Cultivating sustainable developments with makerspaces

Cultivando desenvolvimento sustentável com espaços maker

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RESUMO

Em outubro de 2915, organizamos uma oficina para 80 pesquisadores e praticantes envolvidos em *makerspaces* na Europa. Nosso objetivo era explorar como os *makerspaces* podem fomentar desenvolvimento sustentável. Este artigo relata a discussão na oficina e idéias sobre este tópico, ilustrando o interesse no potencial deliberativo deste tipo de "laboratório cidadão". Interessante notar que, dada a ênfase nas práticas e ferramentas de muitos espaços maker, a discussão no nosso evento concentrou-se muito mais nas capacidades e habilidades de desenvolvimento comunitário na mobilização de alianças para conscientização social. A discussão problematizou dversos tipos de sustentabilidade, observando que ambições sociais e econômicas podem se alinhar com objetivos ambientais neste nível de atividade, mas nem sempre são desenhados para tal. No fundo, a oficina revelou a necessidade de estratégias contrárias às estruturas sociais vigentes que influenciam espaços *maker* ostensivamente "abertos", e portanto capacitam as ferramentas e capacidades disponíveis para desenvolvimentos mais sustentáveis.

Palavras-chave: Desenvovimento Sustentável; Desenvolvimento Comunitário; *Makerspaces*;

ABSTRACT

In October 2015, we convened a workshop for 80 researchers and practitioners involved in makerspaces in Europe. Our aim was to explore how makerspaces can help cultivate sustainable developments. This paper reports workshop discussion and ideas on the topic, and illustrates interest in the deliberative potential for this kind of 'citizen lab'. Interestingly, given the emphasis on tools and making practices in many makerspaces, discussion at our makerspace event focused much more on community development capabilities and skills for mobilising alliances for raising social awareness. Discussion problematized different kinds of sustainability, noting that social and economic ambitions can potentially align well with environmental goals at this level of activity, but are not always designed to do so. At heart, the workshop revealed the need for strategies that counter the incumbent social structures that influence ostensibly 'open' makerspaces, and thereby enable the tools and capacities available to work on more sustainable developments.

Keywords: Sustainable Development; Makerspaces; Community Development; Social Awareness.

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Conscientização Social.

INTRODUCTION

In October 2015 we convened a workshop for 80 researchers and practitioners involved in makerspaces in Europe. The workshop was held at the Machines Room makerspace in London. Our aim was to explore how makerspaces can help cultivate sustainable developments. This paper reports workshop discussion and ideas on the topic. We believe the workshop illustrates interesting deliberative potential in citizen labs.

Sustainable development is not inherent to makerspaces. The maker movement presents an emerging market for suppliers of all sorts of consumer tools, materials, kits and activity. The ability to personalise rapidly the fabrication of objects – presented, for example, by increasingly accessible digital design and machine tools - raises concerns about an intensification in the consumption of materials and objects, such as plastic 3D printed 'crapjets' and 'pongos' that are discarded just as rapidly as they are made (Olson 2013).

Any materials and energy savings in localised manufacture compared to scale efficiencies present in mass manufacture (Gebler et al. 2014) will depend upon the socio-political underpinnings of future distributions and patterns of production and consumption. More hopeful observers note that widening accessibility in design and fabrication can open activity to more diverse social values, compared to restricted participation in mass production, and which might create greater scope for commitments to sustainable development (Gauntlett 2013). Makerspaces can potentially diversify the sites where sustainable fabrication practices can be experimented and cultivated (Schor 2010). Direct experience with making might even cultivate more caring material cultures conducive to sustainable development (Thorpe 2012); or maybe not? Certainly, narratives of production and the branding of effort affect the meaning of objects (e.g. Arvidsson 2006, Light 2014).

With these ambivalent considerations in mind, we organised our workshop proactively around the question:

How can makerspaces help cultivate more sustainable developments?

The workshop was oriented largely towards sustainability issues evident in the materially rich consumer societies of northern Europe. Nevertheless, the technicalities of cultivating specific sustainable developments were found to turn largely on broad social processes and practices of much wider relevance to makerspaces and citizen labs more generally.

The next section elaborates the preparatory research we did for the workshop, and the ways that makerspaces potentially contribute to sustainable developments (section two). Section three describes the organisation and conduct of our workshop. Section four discusses findings from the workshop. We conclude in section five with our own reflections and views for future work.

SUSTAINABLE DEVELOPMENT POTENTIALS IN MAKERSPACES

In preparation for the workshop, we undertook a literature review of research into makerspaces and with an emphasis of issues relating to sustainable development

(Hielscher & Smith 2014). Our understanding of sustainable development was informed by the work of the World Commission on Environment and Development and what became known as the 'Brundtland' definition:

> "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts:
>
> ▪ The concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given;
>
> ▪ The idea of limitations imposed by *the state of technology and social organisation* on the environment's ability to meet present and future needs."
>
> (World Commission on Environment and Development, 1987, p.43).

Makerspaces were found to contribute to sustainable developments in a variety of ways relating to the state of technology and social organisation:

- Prototyping sustainable designs and systems
- Exploring issues of sustainable energy through hacking solar panels and building DIY home energy systems
- Incubating upcycling businesses and furnishing creative hubs for closed loop materials cycles
- Hosting repair cafés and 'Restart Parties', which aim to empower people to use products longer and control them better, including electronics devices, in order to reduce waste
- Building communities interested in making, repairing, repurposing and sustainability
- Hosting citizen science initiatives and building environmental monitoring systems
- Making critically that connects people to the political economies and material realities of production and consumption, and that explores alternative, more desirable futures
- Organising workshops for the social innovation of local sustainability
- Running Outreach activities that connect other sustainable development groups, and mobilising new thinking and action about technologies, sustainability and people
- Cultivating post-consumer identities, values and material cultures.

Whether or not, and how, makerspaces realise these activities depends upon the practices they develop, the relations built with other communities locally, and the contributions makerspaces make to societal level debate and change (Kohtala, 2016). For instance, makerspace sustainability can be measured in terms of viability, with no reference to wider environmental impact, or only in social and economic terms (e.g. Taylor et al 2016, Owen and McGrath 2016). These observations informed the way we organised the workshop.

THE WORKSHOP

The workshop was organised over two days. The first day was devoted to presentations from practitioners and researchers who, collectively, were familiar with the sustainable developments listed above. We invited speakers based in makerspaces, and speakers who take making (and fixing) practices out to other communities, wherever they happened to gather. Table 1 lists the speakers and summarises their contributions. Each presentation became a basis for discussion with the wider participants.

Table 1: workshop speakers

Speaker	Organisation	Description
Susana Nascimento	Policy Lab, European Commission, and ex-Vitruvius FabLab, Lisbon	Sustainable development requires understandings of the world and of social issues that work across different disciplines and involve citizens much more actively. Growth in citizen science and grassroots innovation suggest required kinds of knowledge production are possible. Makerspaces can provide sites for the experimentation, collaboration and creativity that underpin such knowledge production.
Richard Clifford	MAKLab, Glasgow	The development of MAKLab and its activities for empowering people through making. Makerspaces can align production facilities and possibilities with the aims of diverse partner organisations. Examples ranged from specific making projects to training programmes to research and scoping. Project activities included working with socially disadvantaged groups, and some addressed sustainable developments. Such was the public and private interest that partners are helping to open MAKLabs in other cities in Scotland, as well as expanding the range of things they do.
Cindy Kohtala	Aalto University, Helsinki	Researching a variety of Labs around Europe, Cindy mapped the various ways she saw FabLabs cultivating sustainable developments. Practical efforts to date focus on materials use and the processes of making things, such as energy use and waste. However, there was also interest and opportunities to rethink material cultures and explore wider questions of production and consumption. Dedicated sustainability champions can make the issues more visible and support user engagement in convenient, convivial and fun ways.
Diana Wildschut and Harmen Zijp	FabLab Amersfoort	This 'grassroots' FabLab provides facilities and tools for working with other groups, such as Transition Towns, and citizen environmental monitoring and history. Diana and Harmen spoke about how this happens through a very open structure and invitations for participants to initiate self-organised processes for realising their ideas. They noted that this can take some getting used to, and is not always successful. Yet for Diana and Harmen this principle of horizontal action is in itself a key component in hacking new systems for social organisation and also a means of extending their personal potential and sustainability as a small fleet-footed organisation.
Sophie Thomas	RSA Great Recovery Project, London	The Great Recovery circular economy project is co-housed with FabLab London. The Great Recovery project aims to create a more circular economy (thus reducing waste) through a wide variety of awareness raising and agenda setting activities. Included amongst these is use of FabLab facilities in product tear-downs and upcycling initiatives that allows people to design and make things better, and

		to value waste and reduce environmental impacts. Making, hacking and fixing allows people with practical ways to understand abstract concepts like the circular economy, and to raise awareness in a much more active and hands-on way.
Didac Ferrer	Tarpuna Co-operative, Barcelona	Tarpuna has worked with the network of public FabLabs in the city known as Ateneus de Fabricació Digital. The key was to work with local groups over a long period to explore how design and making might complement their expertise in knowing their neighbourhood and its sustainability needs. People are still working out how to develop this activity, which requires patience, but has great potential in making some of the grander visions for decentralised digital fabrication meaningful for local sustainable developments. The short-term nature of coming to a training workshop, playing with the digital fabrication tools and making a plastic memento of limited use needs to be resisted, said Didac, and the use of makerspace facilities attuned to the rhythms of community development.
Max Wakefield	Demand Energy Equality, Bristol	Demand Energy Equality is committed to all communities benefitting from the sustainable energy transition, and ensuring they have the knowledge and confidence to demand a stake. A key activity is the organisation of workshops where participants self-build solar battery chargers. This making activity is used as a stimulating and fun introduction to the basics of electricity, as well as providing a platform for discussion that raises awareness about reducing energy demand in ways that are socially just. Making is a vehicle for cultivating technological citizenship.
Janet Gunter	Restart Project, London	A London-based network that supports the organisation of 'restart parties' internationally. People bring their broken electronic goods to these parties, where volunteers with some repair skills support the party-goers in fixing their broken stuff, but also acquire the confidence and skills to fix things in the future. Janet described how earlier work in international development projects inspired Restart's community-based approach. Fixing activities can lead to a deeper set of consequences, such as empowering people to question the way things are made, and to challenge the designers and producers of electronics to enable people to have a more sustainable relationship with electronics. Fixing activities are seen as a route towards a more caring material culture and a means of asserting concern for the longevity and quality of material goods.
Trystan Lea	Open Energy Monitor,	An open hardware project and online community developing energy monitoring services for households and businesses. Activity involves technical enthusiasts developing software, sensors, controls and a web platform that assists households in understanding, managing, and reducing their energy use. Open source energy monitor also allows households to monitor electricity generated by solar panels and household energy usage. Lea talked about how the households which adopted monitors became more confident and involved in their energy activity.
Justyna Swat	POC21, Paris and Berlin	POC21 seeks a 'proof of concept' of the "disruptive impact that collaborative production, open source and the maker movement can have on mainstreaming the means of sustainable living". POC21 provides a practical approach to sustainable development, in contrast with the international negotiations and bargaining at COP21 – the climate talks in Paris in 2015. POC21 created a temporary 'innovation camp' that brought together over a hundred makers, designers,

		engineers, scientists and geeks, on the site of a borrowed chateau, drawn from various international activist networks, who were committed to prototyping for a fossil-free, zero-waste society. Others joined in via social media and internet. Equipped with the tools for prototyping a variety of technologies of practical and symbolic value for low carbon living. These prototypes made use of open source designs and instructions in order that others can access, adapt and make use of these developments. It was not the prototypes *per se* that mattered, but the open forms of working, and the infrastructure for developing innovations and collaborative demands for sustainability.

Discussion carried over into a World Café activity organized on day two. Participants divided into groups, and each group worked their way around a series of four tables, with a different question posed to them by a host at each table. As groups cycled around the tables, each question accumulated insights and comments, which subsequent groups picked up and elaborated from the preceding visitors to that table. Groups used flip-charts, sticky notes, sketches, and examples to convey their ideas at each table. An audio recording of discussions was made. It is these materials that inform our report.

HOW CAN MAKERSPACES HELP CULTIVATE SUSTAINABLE DEVELOPMENTS?

The World Café questions were designed to cover issues arising from the over-arching question of day one and identified in the literature review. The more specific questions were:

a) *How to sustain and expand commitment to sustainable developments in makerspaces?*

b) *Should sustainability initiatives scale-up or circulate more widely, and if so, how to retain core aims when moving beyond prototyping?*

c) *How can makerspaces work with others to generate conditions for sustainable developments in the wider world?*

d) *If makerspaces are the answer, what was the question?*

Here we report discussions under each question.

How to sustain and expand commitment to sustainable developments in makerspaces?

This question was concerned with creating the conditions in makerspaces for sustainable developments to become a normal activity. The layout, vibe and expectations of conduct can be made conducive to the inclusions and considerations central to sustainable developments: care for other people, care for materials, and care for the consequences of fabrication, good and bad. Interestingly, whilst groups did consider the re-use of materials, upcycling, information, and other practical sustainability activity in makerspaces, discussion quickly turned to a bigger agenda of creating a hub for interconnecting widespread commitment and activity for sustainability.

Ensuring inclusivity, diversity and building an open community was seen as central. Makerspace strengths rest in the encounters they create and the ensuing cross-

fertilisation of ideas, knowledge and practices. It was felt that building a critical mass and momentum requires strategies for continually drawing in a wide range of people. There is scope for running makerspaces in ways that are more welcoming to groups that are poorly represented at present. Strategies will consequently need to be specific and meaningful to each group, as well as sensitive to the locality and the plural aspirations for its development.

Learning to listen was identified as paramount. That way, the risk of fetishizing tools in makerspaces - and seeing all problems as ones that technology can fix - is countered by considering the social basis of problems first, and only then thinking about how to bring different tools into play in the creation of solutions. In a sense, this is meant to bring a design sensibility into play where there has so far been a strong focus on materials and technical skills. But focusing on the social is also to make explicit the dynamics between (and ambitions of) the people constituting the space and the neighbourhood in which it functions.

There was a need identified for community development skills to supplement the technical skills that support growth of a different kind. Whilst the acquisition of community skills can be demanding, the advantage is that both makerspaces and sustainability become framed in ways that attract a wider base of interest and support and could come to have greater meaning, and perhaps resilience, in their local settings. Thinking about makerspaces in this way proved relevant to the other questions too (see later); but with respect to activity within makerspaces, some of the practical consequences from this will be enhanced consideration of the material requirements and resource efficiencies amongst users of makerspaces. This was apparent in hearing the different stories of the day before. Opportunities could be created amongst suppliers of 'waste' materials from local production and consumption activities. Makerspaces could convene activities to attract the suppliers of such materials into thinking creatively about how their waste resources could be used in projects by others, and thus develop a platform for discussing and experimenting with local circular economies. In these ways makerspaces can claim a role in sustainable transformations through incubating use of materials, innovation, and entrepreneurial practice.

Makerspaces could reach out beyond makers, fixers and hackers, and demonstrate a relevance to non-makers also. People could participate in more general discussion, and makerspaces could use activities like product tear-downs to explore wider themes concerning the way things get made, and their social and environmental implications. Fieldtrips and films have been organised by some spaces as a way to engage people not themselves committed to making. Outreach activities can situate makerspaces as a social hub for information, contacts, and action to change the way things are designed and made in societies, who is involved in those choices, and what can be done to influence and change those decisions. This more critical role is often felt to be at odds with a creative capacity, but the ingenious projects described at the event show how making, fixing and reflecting can be incorporated into the same responsive agenda. Residencies, for example, could be encouraged that involve environmentalists, community activists, and social entrepreneurs unfamiliar with makerspaces, to open-up the imagination, ideas, networks and skills of all concerned. So, these spaces can be seen as mobilisers of political alliances as well as incubators for entrepreneurship.

Should sustainability initiatives scale-up or circulate more widely, and if so, how to retain core aims when moving beyond prototyping?

Workshop participants discussed how the characteristics of the sustainability 'thing' created in makerspaces affects the way it moves outwards into communities and businesses. It was felt that there are several paths for diffusion, depending on the 'thing' developed, and each with its own needs. A key distinction was raised between scaling outcomes by exporting solutions, on one hand, and replicating the processes that produced them in different contexts and with attention to local environmental factors, on the other hand. Replicable outputs may take the form of devices, objects, practices, attitudes and more.

For instance, with the example of upcycling: If the 'thing' is a practice, like upcycling furniture, then the processes for moving it beyond the makerspace could be through training activities, and would take time, as people developed the skills and put them into practice. If the 'thing' in focus is rather upcycled furniture objects, then diffusion of the objects might work through the participants commercialising the activity and diffusing objects through sales.

The prototyping activities prevalent in makerspaces cultivate many intangibles whose movement beyond the space can be significant for sustainable developments. These intangibles include skills, experience, knowledge, people, issues, or ideas generated through prototyping projects, relevant for advancing sustainable developments in local communities and businesses. With the example of upcycling practices, the intangible skills and ideas underpinning the practice are recognised and valued, and captured in programmes to train others in that practice. It is important to acknowledge the cultivation and diffusion of these intangible things and plan for the particular characteristics of their circulation as well as maintenance.

Prototyping can also effectively embody and embed locally new ideas for sustainability from elsewhere. Makerspaces can act as a radar for sustainability ideas circulating globally through networks and on 'making' platforms. Makerspaces can develop ideas and examples circulating globally, and they can adapt and emulate them in local situations and contexts. They can, for example, promote the more relevant and interesting advances in circular economy practice and green materials options to local businesses.

Seeking partnerships and alliances is important, with groups that have the capabilities and resources to connect with the communities, businesses, and institutions needed for all these things to diffuse. An infrastructure for mutual learning is essential. And not simply for practical, "how to" knowledge, but also platforms for mobilizing more critical lessons about, say, the institutional barriers to diffusing sustainable practices, and ideas for how to transform those institutions and redistribute power. Practically, this means not only documenting and learning about the products, projects, skills and so forth incubated in makerspaces, but also documenting experiences with diffusion outside makerspaces, and sharing knowledge about the who, what, why, where, how and when of working with allies in communities, business, and institutions: whether through instruction manuals and guides, videos about projects, testimonies of people, social media fora, themed meet-ups, analytical reports, stories, or other means, an open source, commons-based platform, or other tools for social action.

Workshop participants noted how important it was to appreciate the longer time spans needed for the diffusion of ideas and technologies. Prototyping through to product development takes time, as can involvement in a local regeneration initiative.

Some initiatives may move quickly and are very visible, while other initiatives may diffuse much more slowly; it is less easy to see the hand of the makerspace in promoting these ideas. That said, the hosting of public events, design fairs, or entrepreneurship days on the theme of sustainability, for example, can be organised relatively quickly, and immediately engage a wider audience of potential adopters, partners, and investors. We already see this in the buzz at Maker Fairs. But building on those encounters, and creating networks, partnerships and alliances for follow-on activities takes time, resources, and capabilities.

How can makerspaces work with others to generate conditions for sustainable developments in the wider world?

As with the other questions, discussion amongst groups at this table went deeper than naming specific allies or partners. Participants considered which public debates makerspaces could meaningfully engage with. There was recognition that it was hard to be prescriptive about specific partners, and that alliance building is driven by the points that makerspaces wish to debate, the situations they find themselves in, and the resources they can bring to those debates relevant for sustainable developments.

One debate where makerspaces might fruitfully contribute is notions of technological citizenship in a heavily manufactured world. Makerspaces cultivate meanings, belongings and responsibilities for people in relation to objects, technologies, activities and other participants. What does it mean to be a maker (or fixer); to belong to an open source project collaboration, to a workshop with an ethos for sustainability; and/or to associate with a global movement committed to empowering people through access to tools? How these questions relate to notions of technological citizenship is important. These debates inform the rights and responsibilities towards technological developments in society, production systems, and new consumption patterns. Some of this activity is already implied in makerspaces; it is simply not recognised as citizenship. What is currently seen as 'tinkering' or prototyping, might simultaneously be an act of technological citizenship in the making.

Another relevant debate concerns ecological citizenship. Makerspace activities can explore peoples' place within the making, consuming and disposal of things reliant upon our material world and connected within complex ecosystems. This is already apparent in debates about how the relations of production and consumption might be reconfigured, such as through initiatives in local circular economy. More practically, makerspaces might, for example, become labs for citizen-material-scientists exploring the resources available in their bioregion and the purposes to which they might be put in substitution for unsustainable material consumption.

At their most sophisticated, makerspaces can prototype relations between technological and ecological citizenship and help to resolve tensions in the notion of "making" at a time when sustainable resource use and production suggest a scaling-down of some forms of activity.

The commons was the third public issue deemed open to makerspace contributions. An ethos towards openness and collaboration in makerspaces resonates with ideas for 'the commons'. Makerspaces create artefacts that are open source, that is, instructions are provided allowing anyone to make and create the product for themselves, or to build upon the product, for example, with open source software.

As such, makerspaces can provide fruitful places for exploring norms, incentives, and practices for complex commons of knowledge, technologies, resources and environments.

Much institutional and outside interest in makerspaces is as a novel and dynamic site for incubating novel prototypes and entrepreneurship. Ideas for supporting such incubation include connecting makerspaces to more conventional manufacturing systems and scale-up through product development and commercialization. Participants at the workshop acknowledged value in making these connections, but they also recognized the asymmetric power relations between these two worlds. The discussion concerned whether collaborating with mainstream manufacturing communities was a better source of influence for promoting sustainability compared to insisting on being part of a movement building new systems. Engaging with manufacturers and markets to try and promote sustainability involves compromises, but has the advantage that innovations have the potential to diffuse widely. However, this opened up other concerns, such as whether manufacturing communities are interested in the debates above relating to sustainability. Alliances elsewhere, beyond incumbent institutions, and with social movements, might prove more fruitful.

If makerspaces are the answer, what was the question?

The point of asking this question (if makerspaces are the answer, what was the question?) was to recognise and reflect on the many assumptions made about makerspaces, including those in preceding questions. Why do we need makerspaces? Why have they emerged? What gap or need or aspiration are they fulfilling? What was going unresolved before, and what are makerspaces seeking to solve now?

We can first note the diversity of makerspaces, makerspace situations, their histories, the activities within them, the motivations of participants, members and sponsors, and the networks in which each sits. Beyond some abstract general features, makerspaces are not really a singular thing. This was also apparent in the diversity of speakers and their goals, despite some high-level shared values. In many respects, makerspaces are part of a perennial need for communal and unstructured spaces for doing things together. The continued erosion of space in public ownership or control has surely contributed to the increasing popularity of makerspaces. The creativity possible in common spaces has caught the attention of a wide variety of institutions including schools, universities, libraries, museums, business incubators, training providers, development agencies, local authorities, firms, and other institutional bodies. They have all seen in makerspaces a means to reviving some aspect of their traditional activity. Not all of these designs upon makerspaces are committed to principles of sustainable development. This reflection returned discussion to where the workshop opened, and that the critical fact that the ideas discussed and presented above do not happen automatically and need to be actively worked at within ambivalent makerspace and social situations. Inasmuch as it is possible to design spaces as emergent and 'open' as makerspaces, how values are interpreted in inclusive practices and sensitive resource use is key.

DISCUSSION

The workshop convened considerable experience for making sustainable developments with makerspaces. The workshop itself, held at a makerspace, is an

example of the kinds of forum makerspaces can provide. Participants generated a wide variety of ideas and insights for how makerspaces can help cultivate sustainable development. However, the mobilisation and implementation of those ideas has to overcome two, related tendencies that we (as conveners and researchers) notice in makerspace communities internationally. These tendencies are, first, a simplistic approach to openness, and second, technical prescriptiveness. We stress that some makerspaces are working hard to counter these tendencies.

An attractive claim for makerspaces is the provision of unstructured spaces for experimenting with design and prototyping, using the versatile combination of digital fabrication technologies, electronics, and the more conventional tools on offer. Makerspaces aim to create settings where people can playfully and creatively explore new design and fabrication possibilities. There is an ethos of encouraging people to be open, collaborative and imaginative, and to freely pursue their curiosity and aspiration – to 'be awesome', as a slogan popular among hackerspaces puts it. As a result, directing people along certain (sustainability) pathways in makerspaces appears to contradict the cherished spirit of openness and autonomy found in them.

And yet, we live in a structured world: a world that makes it easier for some groups to access and make use of makerspaces in particular ways, and discourages or excludes the aspirations of other users, actual or potential. Dominant social, cultural, economic and even political relations can and do exercise influence in makerspace activities. The limited gender, class, race, age and educational diversity in makerspaces attests to this concern (SSL Nagbot, 2016). There is no simple 'openness' that does not reproduce the status-quo of privilege and exclusion implicit in most arrangements, because it takes structured work to challenge this.

Similarly, there are pressures to demonstrate the value of makerspace facilities in terms of start-up incubation and entrepreneurship over social goals. We see, for example, how consumer culture enters makerspaces in the tendency towards the mass personalization of objects, throw away production of 'crapjects' or 'pongos', and inattention to the complex and contradictory scale efficiencies associated with decentralised production. Making could continue to be deeply unsustainable.

This tendency is aggravated in those networks, such as some associated with the Fab Foundation, that lean towards a fairly technocratic philosophy and define specific attributes, or even the tools and behaviours, to be adopted in working areas. For instance, if a bank of 3D printers must be included in every makerspace as a means of spreading certain technical practices and joining an international 'club', then the space for negotiation with members and users – or developed in response to the locality and its needs – will be limited. An emphasis on only some types of making and a formula for spreading these ideas worldwide comes at the cost of versatility, without which sustainability cannot flourish.

Of course, these tools are versatile. The Fab Foundation, to continue the example, has carefully chosen a suite of digital design and fabrication tools for making 'almost anything'. And there is an impressive commitment to making the tools as widely available as possible. Nevertheless, one should be aware that even versatile tools carry the likelihood for working in particular ways more readily than others. There may be valid reasons locally for approaching things with other tools in mind and hand. Neither should one believe that tools are value-free. Nor should having the tools and competencies to make 'almost anything' mean one has licence to do so. Nor, equally, should marketing, owning or sharing these tools become a prerequisite

for having a say in what gets made, and how it is made, to the exclusion of more flexible and responsive practices.

Both the leaning towards uncritical creative 'openness' and the seemingly contrary trend to pin down technical structures potentially can obscure the potential for more sustainable outcomes to emerge from the makerspaces. As our workshop demonstrates, there is awareness of these tendencies amongst makerspace communities. Any counter-structuring of makerspaces needs to be flexible, place-specific and thoughtful. It would be unfortunate if dogmatic views on sustainability snuffed out the kind of situated creativity and dynamic relationship building identified above. The Machines Room workshop indicates a number of eminently practical ways in which flexible structures can be adopted by makerspaces in order to cultivate sustainability. Our concluding point is merely to draw attention to the fact that this does not happen automatically. Considerable effort by people, organisations and institutions hitherto not as committed as our workshop participants is required in order to emulate their activity and achievements (Smith, Fressoli, Abrol, Arond, & Ely, 2016). Effort is needed in terms of values negotiation, design and implementation. The challenge is developing further the strategies identified in the workshop and reported in this paper.

ACKNOWLEDGEMENTS

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