really challenge, and even reshape, the agendas of sponsors and partners.

Concerns about co-option link to criticism over new forms of exploitation in maker-related design and fabrication platforms. This criticism is an extension of the 'free labour' argument levelled at content creation and data provision over the Internet (Scholz, 2013). The accusation is that capital and manufacturers are encroaching upon the free/open design platforms emerging from makerspaces (Maxigas & Troxler, 2014). There are various business models being innovated. All involve makers submitting their prototypes to platform owners, who decide, sometimes with recommendations from a community of platform users, which designs merit investment for larger-scale production. The selected prototypes are developed by platform owners into consumer goods. Prototype designers receive a fee or share in any sales. However, the platforms (Quirky is an example) require prototype content to be submitted and involve up-front development and labour without pay. Innovation prizes and hackathons involve similarly precarious relationships, which critics argue is an exploitative labour process (Gregg, 2015; Soderberg, 2012).

Exacerbating the sense of injustice are contradictions with the open ethos of hacking and making. Makerspaces have, for example, been important sites for the RepRap 3D-printer project, and which has iterated through rapid evolution since 2005 thanks to the open development of both hardware and software (Söderberg, 2013). Developments in these entry-level printers proved so impressive that a group spinning-out of the New York Resistor hackspace controversially began marketing a proprietary version, known as the Makerbot. Aspects of their modified design were given intellectual property protections, breaking with the open ethos of the community. Their Makerbot business was subsequently bought for $400 million by industrial 3D printer manufacturer Stratosys in 2013. This 'enclosure' attracted considerable criticism from hackerspace communities because it was seen to contradict the radical roots of these workshops in free software and free culture movements (Maxigas, 2012). Isolating rewards to an appropriating agent or selective commercialisation fails to recognize (nor value and reinvest in) the wider social activity. The vital circulation and development of ideas through collective work is bracketed out of the picture.

In response to the injustices of such exploitation, has been renewed interest in cooperative models for pooling resources and producing goods and services. This 'platform cooperativism' is currently associated with Internet-enabled activities for the most part, but there is interest in how makerspaces and their networks might also adopt this socially innovative way of organizing activity (Kostakis & Bauwens, 2015; Scholz, 2016). Groups and initiatives are trying to develop social business models using ideas about peer-to-peer value, knowledge and design commons, and mutualist techniques of reciprocity (Quilley, Hawreliak, & Kish, 2016). Another response has been the public (state) funding of more open-ended makerspaces and justified under policies of general taxation and spending for social goods. Public makerspaces are conceived as municipally supported infrastructure for the public good, such as with

Medialab-Prado in Madrid, or as promoted with Ateneus de Fabricació Digital in Barcelona and FabLab Livre in São Paulo.

For many makers, however, the aspiration is not so radical – simply a convivial place to hack and make – and so the criticisms above appear irrelevant or unwarranted. More widely recognized are the social imbalances in many makerspaces. Demographic data on makerspace participants is hard to come by globally. A survey for Nesta in 2014 found 80 per cent of UK makerspace members were male, and a similarly high percentage had white ethnicity. An earlier survey of hackerspaces in Europe identified a similar demographic, and noted the high-levels of formal education amongst members (Moilanen, 2011). A survey of 73 FabLab managers in 2017 found a similar picture (Claude, 2017).[4] Obviously, these patterns of participation are from particular places and regions. Anecdotally, however, it is noticeable that makerspace organisers typically come from a cosmopolitan, educated and mobile milieu that enables relatively easy access and which can overlook the greater social distances others have to cross.

Social privileges and structures do not disappear at the doors of makerspaces. Feminist hackerspaces show how more inclusion can be brought about actively in makerspaces. The kinds of activity and project held up to be important culturally and displayed in the workshop and the layout and organization of the workshop are important. Sensitive and proactive community development that carefully and attentively connects makerspaces with excluded neighbours can also be effective, especially when the space is organized with an ethic of inclusivity and appropriate outreach activity (Dunbar-Hester, 2014; SSL Nagbot, 2016). FabLab Belfast has, for example, used makerspace activities to bridge community divides and histories of conflict in their city. Incite Focus in Detroit uses its FabLab as part of a broader programme of local economic empowerment for disadvantaged groups. Access Space in Sheffield uses arts funding to creatively engage the unemployed in technology and to reach out to disadvantaged groups in their city. Intriguingly, FabLab Lima has been running projects that try to bridge digital fabrication with traditional handicrafts like weaving. Makerspaces like these are a reminder that social skills in community development are vital for facilitating transformative social innovations: perhaps even more important than the default emphasis upon technical skills (Smith & Light, 2016).

4: Discussion

Given the theoretical points made earlier about the politics of innovation, perhaps we should not be surprised to find makerspaces reproducing dominant values and visions in society - especially where mainstream institutions for education and entrepreneurship exercise influence. Nevertheless, some activities in and around makerspaces point to transformational and democratic potential. It is a potential that some participants recognize and aspire to, but which sits uneasily with more conformist developments. When trying to do things differently makerspaces produce knowledge critical towards the dominant ways in which things are designed and made in society. Such critical knowledge is valuable when it helps generate constructive reflection and deliberation for more sophisticated transformation strategies. In that respect, the debates that makerspaces criticisms prompt, and the different visions and values they highlight, means makerspaces are already contributing to innovation democracy.

[4] 78 per cent were male, and 22 per cent female; 41 per cent were aged 25 to 34 and 32 per cent aged 35 to 44; 65 per cent were educated to Masters degree level or higher, with nearly all having a degree; and the majority had backgrounds in either technology, design or arts.

But we should not let such criticism, helpful as it is, eclipse the multitude of inspiring initiatives emerging in makerspaces. Makerspaces equip people to participate in projects that raise profound questions about the material culture and political economies of technology, design and making, as well as offering intriguing alternatives. Whilst much activity is focused upon the acquisition of tool-based skills and the prototyping of objects, many more things are being produced through these object-oriented practices. New actors and subjectivities are arising in design and fabrication, as people experiment with the tools available, and become makers, hackers, fixers, design entrepreneurs, and grassroots innovators. New relationships are forged between people and between people and things, as participants connect and prototype in new ways, and explore the possibilities for a more open and innovative interaction with the material world. Some of the makers moving into productive activity in manufacturing are seeking more open and co-operative business models, and are resisting conventional business practices. Others are exploring how globally-connected yet locally-rooted production capabilities might help kick-start more inclusive, locally-rooted, and sustainable remanufacturing economies, based in greater community involvement and repurposing the materials and goods available locally. Such a conceptualization of an 'open source circular economy' contrasts with the global-scale circulations of reprocessed materials envisaged by incumbent businesses and policy elites, and which present a different kind of (energy intensive) circular economy (Diez, 2012). As such, new concepts and agendas are being advanced through makerspaces, opening up technology to social development and where updated ideas for co-operative political economies based in commons-based peer-production can find material expression (Kostakis & Bauwens, 2015).

From an innovation democracy viewpoint, makerspace value comes precisely from this capacity to enable people to bring a variety of visions and values into material interventions in the world, and thereby generate new kinds of politics (Marres, 2012). Compared to professional design and fabrication institutions, makerspaces provide an open forum for exploring such activity from diverse viewpoints (Cardoso, 2010). With careful cultivation and support, makerspaces can contribute to an infrastructure for innovation democracy. Makerspaces can also seed a wider diversity of social and technical developments, through the myriad projects that people undertake. The variety of prototypes reported and shared online is testament to that. Such diversity enriches debate about the directions and purposes towards which technology development is put, which is a further important capability for innovation democracy. As such, it is through opening up material culture to wider deliberation and greater diversity that makerspaces can contribute democratizing capabilities and underpin transformative social innovation.

However, it is important to retain perspective. Makerspaces alone will not overturn dominant political economies of production and consumption. The notion that makerspaces prefigure a substitution for global manufacturing is fanciful and an inappropriate benchmark for appraising their potential (cf Anderson, 2012; Cohen, 2016). More reasonably, some practices developed in makerspaces will enter wider and influential use. It is a curious feature of makerspaces that they are alluring both to followers of conventional and transformational innovation agendas. Different interests take makerspace affordances for open prototyping in a variety of directions. Some interests see makerspaces facilitating design entrepreneurialism and kick-starter fabrication. There are programmes to better connect makers with manufacturing, and build capability for plugging into conventional manufacturing circuits. But at the same time, activists see in makerspaces an inchoate infrastructure for a commons-based, sustainable and inclusive design and manufacturing economy.

Institutions are important here because they can mobilise resources on the scale needed for connecting makerspaces to more widespread activity. Take, for example, an infrastructure for collecting, storing and processing discarded goods and materials, and that a local ecosystem of makerspaces could use for upcycling and local circular economies. Such an infrastructure could come about with greater facility through local government support, and by market and regulatory interventions globally that require design for disassembly, remanufacture and upcycling. Even if a rudimentary infrastructure could be generated by a network of makerspaces locally, an innovation system for really making a mark in local sustainable production and consumption is beyond makerspace agency. But the experience, knowledge and energy of sustainability makers would be a valuable input to institutional reforms that could make a bigger mark. Transformations along those lines will require radical reforms capable of shifting power in more profound ways than any seen to date. Makerspaces can and do provide practical, pre-figurative initiatives whose anticipation of new relations in material culture and political economy constitutes a challenge to business as usual. They have to contend makerspace initiatives that meanwhile plug into business-as-usual developments. Which makes makerspaces a site of struggle over profound issues material to social futures, and hence an example of innovation democracy in action.

5: Conclusions

This paper began with the argument that transformative social innovation cannot 'simply' redirect existing innovation capabilities towards issues of social concern, but needs instead to redefine, reconfigure, and redistribute innovation capabilities. Capabilities for participation, deliberation and community development need to become central. Drawing upon critical theory in technology studies, an argument was made that innovation democracy has to underpin these transformation capabilities. Experience in makerspaces to date verifies the complexity and struggle involved in bringing such transformations about. Makerspaces also underscore the limits to which transformations can be brought about through innovation activity alone.

As innovative spaces, makerspaces have a complicated history, and which shapes the way they are framed simultaneously as socially transformative, educationally useful, and entrepreneurially promising. Makerspace activities are being pulled and pushed in different directions. One direction arises from a cluster of activity around what can be called an *open innovation* agenda, and which is not transformative at all. The open innovation agenda simply wishes to insert makerspace creativity into global manufacturing circuits under business as usual – with some local drawing down of beneficial economic activity, but also compounding the unsustainable exploitation of people and planet inherent to that economic model.

Institutional moves towards an open innovation agenda fall short on the *innovation democracy* possibilities in makerspaces, and which hitherto has been carried furthest by the hacker and activist strands in makerspace histories. There are contradictions between these two kinds of makerspace future. Unwittingly, 'open innovation' institutional encroachments become an issue of debate that serves to mobilise further the continuing activism for 'innovation democracy' in makerspaces. Those concerned about questions of participation and purpose propel these struggles, pursuing projects and activities that explore issues of social inclusion, technology politics and sustainable developments.

In terms of the power relations between these contending pathways, then much depends upon the specific spaces and institutions under consideration. More humanities-oriented institutions

can and do support critical makerspace activity. Institutions committed to social development can do more to recognize and support the democratizing capacity in makerspaces. And, as always, it will remain with the rich and vibrant culture of activism to push for these transformations. It is therefore important to continually acknowledge the social value produced by activist communities. Transformative social innovation will only prevail if institutions are attentive to the ideas and practices of these communities, and when institutional resources are dedicated to innovation democracy in makerspaces, and elsewhere.

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