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VOLUME 2 OF 3

Makerspaces are subjects in a plurality of institutional advances and developments. What kinds of hybrid arrangements emerge through these encounters, and what becomes of the occupied factories for peer production theory? This special issue features 13 peer-reviewed papers that report rich, empirically-informed insights into makerspace institutionalisation and the possibilities for transformational change, and 7 alternative reflections from key practitioners in the field.

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EDITORS' INTRODUCTION: LIBERATORY TECHNOLOGIES FOR WHOM? EXPLORING A NEW GENERATION OF MAKERSPACES DEFINED BY INSTITUTIONAL ENCOUNTERS

by Kat Braybrooke, Adrian Smith

INTRODUCTION

In October 2014, issue five of the Journal of Peer Production described makerspaces (or sites for making and learning with technical tools and mentors, also referred to under many other names) as the "occupied factories of peer production theory" (Maxigas & Troxler 2014). Authors contributing to that special issue compiled a theoretically and empirically grounded analysis of member-owned spaces like shared machine shops, hacklabs, hackerspaces, fablabs and makerspaces — spaces that appeared to signal a revolution for new commons-based, peer-produced modes of design and manufacturing. On closer inspection, however, the contributors found a variety of tensions and contradictions amidst the exciting possibilities. Whilst some practices anticipated democratic transformations in making and remaking things in society, other practices appeared to be epiphenomenon for neoliberal business-as-usual, such as the exploitation of precarious creative labour by various business and government institutions.

Three years later, the darker side of makerspaces burst into flames. On the night of 21st November 2017, a group that others labelled anarchists burnt down Fablab La Casemate in Grenoble, France. Fortunately, no one was hurt. The communication by the perpetrators stated that hacker notions of liberation through technology were illusory, and that no matter what the utopian aspirations, makerspaces were irredeemably and inseparably part of a hegemonic technological society. To the saboteurs, the popularisation of digital fabrication and culture in La Casemate connected directly to the oppression of dominant social institutions, and they had to be challenged. In an echo of the anti-automation protests of late 1970s France levelled on computer companies by the Committee for Liquidation of Subversion of Computers (CLODO) who described the computer as a tool of repression, the sabotage assaulted mainstreamed notions of social progress through technology.

Like others, we were shocked by this act. Even if such violence were ever justified, which is debatable, there are many more obviously oppressive technology installations ripe for sabotage and critique. The trouble with violence is that a deplorable medium inevitably does a disservice to its message. Whilst the violence itself must be condemned, its underlying challenge nevertheless warrants further examination. Today's makerspaces need to reflect upon how, precisely, they provide progressive social possibilities. Hope in such possibilities are held by many, including us – but where is the proof? Who is liberated by the liberation, and who is not?

Technology is never neutral, as the saboteurs remind us in their communique; but neither should digital technologies be viewed as hard-wired and deterministic (Matthewman 2011). Technologies embody and advance ever-evolving constellations of social values, choices and power geometries. Technologies are adaptable, depending upon the

situations in which they are produced and put to work. Technologies form part of dominant sociotechnical regimes which can be both hegemonic and hackable, and whose trajectories of development can be opened up and altered. The experience of using, say, a router in a community-project dedicated to the participatory provision of street-furniture that reclaims a public space, is quite different to that of machining for one's boss in a factory, where the operative has no control and is alienated from the flat-pack furniture being sold. The sociotechnical configurations are different. The significance of the technological element employed within these configurations is different. The social relationships tied together and mediated by the technologies are different. The value created and distributed is different. Makerspaces enable such sociotechnical experimentation. But is the experimentation not as open, inclusive and progressive as many of us had assumed?

BACKGROUND TO THIS SPECIAL ISSUE

These were the questions raised in a conference track in September 2016 that became the genesis of this special issue. The track – *Whose 'liberatory technologies'? Digital fabrications amongst hackers, makers and manufacturers* – was organised by Adrian Smith, maxigas and Johan Söderberg as part of the 'Science and Technology by Other Means' conference held in Barcelona by the Society for Social Studies of Science and the European Association for the Study of Science and Technology. Revised versions of some of the track's contributing papers feature in this special issue.

The conference track began by noting the fact that many of the digital design and fabrication technologies promoted in makerspaces hold particular historical ironies and contradictions: for example, the early introduction of computer-numerical-controlled machining (CNC), computer-aided-design (CAD), and computer-integrated-manufacturing (CIM) threatened skills, livelihoods and identities amongst manufacturing communities in Europe and North America in the 1970s and 1980s (Noble 1984), even as their more accessible technological descendants are celebrated today for enabling new kinds of agency, learning and communities for makers (Gauntlett 2013).

Can the technology of digital design and fabrication really escape their origins in earlier waves of manufacturing as automation? Just how open to radical sociotechnical reconfiguration are they? Whilst primitive anarchists like John Zerzan might argue that any historical turnaround in the significance of automating technologies is a mirage, and that activity today is still based in an inherently technological (and therefore oppressive) society, social anarchists like Murray Bookchin might be more hopeful and enthusiastic regarding their alternative technological possibilities. Fifty years ago, Bookchin, like other activists, welcomed a post-scarcity future in which technological progress would give collectives the opportunity to own tools and organise production non-hierarchically and sustainably, harnessing 'liberatory technologies' for socially useful purposes (Bookchin 1967). In this view, as Janet Biehl (2007) has written, the onset of technological innovation would not merely lead to embourgeouisement and complacency, but would instead provide everyone the freedom to build a more cooperative society.

In a different setting, organized workers in Scandinavia and other countries worked with leftist researchers in the 1980s for the introduction of human-centred computer technologies into workplaces, and in ways that would democratize the labour process. Whilst they failed to convince owners and management, in pursuing a different sociotechnical pathway, they did pioneer methods in participatory technology design (Ehn 1988; Asaro 2000; Smith 2014). Do the grassroots appropriations built today in hackerspaces and makerspaces and in open hardware groups on the web mean we are closer to this democratic, tool-based creativity? Or does the design entrepreneurship also practiced in makerspaces merely feed into (and actually reinforce) the ongoing automation and alienation of manufacturing as digital progress? The debates

about the action at La Casemate, including the conflicting views of different anarchist groups, perpetuates a long-running and ongoing concern.

Contributors to the conference track found the posing of binary questions like those above to be of limited help, even though the issues raised are important (for a track report, see Boeva & Chies 2017). Their contributions also highlighted the increased importance of institutions in shaping both makerspace possibilities and limitations, and influencing how issues of oppression and liberation play out in practice. Looking at institutions means suspending, at least initially, broader hegemonic/counter-hegemonic characterisations, and not overloading situations with revolutionary expectations. Whilst radical characterisations and criticisms remain helpful in situating makerspace practices within a wider conceptualisation of power in society, they risk rushing too quickly to a definitive evaluation of heterogeneous activity: oppressive or liberatory; captured or transformational; 0 or 1? Such definitiveness risks overlooking more nuanced possibilities. After all, as Stuart Hall, Doreen Massey and Michael Rustin have reminded us, reframing a society's norms requires the right conjunctural moment, a 'ruptured unity' (2013, p. 12) where many different political, cultural and economic actors converge to produce a different settlement (2013).

Situating the dynamics of makerspaces within more textured relationships with prevailing social institutions, and viewing such relations as more open-ended and susceptible to change, permits a finer-grained appreciation of makerspace possibilities and limitations. The plural relationships between makerspaces and institutions seemed, to us, one way to approach the task of power and politics in makerspaces that unpacks the binary questions above. Social institutions influence the emergence of sociotechnical configurations in societies; they help stabilise some configurations and underpin their development into dominant 'sociotechnical regimes' (Fuenfschilling & Truffer 2014). Dissatisfaction with such regimes and criticisms of institutional influence can prompt the creation of alternative sociotechnical configurations. Makerspaces are simultaneously autonomous spaces where experimental configurations arise, and spaces where conformity and isomorphism with and between institutions takes place. The plurality of these relationships with and against institutions do not fall neatly into either/or categorisations: oppression versus liberation; capture versus autonomy; business-as-usual versus fabrication-as-democracy.

Seen in this light, questions can be reformulated in a more open-ended manner: how are makerspaces encountering institutions in practice, and how are makerspaces institutionalising their practices? How are autonomous spaces maintained beyond the designs that different institutions may have? How are practices reinvigorated or altered in response to these encounters? Throughout the editorial process, we left what was meant by 'institution' deliberately open – though we did encourage contributors to be explicit in how they understood and approached institutions in makerspaces. The result, we're pleased to say, is 13 papers that report rich, empirically-informed insights into makerspace institutionalisation and the possibilities for transformational change, along with 7 alternative reflections put together by key practitioners in the field.

INSTITUTIONAL ENCOUNTERS

Institutional theory seeks to explain the settled social environments in which organisations operate and the consequences those environments have for organisational development. W. Richard Scott defines institutions as those, 'cognitive, normative, and regulative structures and activities that provide stability and meaning to social activities' (Scott 1995: 33). Douglass C. North provides another highly cited definition that is broadly similar: 'Institutions are rules, enforcement characteristics of rules, and norms of behavior that structure repeated human interaction' (North 1989: 1321). Institutions can be very broad and cultural, such as those

concerning property, and tied to bodies of theory, like the neo-classical economics that were a focus for North; or institutions can be specific and instrumental, such as a particular regulation, the work of a government agency, or the formation of a law.

Whilst institutions constitute a powerful pressure for conformity – such that organisations often start to resemble one another (Di Maggio & Powell 1983) – there is nevertheless scope for strategic manoeuvres by organisations encountering these pressures. Depending upon circumstances, and the resources available to an organization, strategies can variously involve acquiescence, compromise, avoidance, defiance, or manipulation of institutions (Oliver 2018). Institutional environments can also be complex, consisting of multiple institutional logics whose (conflicting) demands can be played off one against the other and negotiated (Pache & Santos 2013).

Criticisms of institutional theory cast it as overly static and conservative (Munir 2015), prompting perspectives that view institutions more dynamically, and that propose approaches interested in the creation of new institutions that transform social environments through organizational agency and shifts in the power relations that otherwise maintain institutions (Hirsch & Lounsbury 2015; Suddaby 2015; Fuenfschilling & Truffer 2014). Institutional entrepreneurs can work to reform or transform institutions, for example, by exploiting social movements and shifts in social discourse, and that undermine the legitimacy of incumbent institutions and open space for the development of alternatives (Zietsma & Lawrence 2010; Levy & Scully 2007). Despite this, doubts linger about the critical and emancipatory potential of institutional theory and practice. By definition, institutions seek to normalize and routinize and, when challenged, tend to adapt and elaborate rather than transform and liberate (Willmott 2014).

These themes will be familiar to observers and participants of makerspaces. Makerspaces have caught the imaginations of a wide variety of people and organisations coming from different settings, inspiring institutional actors to see an exciting buzz of organized possibilities. Depending upon the specific institutional encounter, makerspaces are becoming cradles for entrepreneurship, innovators in education, nodes in open hardware networks, studios for digital artistry, ciphers for social change, prototyping shops for manufacturers, remanufacturing hubs in circular economies, twenty-first century libraries, emblematic anticipations of commons-based, peer-produced post-capitalism, workshops for hacking technology and its politics, laboratories for smart urbanism, galleries for hands-on explorations in material culture, and so on and so on … and not forgetting, of course, spaces for simply having fun.

Sometimes institutional interest derives from the possibility makerspaces present in delivering longstanding agendas in novel ways, promising a reinvigoration of the norms and routines by which that agenda is realised. An example here might be makerspaces providing an engaging, hands-on way to educate youngsters in the institutions of mainstream science and technology (e.g. using scientific methods, formalising bodies of knowledge, and reinforcing the significance and standing of science in society). In other cases, makerspaces attract interest because they anticipate new institutional possibilities. An example here could be new norms for manufacturing in open and circular ways. Often, as we see in the contributions to this special issue, there are complex mixes of both these currents: existing institutional agendas moving in, and new institutional possibilities emerging out of these sites of experimentation.

So, makerspaces are subjects in a plurality of institutional advances and developments. There are pressures to conform (sometimes willingly, for example when institutional encounters bring welcome opportunities for securing resources, stability and status). But makerspaces simultaneously remain a source of variety, generating narratives and practices ripe for

institutional entrepreneurship and transformational possibility. But isn't there a contradiction at the heart of these encounters? Makerspaces are about experimentation, improvisation, and unruliness. Institutions promote regularity, certainty, and orderliness. Does this mean institutional encounters in makerspaces will inevitably and ultimately prove unstable? What kinds of hybrid arrangements are negotiated and emerge through these encounters? How do makerspaces maintain autonomy such that they can deal with institutions on their own terms? What happens to spaces for diversity, contrariness, and alternatives, and where do they go, as some activity routinises and normalises and perhaps comes to dominate? What becomes of the occupied factories for peer production theory? And of course, how does power get reconstituted and manifest in these encounters?

PEER-REVIEWED PAPERS

The 13 peer-reviewed research papers that make up this special issue deal with different aspects of these institutional conundrums. Some papers are about institutional entrepreneurship and the institutionalisation of new practices originating in makerspaces. Other papers examine what happens when existing institutions enter into makerspaces. And many papers look at both these directions of travel. In "Institutionalisation and informal innovation in South African Maker communities", Chris Armstrong, Jeremy de Beer, Erika Kraemer-Mbula and Meika Ellis look into the co-existence of informal and institutional practices in makerspaces in South Africa. Institutionalisation, here, emerges through a variety of strategies, including the formalisation of maker community practices, partnerships with formal organisations, and embedding makerspaces in formal organisations. Whilst their evidence points to considerable institutionalisation, they find that even in these more formal situations a commitment to informality is valued, such as working imaginatively in open collaboration with innovative projects, where knowledge appropriation is handled informally. Makerspaces are thus seen as playing a helpful intermediary role in bridging the more formal development of innovation systems with the large informal sectors of South African society.

The ability of institutions to connect beneficially with large informal sectors is a theme in "Making in Brazil: Can we make it work for social inclusion?" by Rafael Días and Adrian Smith. They write about an initiative by the city authorities in São Paolo that opened public FabLabs in different districts, including the disadvantaged Cidade Tiradentes on the margins of the city (literally and figuratively). They discuss the initiative, and its aspirations to seed inclusive developments in the community. These hopes are situated in the Brazilian culture of improvisation and making-do known as *gambiarra*, and earlier programmes for social technology aimed at emancipating people from poverty through other participatory technology programmes. What is striking in this case, and familiar to public support for makerspaces in other cities, is how makerspaces are seen as an instrument that follows a 'script' for development as seen by those institutions, sometimes to the puzzlement of the intended beneficiaries. What will be important in the São Paolo initiative, and others, is the processes by which people can bring their own scripts into technology developments in makerspaces and narratives about the communities in which they are situated and what they'd like those communities to become.

The importance of permitting a diversity of scripts to enter into technology and making becomes especially apparent in the study of makerspaces in Nairobi undertaken by Alev Coban in "Making hardware in Nairobi: Between revolutionary practices and restricting imaginations". Adopting a conceptual approach of performativity, her ethnography shows how institutional presumptions about 'African' development and poverty informed a particular, and questionable, view of social impact for makerspaces. She argues this reinforces (post-colonial) power relations with regards to what kinds of technology project were worthy of support and promotion, and which not. Perversely, good

intentions – materializing in the funding of technology with social impact – end up further performing an exoticized take on poverty, rather than opening up to the wealth of ideas and diversity of talent that exists in Kenya.

Differences in institutional designs upon makerspaces is illustrated in a different way by the comparisons Pip Shea and Xin Gu make between FabLabs in two nations with "Makerspaces and urban ideology: The institutional shaping of Fab Labs in China and Northern Ireland". The provision of open spaces and networks that support participants to do creative things with technology in collaborative projects is supported for differing instrumental purposes by public authorities. In China, they argue makerspaces are viewed as a practical way of promoting innovation culture, entrepreneurialism and a government-led economic agenda, whereas in Northern Ireland value is seen in the ability of making projects to build bridges between communities that carry a history of conflict. Rather than makerspaces rolling-out a universalist commons-based peer-production 'paradigm', spaces are found to be shaped more significantly by local and regional cultural values and expectations, reflected in the availability (or lack thereof) of institutional priorities and support.

Nevertheless, many of the leading figures of makerspaces are motivated by commons-based, peer-production possibilities, even if the practicalities of running a site and working with supportive institutions to keep it open means falling short of this ideal. In "The sociomateriality of FabLabs: Configurations of a printing service or counter-context?", Cindy Kohtala draws upon ethnographic fieldwork to examine conflicting sociomaterialities at FabLabs in Europe, in doing so analysing how a tenuous co-existence between alternative and mainstream values can be negotiated through specific social and material practices. Her paper discusses how the commodification and conformity of some FabLab practices is entangled with the negotiated reconstitutions and aspirations of a more counter-cultural current of activity. This is illustrated by looking at the dynamics evident in specific kinds of work, knowledge and imaginative objects.

Commitments to common-based peer-production can, of course, constitute an informal institution in itself, to the extent that a set of norms and routines are established through such commitment. Compared to the backing by states and corporations for other kinds of institutions, such as those reinforcing market-oriented innovation and entrepreneurship, the informal norms of commoning and working as peers can seem at a disadvantage. Nevertheless, aspects of practices informed by commons-based peer-production can attract institutional entrepreneurs, who see a chance to win support for their activities by aligning with higher-level policy agendas. In "The institutionalization of making: The entrepreneurship of sociomaterialities that matters", Evelyne Lhoste and Marc Barbier look at these dynamics in their history of FabLab developments in France. They explore how notions of innovation and entrepreneurship enable a host of different agents, artefacts and organisations to assemble around and find value in makerspace practices, and the important intermediary role FabLab managers play in the institutionalisation of these practices from a uniquely French perspective, including those at La Casemate in Grenoble.

In "Can one size fit one? A prospect for humane custom production", ginger coons provides some useful historical perspective on the excitement for personalised production that emanates from today's makerspaces, and particularly the increasingly accessible digital fabrication technologies facilitated by these sites. A comparison is drawn with dress-making practices in the 18th and 19th century, and the increasing access to patterns, sewing machines, and possibilities for personalised clothing. In taking the longer view, mass-personalisation today, in which customers can tweak patterns, is seen as an attenuation of the possibilities for much freer user relations with making. Coons argues institutional orientations towards smaller-scale production (as compared to mass-personalisation) would, from a

historical perspective, have a better chance of genuinely involving the user in a more humane form of manufacturing.

Coon's argument is perhaps reinforced by "In situ, 3D printed heritage souvenirs: Challenging conventional spaces and culture", Sam Vitesse and Constantia Anastasiadou's report on the use of on-demand 3D printed souvenirs at a gift shop at Stirling Castle in Scotland. A 'pop-up makerspace' was set up near the castle's gift shop, where customers could choose from a range of designs and materials, and thus create a somewhat personalised memento of their visit to the castle. Vitesse and Anastasiadou look at the implications of this arrangement for material culture, situating the gift shop as an institution oriented not just around sales, but also around materially enduring relationships between visitor and official heritage attraction. Emotionally enduring design is advocated by some as a way of promoting a more sustainable material culture, precisely by making 'made' objects more meaningful to owners and users (Chapman 2009). So whilst a 3D print in a gift shop might appear particularly niche and innocuous, it nevertheless points to the bigger themes of sustainability covered by Cindy Kohtala.

In exploring political economies of the heritage sector in Britain, Kat Braybrooke's research in "Hacking the museum? Practices and power geometries at collections makerspaces in London" considers how 'collections makerspaces' have been used by cultural institutions to create new experiences and hence relationships between artifacts, culture and visitor experience. She has studied their use through an applied, multi-site ethnography of three museums in London – Tate, the British Museum and the Wellcome Collection – and focuses on the geometries of power that are revealed through user practices and interactions at these emergent spaces. Starting with a genealogy of makerspaces that is framed around four temporal waves of innovation, she argues that as recent initiates into an institutionally-oriented fourth wave of spatial interactivity, collections makerspaces may be activated by their users in ways that facilitate critical inquiry into museums themselves, and the conventions of culture and privilege they represent. Power geometries do not disappear, but they do morph and evolve, and can result in a redistribution of power balances through peer production practices, in doing so changing notions of what a museum should and can be.

Redistribution is also the focus of the paper "Redistributed manufacturing and makerspaces: Critical perspectives on the co-institutionalisation of practice" by Liz Corbin and Hannah Stewart – but here, the important relationships occur on a macro-level. They consider how makerspaces are cast in the broader technical possibilities for manipulating the global circulation of design and machining instructions to local fabrication and production. The concept of redistributed manufacturing (RDM) has become alluring for a number of institutional agendas, all of which look to makerspaces as pioneers, prototyping systems and practices that enable revolutionary ways-of-doing. By looking into the tensions and contradictions of RDM discourse, and its dismissal of certain techniques, tools and materials while others are championed, Corbin and Stewart explore the increased importance of external agendas to the governance, purpose and focus of peer production communities. In doing so, they are able to peer beneath the peer production 'technomyth' (Braybrooke and Jordan 2017) itself.

Intriguingly, instrumental uses of local production capacity connected to cosmopolitan and mobile design possibilities is the point of departure for a quite different study in "Achieving grassroots innovation through multi-lateral collaborations: Evidence from the field" by Silvia Buitrago Guzmán and Pedro Reynolds-Cuéllar. Here the site of inquiry shifts to Colombia, and the use of citizen innovation events and temporary makerspaces as an instrument for development and peace-building. After a helpful review of issues in development collaboration in technology, the authors provide analysis and reflection of two international design summits convened in Colombia in which they

participated. The summits were intended to catalyze and support local innovation capabilities and peer production. Whilst they succeeding in making visible a rich variety of creative possibilities, the events also made apparent the lack of institutions available to help foster the further development of promising activities after the events. The challenge, here, is creating local institutions that bring universities, international organisations, civil society organisations, and business investment to the service of grassroots initiatives. Sustaining the success of these events requires an appropriate institutional environment.

In "Configuring the independent developer", Tobias Drewlani and David Seibt examine a quite different instrumental use of the possibilities of making-as-peer production when it is harnessed by an influential multinational corporation. They examine the roles played by the 'independent developer' in a work programme organized by Google for the development of a modular smartphone. To build the phone, Google tried to maximize on the potentials of voluntary labour by bringing together a community of (unpaid) technology enthusiasts in the process of creative development – something which open hardware networks are doing in all sorts of domains. Grassroots enthusiasm and the apparent openness of Google were only able to mask the underlying tensions for so long before the project collapsed under the weight of its own contradictions. Drewlani and Seibt argue the experience is typical of current attempts by large firms to engage grassroots production communities in digital fabrication.

Our final research paper, "ReMantle and Make: A cross geographical study exploring the role of makerspaces and the circular economy in Scottish textiles", is written by Paul Smith, Michael Johnson and Lynn-Sayers McHattie. They report on a design study centred on a workshop where makerspace practices are used to explore circular economies for the textile industry at two geographically different sites in Scotland. Issues in making textile production and the circular economy were situated around activities that were embodied in the hands-on making of textile products themselves using off-cuts and scraps. In a similar vein to other studies of this issue that looked at the use of the makerspace as an instrument of collaborative exploration, Smith, Johnson and McHattie find a disconnect between the successful raising of issues and the cooperation of institutions capable of carrying proposals to action, revealing a foreshortening of the makerspace-as-transformational possibility. Nevertheless, they conclude there is a usefulness in the kind of democratic knowledge production that is enabled by these interactions.

PRACTITIONER REFLECTIONS

In additionally inviting more experimental pieces from practitioners as part of this special issue, we hoped to broaden the diversity of perspectives by sharing not only academic research but also on-site reflections about the effects of institutional engagements in these spaces. We were happily impressed by the diversity of knowledge and inquiry shared by those who participated.

Robert Richter and Daniel Wessolek share their reflections on the different traditions of fabrication and making that define the Futurium and the Museum für Naturkunde in Berlin, two institutions that target a similar audience. Artist and Tate Digital Studio Producer Luca M Damiani experiments with new communication formats to illustrate the tensions and opportunities offered by the convergence of art and technology across formal and informal maker settings. Molly Rubenstein, Benjamin Linder and Kofi Taha from the MIT-D-Lab provide valuable lessons from their engagement with the Artisan's Asylum in the United States, noting the distorting effects of financial support on grassroots initiatives, comparing its model to that of the much better-resourced International Development Innovation Network (IDIN). Kazutoshi Tsuda, Mitsuhito Ando, Kazuhiro Jo and Takayuki Ito from the Yamaguchi Centre for Arts and Media (YCAM) in Japan discuss the gradual expansion of its lab and fabrication spaces over the past 30 years of the centre's development, noting the beneficial

possibilities offered by a public institution which allows itself to evolve with the times. The Centre for Sustainable Design's Director Martin Charter, meanwhile, reflects on the emerging consciousness of a 'fixer movement' in the United Kingdom, from repair cafes to other local community efforts aimed at reframing consumer culture. Em O'Sullivan shares photos from her research into issues of accessibility and diversity in the maker movement, highlighting the efforts of a series of inclusivity-focused makerspaces in the United States and the United Kingdom that aim to address these challenges.

We also engaged in a bit of institutional collaboration ourselves for this special issue. Invited to share our findings with a new kind of audience at Tate Modern, we collaborated with Tate Digital Learning to curate a mini-exhibit as part of Art:Work, which we describe in "Space Gather Make: Shared Machine Shop Sound". By asking what worker-owned labour looked and sounded like at the makerspaces featured in this special issue, the sites of this issue's practitioners were envisioned as a series of distinct visual environments, each imbued with its own kind of life. We collaborated with sound artist Vasilis Moschas, who created a conceptual audio installation that explored the sound environments of each site, illustrating typical on-site experiences of flow, discontinuity, repair and breakdown.

CONCLUDING THOUGHTS, NEW POSSIBILITIES AND THE DEVILS IN THE DETAILS

So, what have we learned in coordinating this special issue of Journal of Peer Production in its many facets? And how might those lessons inform responses to the kind of violence witnessed at La Casemate? Our initial response was to suggest makerspaces are sites of ongoing sociotechnical experimentation. The contributions confirm and elaborate on this point. Critics of makerspaces, meanwhile, seem to flip back and forth between sociologically and technologically deterministic views. Technologically deterministic in the sense that the digital fabrication equipment in these sites is considered to be inherently oppressive towards people, and therefore has to be challenged. But at the same time technologies are seen as the tools of capital, whose interests develop and underpin their oppression. Under this sociologically deterministic view, challenging oppressive instruments constitutes an attack on repressive social arrangements.

What unites the case studies, analyses and arguments of this special issue is their call for more flexibility. Alternative sociotechnical arrangements illustrate how some technologies can be subverted, and hegemonic forces countered. Promising sociotechnical openings are found, for example, in the way making can cultivate and express talents and knowledges previously overlooked by institutions and enable their recognition; or in the way making can prompt reflections about our material culture and generate practices for more sustainable cultures; or in the way making can remind us of life beyond that of 'rational' economic man (and it is all too often a man) and the diversity of motivations, conditions and moments of activation under which radical creativity and collaboration emerges. There is plenty of scope in all this activity for informing and influencing progressive institutional reforms.

However, all of the contributions to this special issue also have a critical edge. The institutional agents who direct what gets selected, institutionalized and turned into development pathways beyond the walls of makerspaces do not constitute a wide-open frontier where everyone is welcome. Some paths are easier than others and made more available to some groups than others. Recalling Issue 5 of Journal of Peer Production, whilst peer prototyping is still evident, actual peer production remains challenging. We note how even peer prototyping in makerspaces is structured by institutional biases and has to be proactively countered – see, for example, Issue 8 of Journal of Peer Production on feminism and (un)hacking. The point, however, is that it *can* be countered. We find this in the contributions to this

special issue also, where progressive possibilities are being opened up, and renewed demands articulated to more radical institutional changes; in response to a moment when spaces for radical experimentation in peer production are being closed down, whether due to their capture by institutions, or because experience with the existing institutional landscape teaches us that alternatives are harder to progress than initially anticipated and need a redoubling of effort.

The uneasy co-existence between makerspaces and institutions feeds into the cycle of sociotechnical experimentation reflected here. Actors – and not always the same actors – will continually seek alternatives, such as commons-based peer production. Institutions will continue to be drawn to elements of what emerges through this experimentation, and support the practice and development of those elements. What gets overlooked and left behind by these developments will disappoint those of us with alternative visions. We see this in the plurality of viewpoints around many of the practices outlined by this issue. What an institution thought would be an ambitious experimental encounter is consequently seen as missing the original point, or not going far enough. This mix of successes and disappointments galvanises renewed attempts in more ambitious experimentation, hopefully having learnt from prior experiences.

However, if this dynamic is the basic lesson we take from the special issue, then it is one that has to be treated with caution. Whilst many makerspace managers and users might be motivated by commons-based peer-production, the diversity of settings studied in the contributing papers demonstrate it need not be shared on the ground, nor is it necessarily shared by other cultures. Other purposes come into play, and these play out through specific conjunctions of institutions and grassroots actors in their localities. Advancing commons-based peer-production means ultimately viewing and adapting its ideals *through a local lens*. For all the prospects of nearly instantaneous design and fabrication, file sharing and online collaboration, making must matter locally. While this issue does display broad patterns, its cases more importantly illustrate a diverse kaleidoscope of local histories and geographies that set the important details.

Such details are important, since they can be the source of contingencies in technology development and use, the cultivation of which opens up alternatives that can be emulated and mobilised elsewhere. These contingent spaces are where categorical statements about technology can be countered – and also where the isomorphism of institutions can be undermined and unsettled. Referring to the movement for socially useful production in the late 1970s and early 1980s, which in London opened a series of community prototyping workshops that anticipated today's makerspaces (Smith 2014), sociologist Donald Mackenzie noted, "Whatever the eventual success or failure of these efforts to alter the nature of technology, our understanding of how technology changes can only profit from them. For, by making contingency and choice actual rather than merely hypothetical, they throw into ever-sharper light the ways in which social relations shape technical development" (Mackenzie 1984, p. 502).

Makerspaces, we have argued, are an obvious site where such choices and contingencies can be cultivated through local differences. Mackenzie is careful to write that experimental alternatives cast the social relations of technologies in ever-sharper light. He does not assume that improved insight into those relations automatically leads to greater agency over their transformation. But choices and contingencies arise on the institutional side of encounters with makerspaces also: the museum hacking the material cultures they curate; the education programme reforming its pedagogy; the development agency nurturing grassroots innovation; the businesses seeking new sources of profitable creativity; civil society networks building material expressions of their social values. Makerspaces help provide these institutions with new possibilities. Such contingencies and choices

open up space for new institutional arrangements. Makerspaces do not only open up the technological black box, as Mackenzie would see it, but they also can help open up institutions to social scrutiny and to a better understanding of how institutional changes reshape the prospects of different sociotechnical configurations.

Of course, many of the contributions in this special issue note the relatively limited ways in which institutional change happens. Education might become more stimulating, problem-based, and hands-on, but its openness can still be limited by deeper institutional requirements to build entrepreneurial subjects fit for labour markets. Museum collections might now be reconceived as an active dialogue, but their contents are still set by institutions that determine what is worth curating. And, for all the buzz around open manufacturing, the labour process still privileges capitalist institutions. Institutions are, after all, conservative. By definition, their norms and routines modulate and dampen developments.

These features, however, are brought into a critical light when we scrutinize what it is that limits makerspace practices from reaching more radical peer production possibilities. It becomes evident what deeper institutional changes are needed before social values committed to sustainable development, dignified work, and social justice can really become normal, routine ways to go about making things. Digital fabrication through mass manufacture of flat-pack furniture is still more prevalent than the commons-based, community fabrication of street furniture noted earlier. Makerspaces can help open up institutions, whether they are found in public spaces or homes, and they can inform the design of radical new institutions, but the power to implement those radical new norms and routines requires agency. The social value in makerspaces lies in their articulation of institutional tensions through practical activity, and in some cases, critical reflexivity – but they alone cannot shift such a powerful tide. Transformational projects arise out of the actions of many actors over time. We should not devalue makerspaces simply because they lack the agency to overturn institutional logics all by themselves.

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CAN ONE SIZE FIT ONE? A PROSPECT FOR HUMANE CUSTOM PRODUCTION

ginger coons

In this article, I advance two complimentary arguments. My first argument is methodological. I contend that, in order to understand new technologies and practices in a nuanced way, attending to past analogs is crucial. I support this methodological argument by comparing a historical form of custom production (18th and 19th century dressmaking) against currently dominant practices of mass-customization (flexible mass production customized through online interfaces). A second argument stems from the first: supported by the comparison of a historical and a current mode of custom production, I argue that current modes of mass-customization do not do justice to the potential of custom production. I lay out a set of criteria for doing humane customization and suggest that small-scale production has a better chance of successfully centering the user than does production at larger scales. As such, there is room for those involved in shared machine shops to embody a more nuanced practice of digitally-aided custom production.

Keywords: mass customization, dressmakers, user agency, digital fabrication

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by ginger coons

UNDERSTANDING MASS-CUSTOMIZATION BY STUDYING DRESSMAKERS

This article spans roughly two-hundred years. It starts with dressmakers in Europe and North America, in the century leading up to the widespread adoption of mass-production in the garment industry, moves through current modes of mass-customization, and ends with a hope for the future of custom production in and with shared machine shops. While it may seem counter-intuitive in a special issue on shared machine shops to discuss pre- and early-Industrial custom dressmakers, they represent a past which is frequently invoked in current discourse about digitally-aided custom production and customization of consumer goods. This article is, in essence, about different structures of custom production of goods, and how those who inhabit shared machine shops can productively intervene in evolving practices of digitally-aided custom production. Because various kinds of shared machine shops—makerspaces, hackerspaces, and other collective sites of fabrication—offer access to desktop digital manufacturing tools and are sites of experimentation and expertise-sharing, they represent an ideal locale for small-scale explorations in the utility of digital fabrication for custom production.

The structure of this article is as follows: Historical modes of production are frequently leveraged in arguments about the current and future state of manufacturing. Advocates of new technologies use history as a justification for the significance of the technologies they are promoting. This is especially evident if there is a suggestion that a new technology will bring in a major change. For example, a number of recent developments in digital fabrication technology (especially anything that can be placed under the umbrella of 3D printing) are promoted in the context of past industrial revolutions, in order to bolster the claim that these new technologies will be equally paradigm-changing. 3D printing has been particularly linked with the idea of decentralized, small-scale manufacturing, which in conjunction with

the idea of the circular economy is positioned as an opportunity to intervene in the current paradigm of globalized manufacturing and consumption (eg: Lipson and Kurman, 2013). A problem with these kinds of claims is that, in order to set up a tidy case for the importance of a new technology, history is collapsed and over-simplified. This appears to be especially prevalent in the use of the 18th and 19th century industrial revolutions as events which are seen as similar to changes happening in manufacturing now. Of particular interest in the context of this article is how descriptions of digital fabrication technologies often come along with ideas about how they will make mass-customization (and thus, the ownership of custom-made goods) more viable and widespread. The subtext of such claims is that customization, on a non-mass basis, has been almost entirely eliminated by the advent of mass-production at the end of the 19th century. Thus, the methodological claim I advance in this article is that those who want to develop more nuanced views of new technologies can do so by attending carefully to the history and context behind the arguments used to promote the utility of those new technologies. Looking at the broader context of the histories leveraged offers the opportunity to gain a more nuanced understanding of how we might better accomplish the things we seek to do with new technologies, or even how to better evaluate the claims of others about the capabilities of said new technologies. I do that by comparing the practices of 18th and 19th century custom dressmakers against current systems of mass-customization. Drawing on the comparison of those examples, I argue that there are criteria we should attempt to embrace in order to do humane custom production which centres the needs of the potential user[1]. Such humane custom production, I suggest, is better done at small scales than large ones, providing an opportunity for those active in shared machine shops to develop sensitive and humanistic modes of custom production, different from the currently available modes of digitally-aided mass-customization.

It's a commonly-repeated truism that those who forget the past are doomed to repeat it. This implies that the past is undesirable, something we would not want to repeat. However, we do frequently remember the past with nostalgia, appreciating the things that we believe to be better than the analogs we have now. The risk in such a use of the past is not forgetting it wholesale, but failing to acknowledge and use the portions that may go against our preconceptions and desires. In this article, I use history as a tool for informing the future. In particular, I argue that apparently abstract traits we value from the past, like attention to detail, fitness for purpose, and care, should be seen within the context of broader ecosystems which we often forget or erase. I use the case of custom dressmakers in portions of 18th and 19th century England, France, and North America to understand, illuminate, and provide contrast for current and emerging practices of digitally-aided mass-customization.

Digitally-aided mass-customization, by its very definition, bears a resemblance to mass production. However, digitally-aided custom production, absent the logic of "mass" is something which pervades makerspaces, hackerspaces, and other fabrication spaces. The desire to make something that suits one's purpose is well-represented in the shared machine shops that are the subject of this special issue. Participants in shared machine shops carry out individual tinkering and making tasks for themselves, as well as potentially producing items for broader use, both inside and outside the shared machine shop (Jensen et al, 2016). While the nature of the goods produced varies from person to person and from shop to shop (eg: the examples of projects covered in Niaros, Kostakis, & Drechsler, 2017), the shared act of building an object is one which can be (and is) harnessed in service of custom production of consumer goods. The principle of scratching one's own itch which comes from Free/Libre and Open Source Software and persists in many shared machine shops is an entry point for thinking about how one might tailor a self-made object to one's own needs. Another F/LOSS trait, decentralization of labour, is also frequently cited as a factor in shared

machine shops, allowing participants in one venue to make use of the efforts of those located elsewhere (Kostakis et al, 2015), which offers opportunities for the production of customized goods based on pre-existing template objects.

It is important at this point to note a distinction between customization and custom production. I take customization to imply the ability to make modifications to a template object, while custom production implies a good produced from scratch, absent the template. Custom production is tied up in the story of pre-Industrial production, just as mass-customization owes its existence to mass production. In drawing such distinctions, I do not wish to advance the idea that the pre-Industrial era was some kind of golden age during which craft producers perfectly attended to all of the needs of their clients. Rather, I acknowledge the popular fallacy of conflating the current state of digital fabrication with an idealized conception of artisanal production (Morozov, 2014 further troubles the similarities between Makerism and the American version of the Arts and Crafts movement). While a flat view of industrialization is often presented in support of rhetoric about a new industrial revolution, there is significant scholarship backing up the idea that industrialization was complex, messy, and unevenly distributed, with craft practices and industrial methods coexisting for some time (Blaszczyk, 1995; Sabel & Zeitlin, 1985). Instead, I wish to point out that custom production, co-existing with industrial methods, embodies a co-creative and complex relationship between a producer and a consumer. I use the example of dressmakers to describe a mode of custom production which provides a number of points at which the end user is invited or expected to participate in the production process.

I contrast the case of the dressmakers against current modes of digitally-aided custom production in order to support a methodological argument. I contend that, in order to understand new technologies and practices in a nuanced way, attending to past analogs is crucial. My second argument stems from the first: supported by the comparison of a historical and a current mode of custom production, I argue that current modes of mass-customization do not do justice to the potential of custom production, and that there is room for those involved in shared machine shops to embody a more nuanced practice of digitally-aided custom production. I use the word “humane” in this context to describe a kind of relation between consumer and producer which embodies care and consideration for the individual, traits which are not generally associated with industrial systems of production.

THE PROBLEM WITH PARAMETRIC CUSTOMIZATION

There are two terms at issue in this section. Though the terms themselves differ, they describe similar processes. The first is mass customization, a term which, as it is most frequently deployed, describes the idea that a customized good can be made on a mass scale. Mass customization generally entails the use of digital fabrication technologies in a flexible mass production context, which is to say that a manufacturing facility is configured in such a way that the nature of the goods produced can be changed without necessitating a complete refit of the factory (Blaszczyk, 1995). Zipkin (2001) suggests that mass-customization has three basic traits: a means of eliciting requirements from the customer, a production process flexible enough to produce one-off variations of goods, and a system of logistics capable of tracking and delivering goods on an individual level. The second term, parametric customization, follows on from the need to elicit user preferences and make a flexible production system feasible within the confines of a mass-production environment. Parametric customization is how most current mass-customization is done. It is a process by which a consumer uses a parameterized system (often in the form of a website) to customize a few variables in a product which is then produced through a wholly or partially automated process. By parameterized, I mean to say that a few specified elements of the good being

customized are capable of being manipulated. In a garment, for example, a user might be able to specify custom values for particular measurements (eg: inseam, chest circumference, etc.), what kind of fabric is to be used (from a set selection of fabrics), or the style of a particular element (different kinds of cuffs on a shirt, for example). All of these parameters are built into both the system by which the user customizes their good—often referred to in the literature as configurators (Aichner & Coletti, 2013)—and are accounted for in, or even constrained by the mode of production.

While it is not necessarily the case that all mass-customized goods are produced using parametric customization and online configurators, at the moment, many are. Possibly in order to fit into existing industrial processes, popular mass-customized products (shoes, garments, computers, furniture, etc.) offer users configurator systems through which components, materials, measurements, and combinations can be modified or swapped. The modifiable parameters, and the extent to which they can be manipulated, vary from system to system and from product to product. For example, NIKEiD, which allows the parametric customization of various athletic shoes, has differing materials, colours, and themes available from shoe model to shoe model. Some of these are sold as functional options (such as the Flyknit range, which promises technical benefits [Etherington, 2012]), while others are more explicitly aesthetic (such as one shoe which offers a seemingly deliberately small range of available colour choices for its configurable elements).

Though a custom product can indeed be something which is uniquely made for an individual, most products and systems articulated in the logic of mass customization rely on many of the same assumptions as mass production. Most important of these assumptions is that there is no meaningful change in the process of production or requirement-gathering. In part, this is for practical reasons: the "mass" in "mass-customization" is not feasible if new design work or new modes of conveying user requirements and preferences must be devised or specified every time a template good is customized. There is an opportunity in customization for the user to put their own mark on a good. However, when opportunities for intervention are curtailed or over-structured both by the system through which input is collected, and by the mode through which the good is built, the potential value of the user's intervention diminishes somewhat. I indicated briefly in the previous section that the term "customization" implies a distinction from custom production: something is being customized, modified from a standard or generic form to become more appropriate for a given user. This could be thought of as distinct from custom production, a term which implies that a good is being made, from scratch, to respond to the requirements or specifications of a given (and known) user. Marsh (2012) offers definitions of what he calls mass customization and mass personalization. Mass customization, he suggests, is a process by which modular options are chosen by a consumer in order to customize a previously standard good. Mass personalization, he suggests, is the act of producing a totally unique custom good for a customer. Marsh's mass customization is a kind of mass production, but with modular parts which can be swapped in order to make a good more individual.

Who gains value from a custom or customized good is also at issue. Zwick, Bonsu and Darmody (2008) suggest that the benefit for producers in mass customization comes from a potential increase in customer retention and satisfaction. But does that satisfaction extend to broader benefits for the purchaser of a custom good? Some existing literature on consumption argues that agency is an important facet in one's relationship with an object. The ability to modify or put one's own mark onto a good, so the argument goes, mitigates some of the alienation that comes from having little or no stake in the industrial process that made the good. Campbell (2005) charts a move in the conception of consumers from "dupes, conned into buying quantities of aesthetically uninspiring standardized products, many of which they did not actually need

and few of which were capable of bringing any real or lasting satisfaction" to critical, resistant, and self-aware consumers engaged in building identities through engagements with products (p. 26). Campbell goes on to advance the idea of the craft consumer, "someone who transforms 'commodities' into personalized (or, one might say, 'humanized') objects" (2005, p.28). Watson and Shove (2008) argue this this idea of the humanization of objects through personal labour is consistent with ideas of craft production advanced by Marx and Veblen.

From a very different perspective, work in marketing and consumer behaviour suggests that having a stake in the design or assembly of a good can increase an individual's subjective valuation of the good (Dahl & Moreau, 2007; Moreau, 2011; Franke, Kaiser, & Schreier, 2010). This has been dubbed the "IKEA effect" by Norton, Mochon, and Ariely (2011). The idea that an individual can have a stronger affective relationship with a good is often leveraged to gain profit. Stories in the history of marketing and product development are circulated as reminders that there is a sweet spot between effort and potential failure. We are famously reminded of the early days of Betty Crocker cake mix, which rendered a cake too easy to make, supposedly causing those baking it to find the act/product unsatisfying, and too unlike the process of cake baking they were used to. In the story, the problem is solved by taking the egg powder out of the mix, instead asking the user to add an egg themself (this story is told in many places, one of which is Norman, 2010). The story can be seen in two ways. It is frequently taken as an example of a marketer finding a sweet spot at which a consumer can experience a desirable combination of satisfaction and convenience, which will cause them to feel pleased and accomplished, and thus buy the mix again—a tactic which seems to have worked, given the continued existence of Betty Crocker cake mix. Norman (2010) describes it as a kind of passive instruction-following, rather than a real creative act. Beyond the judgment of whether or not following instructions for baking a cake counts as a creative act, the story can be viewed as an example of the manipulation of affect for the purposes of profit. By contributing some additional labour and materials to the production of the cake, the user of the mix feels more positively towards the outcome of the process.

Even when one is supposedly co-creating a product by contributing labour, materials, or ideas, the user/consumer is all too frequently seen as separate from the process of production. The addition of user labour, in cases like the cake mix or a customized running shoe is not about creating an efficiency for the producer. While the rationale behind an IKEA flat pack might well be a saving in production and shipping which is then passed on to the consumer—along with the need for assembly—other experiences are designed to use labour to generate an affective tie. When you have chosen the colour of each portion of your new running shoes, they feel as if they are more *your* shoes than they might otherwise be. The contribution of labour, though it is a negligible addition to the process of production, adds value to the product in the eyes of its purchaser.

DRESSMAKERS AS PRE-INDUSTRIAL/EARLY-INDUSTRIAL CUSTOM PRODUCTION

Current practices of mass-customization are rooted in flexible mass-production processes and parametric customization. These processes differ starkly from many forms of pre- and even early-Industrial custom production. In this section, I look at a historical case: dressmakers. I use the word "dressmakers" to refer to (predominantly) women in (mostly) urban centres of the United States, England, and France during the 18th and 19th centuries who worked in a subset of the garment trade. While working methods were not entirely homogeneous between all of the cities and times encompassed in that range, they were similar in broad strokes, differing in specifics like whether or not a given dressmaker belonged to an incorporated guild, her proximity to centres of fashion, and whether or not she had clients who required court dress (a requirement in 18th century Paris, for example, but not 19th century Boston). Common to

all the dressmakers, however, is that they were engaged in a practice of custom production.

Dressmakers in the 18th and 19th centuries produced custom-made garments for known clients. Custom production of garments was a widespread and dominant practice. This is not to say that no mass-produced clothing existed at the time, but pre-made garments were neither of high quality nor of great desirability (Rogers, 1997). Those who could afford to employ a dressmaker, did. Many of the women who could not afford to employ a dressmaker (or could for some garments, but not an entire wardrobe) sewed their own garments, and indeed produced garments for their families. In the earlier part of the period, commercial sewing patterns did not yet exist, meaning that if women chose to make their own clothing, they would be dependent on existing clothing in fashioning a pattern for a new garment (Hafner-Laney, 2010). Dressmakers, as a profession, held the knowledge of how to draft a pattern—a task which would often be carried out on the client's body, sometimes with light fabric which would eventually become the garment's lining, as well as a pattern for the exterior portions of the garment (Crowston, 2001). Similarly, sewing machines were not introduced until comparatively late in the 19th century (Schorman, 1996), meaning that tedious tasks like the stitching of the hem on a skirt were carried out by hand.

Dressmakers worked in consultation with their clients. Customers of dressmakers would be invested in the design of their garments, providing guidance on what they wanted, at multiple stages during the process of production. In addition to providing both an initial idea and ongoing feedback, the customer was also in charge of providing the fabric from which the garment would be made. Fabric was an expensive commodity, and the businesses of dressmakers were generally small, with little scope for speculatively carrying large amounts of costly materials (Gamber, 1992). The cost of the components of a dress would equal or exceed the cost of the labour put in by the dressmaker and her employees (Hafner-Laney, 2010). The customer would be responsible for sourcing the materials she wished her garment to be made from, which would be fashioned in the dressmaker's workshop. A dressmaker on a smaller scale might well have had no permanent employees and indeed even a mistress with employees was very likely to use her own home as a workshop, doing her fittings in the home of the client (Crowston, 2001). There is historical evidence to support the idea that, in small towns in the United States, some dressmakers split labour with their clients, with clients paying for the specialized labour while doing the tedious but less-skilled plain stitching themselves (Fernandez, 1994).

In regions in which a system of indenture existed, the mistress dressmaker, proprietor of an establishment, would be paid a fee to receive an apprentice (paid for by the apprentice's family, a charitable institution, or some other benefactor), who she would then be responsible for training and housing over the course of several years (Rogers, 1997; Ginsburg, 1972). Apprentices carried out the least skilled tasks in an establishment (such as sewing the hems of skirts), while progressively more skilled workers would carry out commensurately-skilled tasks. In some workshops, the least skilled tasks might be outsourced to women who sewed in their own homes, for piecework rates (ibid). The outsourcing of plain sewing in such a case would allow the workers in the dressmaker's shop to focus on the parts of the task that required a higher level of skill. Cutting would be done by the mistress of the establishment or one of her more senior employees, as it was both an opportunity for costly mistakes (a wrong cut could ruin an expensive piece of fabric provided by the client) and the instantiation of the most prized skill in the workshop: the drafting of the pattern. For this reason, fittings were also carried out by the mistress or a high-ranking member of her staff (Crowston, 2001; Ginsburg, 1972). The system was not perfect, of course. For example, working conditions in the 19th century London garment trade were poor (Rogers, 1997) and the vast majority of 18th century Parisian apprentices never became mistress dressmakers (Crowston, 2001). And, being

a profession of women at a time when women were not generally seen as equal in business, dressmakers could be at a structural disadvantage compared to their male counterparts in the draping and tailoring trades (Rogers, 1997; Ginsburg, 1972).

Towards the end of the 19th century, styles of dress in the British and American spheres of fashion influence changed, with a garment called a "waist"—a kind of blouse—becoming increasingly popular. The move away from tailored suits and dresses, and towards waists and skirts has been seen as a contributor to the growth of mass production in garments for women (Gamber, 1992). Nancy Green (1994) has argued that a crucial move at the time was from production for a known customer to production for an abstract one. In the absence of a known customer, standard sizes and assortments began to stand in, in place of the individual and her particular requirements.

DRESSMAKERS VERSUS PARAMETRIC CUSTOMIZATION

Comparing pre-/early-Industrial dressmakers to parametric mass-customization systems reveals three key areas of difference. Those differences are the existence of a known client, the structure of interaction between client and producer, and how parameters for customization are defined. In this section, I elaborate on those three areas.

The prime difference between parametric mass customization and pre-/early-industrial forms of customization is the existence or not of a known user. In parametric mass customization systems, the user is treated as a mass-user. In the previous section, I raised Green's argument that an important move in the industrialization of garment manufacture was from the idea that a garment should be made for a specific, existing, real customer to the idea of a generic customer who does not need to be present for the good to be made. In the kind of custom production enacted by the dressmakers, a customer is necessary for a garment to be called into existence. In mass production, a garment is made speculatively, to be purchased by a customer in general rather than a specific customer. The contrast between a known customer and an unknown one also holds in parametric mass-customization. While the dressmaker has a specific customer in mind, the designer of the system through which mass-customization is done not only does not draw a one-to-one relationship between the good and its purchaser/user, but must assume some notional user, albeit one with slightly different tastes from another notional user. While an individual customer may well have the power to make modifications which render the garment more useful or better fitting, they are simply another user of the system. The system itself does not change to accommodate the user. In the context of a shared machine shop, individuals frequently build things for themselves. The Do-It-Yourself practices embedded in makerspaces and hackerspaces not only offer opportunities for individuals to make for themselves, but to share ideas, skills, and best practices with others participating in the shared context (Rosner & Fox, 2016; van Holm, 2017; Schmidt & Brinks, 2017). While shared fabrication spaces are often viewed as potential sources of innovation (van Holm, 2017; Lindtner, 2017), there is the potential for commercial engagement on a more modest scale: extending the existing DIY activities to encompass custom production for others. While I am not arguing that all shared machine shops should be aiming to spin off or host businesses, there is certainly the potential and the infrastructure for individuals in such spaces to be making goods, on a custom basis, for others. This leads to the second difference: how interaction in custom production is structured.

Parametric mass-customization systems that rely on configurators offer a very narrow range of opportunities for the user to intervene in the design of the good being customized. During the customization process, it is impossible to break out of the script provided by the producer. From a practical perspective, this does make sense if production will be carried out through a

standardized process, as is often the case in mass-customization. But, as with the dressmakers, it does not need to be the case when smaller numbers of goods are being produced. For the dressmakers, the process of design takes place in consultation with the user, who is capable of asking for modifications to not just specific measurements and elements, but to the whole garment. Such an in-depth consultation seems far less feasible when the interaction is constrained by a fixed interface. However, the use in shared machine shops of general purpose tools like 3D printers and laser cutters offers an opportunity not currently open to many mass-customization systems: the chance to make goods unconstrained by a specific industrial process. While the output of a given machine is of course bounded by the materials it is capable of using and by other exigencies, the one-to-one relationship highlighted in the previous paragraph offers an opportunity for a motivated producer to work creatively within the given boundaries, to the benefit of the end user.

Constrained interaction leads to the third element: when an interaction is structured solely by an interface which cannot be changed by the user, the range of parameters to be customized is also fixed. This differs from more traditional modes of custom production in which the selection of modifiable parameters is only limited by the construction requirements of the garment, the budget of the user, and the skills of the dressmaker. When I use a web-based configurator to customize a pair of Nike shoes, I am offered a constrained set of options which cannot be expanded. I am allowed to make choices about the colours and materials of certain elements of the shoe, but cannot, for example, choose a different kind of insole or different amount of padding on the tongue of the shoe. The design of the configurator restricts the user to the customization of a curtailed set of elements. This is an important problem when an edge case presents itself. If a user's requirements fall outside of the range of what is considered normal practice, a system of parametric customization bounded by a prescriptive configurator will not allow enough leeway for the user to have their needs met. For example, some activities which might be undertaken while wearing a garment wear more heavily on the fabric of the garment than "normal" usage. Cycling, gardening, or using an assistive device (like a brace or prosthesis, for example) might all cause wear on a pair of trousers. A tailor might choose to line the garment, or build in an additional layer of fabric in a certain spot in order to account for the anticipated wear. Such an option is unusual enough that it is unlikely to make an appearance in a generalist parametric customization routine, and would instead need to be undertaken as an after-market modification. Von Hippel offers the idea of the "lead user" (2005), an individual who pushes the boundaries of product design in order to meet a niche personal requirement. Van Holm (2017) suggests that many shared machine shops are populated by lead users, who, after meeting their own needs, may go on to commercialize their solutions. One hopes that such commercialization, coming from a recognition of non-standard needs, might build in a degree of attentiveness and care for the end-user.

The three items above are areas where modes and methods differ between how traditional forms of custom production have been carried out and how current systems of parametric mass-customization structure use. In the next section, I take those three items and turn them into actionable criteria for doing humane custom production and customization which is user-centric and carries over some of the valuable aspects of historical custom production As indicated above, some of those practices are already taking place in shared machine shops. In the following section, I provide a framing for the application of those existing practices in the service of humane custom production.

CRITERIA FOR DOING HUMANE CUSTOMIZATION AND CUSTOM PRODUCTION

In the previous section, I outlined three areas in which current modes of parametric mass-customization differ processually from historical

modes of custom production. I argue that, while the benefits of historical custom production are often ascribed to mass-customization, current modes of doing parametric mass-customization often do not provide many of the valuable benefits of older modes of custom production. Below, I build on the problems outlined in the previous section to suggest three ways in which we can do a more humane and user-centred job of customization and custom production of digitally-produced goods. The idea of "humaneness" I am advancing is not grounded in a particular discipline or literature, but is instead an everyday kind of attitude. To be humane, in its dictionary definition, is to be "characterized by sympathy with and consideration for others; feeling or showing compassion towards humans or animals; benevolent, kind" (Humane, 2009). I propose, as such, that to be humane is to be attentive to the needs and desires of another individual, and to exercise a degree of compassion. This orientation, I argue, is often eclipsed by the idea that a consumer has rational choice and the power to act on it. I propose that humane custom production puts some of the onus of care back onto the producer, and onto their partnership with the person for whom they are producing a good.

I argued above that what differentiates historic custom production from current forms of parametric mass customization are three factors: the existence of a known client, the absence of a constraining user interface, and the ability to modify or expand which parameters of a good are customizable. In order to do digitally-aided custom production and customization which carries over the best parts of the historical practice, we need to take on board the differences that currently exist between the two. I suggest that custom production which is humane and user-centric should be rooted in a real user, provide opportunities for interaction outside of a rigid interface, and offer flexibility in the range of parameters that can be modified. While I recognize that these criteria are not easy to implement on a large scale, that is perhaps what is most exciting about them.

The bulk of this article has been concerned with two modes of production: pre-/early-Industrial custom production and current modes of parametric mass-customization. I have offered some indications about how shared machine shops fit into the picture by providing spaces in which individuals and groups can and do think about how things are made. I now argue that the criteria I have outlined for humane and user-centric custom production could be best carried out in the context of shared machine shops. I outline my rationale below.

Rooted in a real user

Small scales make it easier to actively involve the user in the process of production. It is difficult, in current systems of industrial manufacturing, to attend to the specific needs of an individual user, rather than to the needs of the existing system of production. Attending to the individual user is far more achievable at small scale. It is easier for an individual or organization with modest throughput to provide a service in which a user can be seen as an individual than it is for a larger organization with commensurately large-scale production to do the same. Certainly, as manufacturing becomes more flexible through the integration of general-purpose tools like 3D printers, the promise of custom production becomes more tangible. But, I argue, when the manufacturing itself becomes more flexible, the problem of humane customization comes to be downloaded onto the interface for designing the good. Even if a system of production with comparatively few constraints is available, in order to operate at a large scale, there must be some constraints in the process of design. Otherwise, users are simply left to upload CAD (computer-assisted design) files, which—given the amount of labour and specialized skill currently involved in producing them—is not an outcome with enormous popular appeal. An individual rooted in or with skills gained in a shared machine shop could ease such issues by taking on the role of intermediary, offering the design expertise necessary to produce a good, using some off-the-

shelf 3D models, while working at an individual scale, attentive to the needs of the individual client.

Breaking out of the rigid interface

My second recommendation, that humane customization needs to allow and promote interactions that are not curtailed by the dictates of a static interface, equally lends itself to small scales. A routinized system of production and logistics can necessitate a constrained system of input. When the parameters for a good need to fit into a specific production framework, it makes practical sense for the system of input to map to the exigencies of the mode of manufacture. As such, small-scale efforts at production, which have a greater capacity for ad hoc solutions, offer opportunities for less rigid interfaces. In small-scale production, the producer has an unparallelled opportunity to elicit input and requirements from the user without the rigid constraints of something like a configurator. Indeed, one might consider doing taking a tip from the dressmakers and simply making the human the interface.

Flexible parameters

Following on from the idea that a less-rigid interface between the user and the producer is essential for humane custom production, I further contend that flexible parameters are also a key element differentiating what I am calling humane customization and custom production from currently-dominant forms of mass-customization. Flexible parameters make serving edge cases more feasible and are well-suited to smaller production millieux. Peter Marsh has argued that “[w]hen 3D printing techniques become an everyday part of manufacturing, mass personalization will truly have come of age” (2012, p. 61). I make the more general suggestion that the range of tools frequently used in shared machine shops to increase capacity and production skill (eg: a laser cutter or CNC mill offers the ability to do more complex woodworking than is feasible without) also offers the opportunity for producers situated in such locales to do forms of custom production which are not bounded by strict parameters dictated by existing industrial production processes.

CONCLUSION & AREAS FOR FURTHER WORK

In the previous section, I outlined three criteria for doing humane customization. More broadly, those three criteria can be encompassed in the idea that one way to leave room for discussion between users and producers is to leave some spaces where human intervention is necessary in order to complete a process. The act of intentionally leaving room for interaction and intervention fulfills the criterion of being attentive to the needs of a specific user. And that is an area where shared machine shops can be of especial value, offering a space for the small-scale digitally-aided production of custom goods, as I indicate above. While I am by no means suggesting that the value of shared machine shops is in being places of business or incubators for spin-off enterprises, I do contend that they offer an opportunity to consider the place of human agency in the production of niche and specialized goods. Humane custom production and customization, I contend, should be about the augmentation of human skills and capacities in order to meet user needs.

In the bulk of this article, I have contended that digitally-aided customization and custom production should (and does already) take place in shared machine shops. Others have already documented at some length the kinds of user-centric production which take place in Hackerspaces, Makerspaces, and Fablabs. Toombs, Bardzell, and Bardzell (2014) have notably documented tool-making practices in a shared machine shop, a kind of making for onesself which is extremely attentive to a particular desired use. I argue that those resident in shared machine shops are well-placed to scratch not just their own metaphorical itches, but also the itches of others.

I have aimed in this article to use a historical example to shed additional light on how we might

think about custom production. I suggest that historical analogs can be used to consider other issues relevant to the adoption of new technologies. In the case of custom production, the historical example of the dressmakers provides a litany of traits that can be used to evaluate the claims of current modes of mass-customization. While digitally-aided mass customization makes a grab for the terrain of "custom", the example of the dressmakers shows areas where mass-customization does not succeed in seizing that territory. Using historical analogs to evaluate current claims represents a way of finding what terrain is up for grabs, functionally and rhetorically.

NOTES

[1] The word "user" appears with some prevalence in the latter portion of this article. I employ the word "user" in particular because it implies a degree of agency which "consumer" does not always carry, while also implying the use of a system, something which "client" does not do.

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ABOUT THE AUTHOR

A researcher and designer, ginger "all-lower-case" coons studies and intervenes in the intersections of individuality, mass standards, and new production technologies. She is interested in the place of the user in the production process, and how individuals take control of the goods they use. Supporting those interests, she does research which combines

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IN SITU, 3D PRINTED HERITAGE SOUVENIRS: CHALLENGING CONVENTIONAL SPACES AND CULTURE

Samantha Vettesse, Constantia Anastasiadou

This paper outlines an Arts and Humanities Research Council (AHRC) funded Design Innovation Development Award project titled 'Enhancing the Authenticity and Sustainability of the Visitor Heritage Experience through 3D Printing Technology', undertaken in collaboration with the heritage organisation Historic Scotland at Stirling Castle, between academics in the Schools of Tourism and Design at Edinburgh Napier University. In this study, the research team produced a collection of 3D printed souvenirs in a variety of materials and scales on an Ultimaker 2 3D printer. It was set up within the castle next to one of the halls that formed part of a tour as a small, 'pop up' maker space and gift shop.

Keywords: heritage, souvenir, 3D printing, engagement, maker space

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by Samantha Vettesse & Constantia Anastasiadou

INTRODUCTION

This paper outlines an Arts and Humanities Research Council (AHRC) funded Design Innovation Development Award project titled 'Enhancing the Authenticity and Sustainability of the Visitor Heritage Experience through 3D Printing Technology', undertaken in collaboration with the heritage organisation Historic Scotland at Stirling Castle, between academics in the Schools of Tourism and Design at Edinburgh Napier University. In this study, the research team produced a collection of 3D printed souvenirs in a variety of materials and scales on an Ultimaker 2 3D printer. It was set up within the castle next to one of the halls that formed part of a tour as a small, 'pop up' maker space and gift shop.

The researchers invited visitors to take part in a short survey and then offered them a 3D printed item at the end (a small unicorn from Thingiverse to reflect the castle's branding). This study took place in situ to demonstrate the technology and processes involved with 3D printing and to engage the public and staff with the design process of 3D printing a souvenir from start to finish using these technologies and to experience, fleetingly, certain characteristics of a shared maker space.

The project started with the idea that traditionally produced souvenirs can often be thought of as inauthentic, mass produced, cheap, meaningless objects that are not worthy of serious consideration. (Swanson, 2004) However, souvenirs may be viewed as texts that reveal meanings and events behind their production. They can, therefore, act as tangible evidence of a visit that enables a reliving of an experience and retains the memory of a special occasion and location. (Morgan and Pritchard, 2005) Additionally, souvenirs are expressions of highly personal individuality, sense of self, creativity and aesthetic taste. (Swanson and Timothy, 2012)

Many contemporary museums and galleries have extended souvenirs' use as 'memory triggers', not only by expanding gift shop variety, but also by experimenting with digital technologies, such as 'apps', that allow the visitor to take home physical experiences and absorb them in their everyday lives, mediating place and enveloping the past with

the present. (Tung and Ritchie, 2011) There are also instances of maker spaces being set up within the museum locus as educational tools to engage visitors with particular exhibitions or themes in interactive and creative ways.

This study, in particular, concentrated on unlocking the potential of the established heritage attraction 'gift shop' and the personal significance of the souvenir object itself, employing many of the intrinsic qualities of an unregulated maker space, while exploring the dichotomies of this juxtaposed with commercial retail.

Heritage environments and an understanding of the history, societal inclusivity and public ownership of the buildings and artefacts can be lost in the institutionalised approach that heritage is often presented and funded. This can be because of the conventional dissemination of exhibited information, charging entrance fees or commercial gift shop provision, potentially excluding and disengaging segments of the population and even the local community. It can also be that children and young people do not fully engage with traditional heritage educational materials. This study, through the use of in situ 3D printing and experiential souvenirs, challenges these concepts by adding digital making, customisation, peer production and interaction to this encounter. The ability to potentially customise and interact with the making of souvenirs that 3D printing heralds may create opportunities to escape the serial reproduction of culture and engage the visitor in the creation of personal meaning. (Richards and Wilson, 2006)

This research also evaluates the outcomes of disrupting, through the introduction of several traits of a peer based maker space, a heritage retail environment, in this case frequented by a relatively affluent demographic with, arguably, 'cultural capital' (Bourdieu, 1984 : 43). This is defined as 'the sum of the resources, actual or virtual, that accrue to an individual or a group by virtue of possessing a durable network of more or less institutionalized relationships of mutual acquaintance and recognition' and 'a taste for fine art because they have been exposed to and trained to appreciate it since a very early age, while working-class individuals have generally not had access to 'high art' and thus have not cultivated the 'habitus' appropriate to fine art [understanding].' The paper will also discuss how aspects of the maker movement, including the use of desktop tools, sharing and collaboration and the use of common design standards to facilitate fast iteration can be beneficially assimilated into a seemingly dissimilar heritage retail culture and public and what the societal benefits of this may be.

LITERATURE REVIEW

Souvenirs as meaningful 'things'

Bjorgvinsson, Ehn and Hillgren (2010: 41), describe a 'thing' as something that 'challenges when entering the public sphere and the field of innovation research. A major challenge has to do with what is being designed – a 'thing' (object or service) or a 'Thing' (socio-material assembly that deals with 'matters of concern'). In this study, the researchers have treated the public interaction with the digitally made souvenir objects and their relationship with the deconstructed use of the heritage space as meaningful.

Souvenirs and the 'gift shop' are often overlooked as having any significance in how the public interact with their heritage environment. However, according to Norman (2004: 48), for example, 'we become attached to things if they have a significant personal association. If they bring to mind pleasant, comforting moments. Perhaps more significant, however, is our attachment to places. Our attachment is really not to the thing, it is the relationship to the meanings and feelings the thing represents.' In this way, the souvenir may, in some cases, eclipse the actual exhibit in the way that it is remembered or personally, authentically engaged with. Through digitally made souvenirs, this study moves the institutionalised heritage experience out of the prescribed space, into the gift shop then into

a domestic environment and considers the implications of this.

Gordon's research (2004: 135) claimed that, 'the universality of the souvenir can be understood in light of its underlying role or function. As an actual object, it concretizes or makes tangible what was otherwise only an intangible state. Its physical presence helps locate, define and freeze in time a fleeting, transitory experience and bring back into ordinary experience something of the quality of an extraordinary experience.' Souvenirs have the ability to be 'tangible, magical, sentimental, cherished objects of memorable experience, intangible reminders and golden memories' (McKercher and du Cros, 2002: 80). By providing a material point of reference for a specific memory, souvenirs create, recreate and mediate a multi-sense tourist experience (Morgan and Pritchard, 2005) and are a means of mediating or transferring messages from one reality to another (Collins-Kreiner and Zins, 2011: 19).

DIGITALLY MAKING COLLABORATIVE 'AUTHENTIC' SOUVENIRS

In this project, albeit a short pilot study where the publics' interaction with the actual 3D printer and designing process was relatively limited, aspects of the tourist and design co-creation processes were applied and the feedback was appraised. According to Binkhorst and Dekker (2009: 320) 'modern consumers want context related, authentic experience concepts and seek a balance between control by the experience stager and self determined activity with its spontaneity, freedom and self-expression.' Sanders and Stappers (2008: 6) define co-creation as 'the creativity of designers and people not trained in design working together in the design development process'. The ability of the visitor to simply interact with the making process of 3D printing, through colour choices, scales and inclusion of inscription, in addition to the occasional flaws and imperfections in the printing process, can lead to the additional experience of serendipity, often experienced by skilled makers.

The in-situ 3D printing experience that the research team facilitated for the heritage public seemed to elevate their souvenirs from being throwaway plastic unicorns into co-created experiential objects, embedded with 'authenticity'. Traditional 'craft' produces souvenir objects that are often perceived as more 'authentic' by visitors. (Littrell, Anderson and Brown, 1993) Elements of authenticity are thought to be implicit in craft production processes, materials, workmanship, exclusivity and authorship of the souvenir objects. (Paraskevaidis and Andriotis, 2015) This has been a long held belief, reflected in Redgrave's report of the Great Exhibition in 1851 which argued, 'wherever ornament is wholly effected by machinery, it is certainly the most degraded in style and execution; and the best workmanship and the best taste are to be found in those manufactures and fabrics wherein the handicraft is entirely or partially the means of producing the ornament' (Auerbach, 1999: 136). Handicraft and human touch can therefore equate to extended engagement with the object and a more intimate experience of ownership (Kettley, 2010).

The processes, outputs and experience of 3D printing technologies seem to be in contrast to this. Digital making, particularly 3D printing, engage the maker in a number of ways that differ from 'pure' handcraft or that which has been uniformly 'manufactured' by machine (Rotman, 2012). Pye (1968: 4) defines 'the workmanship of risk' as 'workmanship using any kind of technique or apparatus, in which the quality of the result is not predetermined'. The 'workmanship of certainty' is that 'always to be found in quantity production. The quality of the result is always predetermined before a single saleable thing is made.' It could be argued that 3D printing combines the best attributes of risk and certainty. Through the particular traits of 3D printed making in a shared, informal setting, the public applies 'communicative self steering' (Cornelius, 1988) and personal value to their relationship with the heritage environment and the exhibit.

MAKER SPACES AND THE CONCEPT OF 'LEISURE'

This project brought aspects of an open, accommodating maker space to the institutionalised setting of the commercial heritage environment. However, the tourist public had entered the heritage environment with a mind to it being a 'leisure' activity, where any engagement or learning would be informal.

Binkhorst (2009: 320) stated that 'during free time people express their quest for ever more unique experiences reflecting their own personal stories.' 'There is also a 'shift towards active rather than passive forms of consumption and an emphasis on living or intangible culture rather than static, tangible cultural heritage in tourism. (Gonzalez, 2008) The fundamental nature of creative tourism seems to lie in activities and experiences related to self realisation and self expression whereby tourists become co-performers and co-creators as they develop their creative skills' (Richards, 2011: 1237). In creative tourist experiences, the host and the tourist mediate authenticity in situ, each playing a role as the originator of the experience. Escapist experiences involve a greater immersion than entertainment or educational experiences. (Tung and Ritchie, 2011) According to Gretzel and Jamal (2007: 7-8) 'play, aesthetics and empathy strongly characterise new creative experiences. Further, stories woven around experiences support meaning creation, which is central to creative experiences'.

Peppler and Bender (2013) state that the maker movement and maker spaces are a diverse movement united by a 'shared commitment to open exploration, intrinsic interest and creative ideas.' Objects made in maker spaces can be, therefore, often social activities, and the learning that takes place is unstructured and has a particular relationship to leisure. (Cunningham, 2017) Maker spaces are related to production, leisure, entrepreneurship and 'creative commons' but the attitude within the spaces does not appear to be motivated by profit. Maker spaces connect the 'do-it-yourself' maker movement, the creative economy and the social reproductive work that makes the spaces feel alternative, 'anti-establishment' and 'radicalised' (Cunningham, 2017: 14). The maker space creates incentives for collective work. Evaluations of the concepts around 'leisure' are therefore important as maker spaces are supposed to be a 'fun' environment for do-it-yourself activities as a form of escape from everyday work. This, in many ways, aligns the maker space to the communal, 'free time' experience of holidays, cultural events and the type of 'creative tourism' intended through this study.

In this study, the heritage public were given a trial of the enabling, active role that being a digital maker allows, in a setting where they were sociable, informal leisure consumers rather than structured, institutionalised learners. Extensive follow on research as to the affect of this experiment may have had on the publics' engagement with the heritage environment was not possible in this project. However, the collected observations seemed to point to changes in the heritage publics' attitudes to their personal empowerment. Firstly, this may have been attributed to their relationship with the 'experienced stagers' of the 3D printing event. Secondly, the public felt that they may have a more creative self expression and a democratic 'say' in the way that the exhibits and environments were seen, mediated and 'owned' and that this might simply be reflected in a 'meaningful' heritage souvenir.

THE 'POP UP' RETAIL ETHOS AND THE MAKER MOVEMENT

In this study, the researchers attempted to set up a 'pop up' temporary, simple, maker and retail space, drawing upon aspects of both the maker movement's democratic, enabling environment and principles of 'experiential' retail and concepts of emotional attachment to the souvenir. Through this it was found that many of the traits of the relatively new phenomenon of pop up events and spaces align themselves to the maker culture well and are worthy

of further exploration.

Toffler (1981) coined the terms 'prosumer' and 'prosumption' to describe how the transition from the Industrial Age Society (second wave), to the Information Age society (third wave) was giving rise to processes that were blurring the boundaries between producers and consumers. Researchers have used other terms such as co-creation, co-production and collaborative consumption to describe situations where consumers collaborate with companies or with other consumers to produce things of value (Gayson and Humphrys, 2008). Fox (2014: 18) commented that 'third wave DIY draws upon the read/write functionality of the internet, and digitally driven design/manufacture to enable ordinary people to invent, design, make and/or sell goods they think of themselves'. Ritzer and Jurgenson (2010: 13) point out that '[economic development's] early years were dominated by production, especially in the factory. Recently, the focus shifted to consumption (with the shopping mall coming to rival, or even supplant, the factory as the centre of the economy)'. Pine and Gilmore (1999), Richards (2001), and Postrel (2003) all assert that there is a change in consumer behaviour where many consumers do not want to simply buy goods and services, they also look for engaging experiences. According to Gordon (2004), to be successful, pop up retail must create an environment that is highly authentic and experiential, focuses on promoting new product or brand attributes and enables a more face-to-face dialogue with 'brand representatives'. Consumers want more choice, personalisation, and participation in the actual retail experience. This engaged consumer also wants products, communication, entertainment, and marketing ploys that appeal to their senses, emotions, and stimulate their thinking. They want the process of purchasing to be fun. (Karolefski, 2003). These 'fun' interactions can include 'pop-up retail,' which involves 'sensation-rich and unique experiences that appeal to the growing desire for innovativeness and open-mindedness towards diverse, unique experiences, measured by consumer innovativeness' (Engelland et al., 2001; Midgely and Dowling, 1978; Steenkamp et al., 1999).

With pop up retail, selling products is often coupled with creating theatrical experiences where 'spectacle comes first' (Trendwatching, 2003). It can appear to offer something that is 'limited, discovery-driven and of the moment'. (Marchinaik and Budnarowska, 2014) 'Pop up stores tap into the current zeitgeist, evidenced through flashmobs where retail brands are keen to align themselves with aspects of youth culture.' (Baker 2008). Pop up offers 'massclusivity' (Trendwatching 2003), wherein exclusive no longer means being expensive.

Collins (2004) says that 'pop up marketing through pop up retail benefits the customer offers excitement from the novel experience, offers customers exclusive products or experiences, offers discovery or a surprise factor, offers a good way for consumers to learn about and test products, provides desired free samples and services to consumers, helps consumers spend money wisely, engages the consumer on a personal level, and provides entertainment desired by the consumer'.

While buying and selling seem at odds with the ethos of the maker movement, pop up appears to mirror the nonconformist, collective, emotionally authentic attributes of the maker movement, whether this is fortuitous or a cynical, commercial strategy. (Niehm et al, 2015) The temporary, highly personal nature of the event, where the public could interact with digital craft and speak directly to the 'experienced makers', in an unusual environment, added to the publics' experience, memory and value of their heritage visit, reflected in the team's observations and potentially challenging the established traditions of the heritage organisation.

RESEARCH DESIGN

The initial study took place in collaboration with Historic Scotland, in Stirling Castle in Scotland, producing 3D printed souvenirs of their visit to the Castle in July and August 2014. A research protocol

was agreed with Historic Scotland regarding the collection of data and the use of photography within the Castle, which also adhered to Edinburgh Napier University's Research Integrity procedures. The researchers excluded visitors under the age of eighteen from the interviews and only took a few photos, as there were many families with young children visiting on the days of data collection. The researchers were aware of the research integrity issues surrounding photography of children in public spaces and had adapted their research design and methods accordingly prior to the data collection process. All the interviewees signed a consent form, which detailed the purpose of the project and the use of the information they provided. The souvenirs were produced in a variety of materials and scales and were formed on an Ultimaker 2 portable 3D printer that was set up within the castle next to one of the halls that formed part of a tour.

The researchers invited visitors to take part and then offered them a 3D printed item at the end of the short survey (a unicorn to reflect the Castle's branding). The survey took place in situ to demonstrate the technology and processes involved with 3D printing and to engage the public and staff with the design process of manufacturing a souvenir from start to finish using these technologies.

Closed answer questions were produced which were then slightly modified to reflect feedback from the visitors after the initial pilot study. The questions were informed by the literature review and sought to identify the respondents' previous knowledge and exposure to 3D printers; their impressions of the printed souvenirs, and their willingness to pay and interest in souvenir personalisation. At the time of the study, and the nature of the collaboration with Historic Scotland and their gift shop, the questions in the survey reflected this, rather than a fuller exploration of the peer process or how the publics' perception of the prescribed, conventional characteristics of the heritage environment were challenged. Questions asked in the survey included:

- Have you heard of 3D printing before?
- In what context?
- What do you think of the printed items as souvenirs?
- If you had the opportunity to personalise your souvenir, is this something you would be interested in? (Anything you saw today when you visited the castle?)
- How much would you be prepared to pay for a 3D printed souvenir?

In total, 139 short surveys were completed on location over the course of four days and responses were also audio recorded to check for accuracy. The printer was set up so that participants could see and hear the items being printed whilst they were being interviewed. After the completion of the data collection process, the researchers also noted their observations of the visitors' engagement with the objects and their interactions with the printer in situ. The participant sample achieved consisted of 75 females and 64 males. 90% of the participants had heard of 3D printing before through public media (The Big Bang Theory sitcom and a news story item of a 3D printed gun were the most frequent associations/references made). Several participants had seen or used 3D printers in their work environment (as designers, engineers, information technology and scientific researchers); others also mentioned the use of 3D printers for a medicine/prosthetics purpose or the construction of aeronautical parts. Some respondents had used 3D printers in their school or had a museum/festival science experience with the printers. Only two respondents owned a 3D printer and one was a prospective 3D printer buyer. A number of participants stressed that although they had heard of 3D printing, this was the first time they were seeing a 3D printer in action. The findings were synthesized including respondents' comments and the researchers' personal reflections and observations of the visitor engagement with 3D printing in situ.

FINDINGS

In the context of this piece, survey answers and

observations relating to the 'value' of the souvenir and the 3D printing experience within the heritage environment, will be concentrated on for their relevance to the challenge to conventional heritage culture. Value will be defined as 'a reflection of the owner(s)'/ buyer(s)' desire to retain or obtain a product, introducing subjective aspects to the value of a product.' (Neap and Celik, 199: 181) Appadurai (1988: 70), says, 'economic exchange creates value. Value is embodied in commodities that are exchanged. Focusing on the things that are exchanged, rather than simply on the forms or functions of exchange, makes it possible to argue that what creates the link between exchange and value is politics, construed broadly. This argument justifies the conceit that commodities, like persons, have social lives.' Lin and Wang (2011) suggest that souvenir value lies in its authentic and hedonic characteristics. A selection of responses related to the concept of the experience and souvenir's 'value', from the survey and the observations include:

It is insane; it is awesome, absolutely incredible. I can feel the ridges, I guess it's how it's done. Being able to create something sounds cool.

Pay more for personalisation. Have a hand in the making. Seeing it produced at source is important. It's less tacky, more a souvenir as it's made there and not made in China.

I think it would work for people like me who are a bit geeky. The process as well I'm interested in. I would say definitely for me it's important to see it in action.

3D printing offers the satisfaction of visitors 'crafting' their own souvenir without requiring a full crafting experience that would be more demanding in terms of skill and time commitment. While part of the appeal of this particular study may have been the novelty and 'gimmick' of 3D printing, the combination of potential interaction, machine controllability and serendipitous flaws in process and outcomes appears to make 3D printing an appropriate, innovative tool for creative tourist experiences.

Although the pilot study did not involve visitors personalising their objects apart from choosing from a range of colours, their reaction to the prospect of further interaction, including adding their name or other inscription, choosing different materials, instantly seeing, scanning and printing objects in their immediate vicinity and adding visual elements of authentication of the time of their visit was gauged through the questions and observations. Most participants responded positively to these descriptions of achieving these characteristics through 3D printed souvenirs.

I'm not really a souvenir guy, but personalised gives you an extra option. If you could insert the personalised into the souvenir then that would be good.

The experience itself is not as important. The personalisation would be much more interesting.

More value, linking experience to the visit and the personalisation. It's educational.

See it happening makes it more significant, personalise it would be great, [the] interactive process makes it more interesting, like a pressed coin.

There's as many options as there are ideas. What you see when you go into a gift shop, you've seen before. This is 3D it gives it more realism, it is tangible and I like the fact you can personalise it.

The visitors' interest in having their souvenirs further individualised through inscription or certification appears to add to their association with the place and date of their experience, engaging them more emotionally with the souvenir object. Dating and inscribing souvenir objects appears to transform objects, in this case made from coloured plastic that may be mass produced, into highly individual, sentimental objects with personal meaning, whose intrinsic value is increased and may

fluctuate over time. In addition to this, the potential of using a scanned in version of an object related to the visit, where other people have the same object, can become a 'bespoke' item, bringing notions of individuality and uniqueness. These objects may also be consumed and kept as precious, treasured possessions rather than disposable ephemera.

One of the most interesting observations was the interviewees and onlookers' engagement with the process. One researcher observed, '*people were very interested to watch the printer while it printed and some stood and watched for five minutes or longer without speaking at all. Many people pointed and tried to grab who they were with to also have a look. The general feel was positive and engaged*'. Having the 3D printer present and running appeared to add to the overall experience and added value to what was otherwise described at times as 'just a piece of plastic'.

A good idea, I like the idea of scanning items and making what you like.

Seeing it being printed – watching it in action with the software expert, and a demonstration of what's happening becomes part of the experience.

Difference is it is made in front of you – not made in China.

I think that kids would love it, because it's modern. Adults would like it but from a novelty factor. Kids will see it as of their time.

It's one of the marketing ways. Ivory Tower to common world. Great to introduce technology to the public.

A few respondents suggested that 3D printed, customisable souvenirs would appeal more to children. Some respondents also highlighted the educational potential of the technology.

A few respondents commented on how popularising 3D technologies in a heritage environment was a good way to offer access to novel technology by different audiences.

Bringing the 3D printer and team into the castle space and gauging the audience's reactions to the processes and souvenir outcome appeared to point to additional 'value', of the experience and to the object. The way that the souvenir was valued by the public – engaged with in relation to the castle environment and tourist experience – seemed to point to a divergence in their established ways of thinking about heritage and retail. In situ, pop up digital making, within a historical castle space, and the possibilities offered (albeit hypothetically), of seeing them immediately 'owning' a part of the formalized heritage environment seemed like a popular concept with the audience. The experience and souvenir would appear to be 'valuable' to the public without this personal value directly affecting what is considered valuable to the heritage organization; what is displayed, given prominence or turned into souvenirs to be sold in the gift shop.

ANALYSIS

In this study, the research team experimented with setting up a 3D printer within a heritage environment and gauging the reaction to the potential of visitors creating their own souvenirs of that place (through choice of pre-defined imagery, materials and scale). Even at this time, as with maker spaces, it is feasible that when a simple 3D printer such as the Ultimaker used in this project, is set up within a retail environment, a customer could print out their own design or 'make (almost) anything' (Gershenfeld, 2005). Adding and changing materials are relatively simple as is adding one's own 3D printable file. The more difficult process is the CAD modelling of the design, but in doing this in advance, customers could choose from a range of predetermined designs while still feeling that their 'prosumer' experience of making was personal, participative and authentic.

Through the theoretical and empirical research undertaken on this project, several themes emerged where the motivations and, debatably, the

ideologies of the maker movement and 'alternative' maker spaces coincided with that of innovations in the dichotomous institutions of heritage retail and creative tourism. These cluster around ideas of emotional engagement with the objects made, creative and 'magical' experiences, connections between learning and leisure, enhanced opportunities for collective sharing and face to face interaction and new commercial models for prosumption and mass customisation.

Tourist souvenirs largely consist of mass produced merchandise that others have designed and produced for them. The literature on souvenir value has developed because in its current form, souvenir consumption is a passive process. Notions of souvenir 'authenticity' have focused on how close to the 'real' artefact the souvenir item or the significance of the item for the construction of self-identity (Belk, 1992) and associated meaning(s) (Baker et al, 2006). The opportunity to 'craft' your own souvenir alters our notions of identity construction and associated meanings attached to them. 3D printed souvenirs lead to self-extension through immediate, creative means – they offer further opportunity for self-expression and singularisation. Tourists may 'sacralise' these objects as they hold extraordinary power and carry stronger emotional and affective meanings. (Belk et al, 1991) 3D printing symbolically revises the standard souvenirs.

Visitor interaction with 3D printed souvenirs and their subsequent experience of their heritage environment has been considered in this study. Visitors' ability to choose, add to and change their own souvenir adds their individualism and 'self' to the object. In addition to this, the visitors incorporated individualised emotional investment in the object, which visually signifies a particular artefact, location and time, further bound them to their visit. The souvenirs, therefore, have a positive effect on the visitor's relationship with the heritage site at the time of their visit and their memory of their experience through the souvenir once it is taken off site, as they are personally 'embedded' within the object. In this case, as with pop up retail that is not necessarily in a heritage environment, the experience was further enriched by the publics' interaction with the research team and other interested members of the public at the site of the demonstration. This added to the unique, personal nature of their experience.

Through this study, the role of souvenirs have been reappraised as non-static mediators of individuality, memory, sentiment and experience. Despite this study's use of plastic and devices of mass production, the traditional role of the souvenir as a tool of mass consumption is questioned and repositioned as a multi-facetted, controllable, yet serendipitous, personal but co-produced, inexpensive and, at the same time precious artefact.

The way that 3D printing allows for individual, on the spot production of souvenirs also gave a special quality to the memento, meaning that each souvenir was completely unique. It had been made for each visitor at that moment in time, witnessed by them which seemed to give the small talisman even more meaning. Unlike previous research that suggested that the mass production of souvenirs led to a detachment of the visitor from the heritage experience, 3d printing allows for a mass produced but personalised experience that increases the subjective authenticity of the produced souvenir.

The unique nature of the 3D printer, which combines machine with an element of personal interaction, adds meaning to the making and souvenir experience. The 3D printing medium records both hand and machine tool movements as memory traces, further engaging the visitor with the artefact and site. Each product's meaning comes from a specific context that, to the creator, act as a further means of discovery. It can then be that digital making becomes a catalyst for creative expression and experience instead of just a means of production and that digital production with added digital complexities, such as mistakes, ridges and uneven textures, inspired by traditional craft and design processes and historical artefacts lead to

interesting souvenirs.

It was found that participants involved in the study valued their souvenir more because of their in situ interaction with the making process and their ability to personalise, adding something of their 'self' to the object and site specific visit. This embedded 'instant individuality' differentiates the 3D printed objects and processes from traditional souvenir consumption and craft tourism. In addition to this, the imperfect nature of 3D printing, including the break downs in technology, glitches and ridges, while 'unromantic', appear to add the realism, interest and authenticity of the object and visitor experience. The meaning of the souvenirs is, therefore, mediated and can change over time, between individuals between objects that have been printed out using the same file. Mass produced becomes highly personal and bespoke with implications for manufacturing methods, engagement and profitability.

As the 3D printer technology, through this study, has shown to have the potential to facilitate changes in society and social organisation, further research will focus on whether it demands a cultural response, whether it has an 'ideology' built in and what affect this technology could have on culture. 3D printing allows for a means of expression in an age when mass media is able to instantly introduce images and cultures, past and present, from all over the globe.

CONCLUSION

It could be argued that making anything commercial and concentrating a study on a western, relatively affluent heritage audience is relatively limited, as argued by Braybrooke and Jordan (2017: 43) that 'making practices only make sense within the dominant form of early 21st century capitalism'. It could also be said that while the 3D printed souvenirs and pop up nature of the 'digital making space' in a castle was unexpected and contradictory to what the tourist audience expected to see, the experiment was designed. In contemporary tourism theory, authentic experiences are highly personal and reflective of the visitors own creative inclinations. (Richards and Raymond, 2000) This project could be described as 'experience delivered in a neat package to make us feel we have discovered it.' (Perlis, 2011) However the use of digital making and shared practices brought to the institutionalised heritage environment, looked at through the lens of a collaboratively made souvenir object, affects ownership of the heritage environment itself. The souvenirs produced, and the interactive way that the public were allowed to participate in the digital making and express their sentiments as to the value of the experience, the object qualities, the object content, the surroundings and the formalised heritage offering gave meaning and profundity to their visit and relationship with the heritage organisation.

Aspects of unregulated 'ad hoc' maker space, that describe a maker identity, such as 'the development of a tool and material sensibility that relies on an extensive engagement and practice with tools and materials to learn how to use them well, how to judge which tools are appropriate for which situations, and to understand how to use available materials appropriately; the cultivation of an adhocist attitude, which involves learning to trust one's intuitions and judgments through a maker process and adopting practical approach to project building and learning; and developing a sense of community engagement with other makers' (Toombs, Bardzell and Bardzell, 2014) were lightly introduced to the heritage environment. While the public were participating in the leisure activity of visiting a historical site, they further experienced the leisure activity of impromptu, personalised, interactive making, as they may have experienced within a hobby led maker space. From the results of this project, it seemed to add to public engagement with the heritage environment and a new dimension to their attitudes on ownership and the value and meaning of their souvenir object.

Digital making and the creation of souvenirs, within 'unlikely' heritage environments and reflecting the

visitors immediate aesthetic interests – in this case a historic castle but in further research from this team, within the 'not yet loved' heritage of Brutalist buildings and domestic housing schemes, certainly disrupts the publics' preconceived ideas on tradition and conventions. These include ideas on what the heritage environment is, what souvenirs are, how different aspects of a hobby experience may interact, how digital craft may be considered, peer relationships between 'expert stagers' and non-experts and, most importantly, how the public may have a say in the possession of their experience and surroundings.

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HACKING THE MUSEUM? PRACTICES AND POWER GEOMETRIES AT COLLECTIONS MAKERSPACES IN LONDON

Kat Braybrooke

This paper examines the recent phenomenon of 'collections makerspaces', which are defined for the first time as dedicated public sites in cultural institutions with suites of creative tools aimed at inspiring new engagements with a collection through hands-on making and learning practices. Working from the notion of space as a form of power geometry (Massey 1993), its component parts woven together through an ever-evolving constellation of the overlapping histories, imaginaries and cosmopolitics of myriad actors, the paper begins with a genealogy of shared machine shops in the U.K. as viewed through four cumulative waves of innovation, with collections makerspaces located in a fourth wave that is defined by institutional affiliations. The circumstances of collections makerspace sites situated at three museums in London (Tate, the British Museum and the Wellcome Collection) are then explored through an examination of ethnographic observations of practices that are either canonical or distinctive, and the corresponding geometries of power they reveal. In conclusion, it is argued that the collections makerspace is emerging as a key site of critical institutional inquiry which carries the potential to reframe museum hegemonies through peer production practices.

Keywords: Makerspaces, institutions, hacking, museums, hegemony, power, practices, collections, new museology, digital learning, ethnography

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by Kat Braybrooke

> *"How people think about the institutions under which they live, and how they relate to the culture of their economy and society, defines whose power can be exercised and how it can be exercised."*
>
> – Manuel Castells

INTRODUCTION

Digital studio, innovation lab, makerspace, hackspace, fablab, incubator, Tech Shop, medialab, hardware studio, maker library, design hub – and now, collections makerspace...?! The role of the shared machine shop as a site of situated hacking and making practices is changing, its variations becoming as myriad as the titles used to describe it. What, exactly, is a shared machine shop today? Is it an "occupied factory of peer production" (Troxler & maxigas 2014), an embodiment of the myriad dreams and contradictions of neo-Marxism? Is it an exclusive sanctuary for tinkerers and craftsmen, a place to test out fabrication equipment while harnessing historical ways-of-making? Is it a public community centre that provides tools and machines intended to help people create things together? Or is it an incubator for transformative new models of digital participation in 'high' culture? The answers, it turns out, are as varied as the questions.

What current accounts do agree on is the fact that shared machine shops are evolving in form. There are enthusiastic visions of a digital fabrication uprising, of widespread cultural transformations enabled by peer production practices[1], of a future where anyone

can make anything (Gershenfeld 2012; Fleischmann et al 2016). There are cautiously hopeful depictions of the ways that sites can foster niches of lab-style experimentation, enabling the possibilities for groundbreaking sustainable innovations that can bring about deeper societal shifts in relations of power, capital and locally distributed production (Dickel et al 2014; Smith et al 2013). There are new kinds of sites being founded with feminist, intersectional and anti-colonialist needs in mind for users who do not identify with dominant hacker archetypes (c.f. Toupin 2014). Meanwhile, an increasing number of SMSs are emerging not from the grassroots but instead through cross-sectoral partnerships between communities, companies, institutions and governments. Examples range from the Inspiration Lab, a small site for digital creativity installed in Canada's Vancouver Public Library in 2015 with the support of the municipal council, to the global fablab network, which began as a collaboration between the Grassroots Invention Group and the Center for Bits and Atoms at the Massachusetts Institute of Technology's (MIT)'s medialab in 2001. Aimed at exploring local possibilities for community grassroots fabrication, the model spread to other regions who opened sites with the same suite of fabrication and design tools. As of 2017, thousands of fablabs are listed in 30 countries on fablabs.io, many in partnership with local actors such as India's National Innovation Foundation in Gujarat (Fab City Research Lab).

Even more recently, a new generation of SMSs have started opening their doors within the walls of cultural institutions in an attempt to bring in new sources of funding along with new audiences. In London, census data continues to suggest that while visits to museums and galleries are increasing, there remains a strong causal correlation between sustained public participation in 'high' or fine art culture and socioeconomic status (Department for Culture, Media & Sport 2016, 2017; Trust for London 2015). At the same time, a blurring of boundaries between popular and fine art cultures, combined with neoliberal austerity measures across the U.K., has led to increasingly commodified settings for museums, who now must compete with shopping malls, movie theatres and other consumptive entertainments to entice visitors (Prior 2005). To address these concerns, since the 1970s institutions like Tate have tested out new museology-style[2] experiments which implement 'free learning'[3] and other hands-on pedagogies for engagement. They have also increasingly been drawn to the digital innovations of net art and other critical movements, building on a more general orientation towards participatory and relational aesthetic [4] approaches which attempt to reorient the traditional oppressions of the relationship between artists and audiences (Bishop 2012; Bourriard 2002). Experiments have taken various forms, from commissioned hacks of official museum websites, to robots remote-controlled by visitors to roam exhibits at midnight, to the phenomenon explored by this paper: 'collections makerspaces', or dedicated public sites with creative tools [5] and facilitators aimed at enabling novel engagements with a cultural collection through hands-on making and learning practices.

Some argue the critical potentials of once-autonomous shared machine shops are being diluted by the contradictions of partnership models. Initiatives like Living Labs [6], for example, have been criticized for presenting themselves as alternative, horizontal and user-centered while reinforcing neoliberal and technocratic models of urban governance that still serve the interests of capital (Cardullo et al 2017; March & Ribera-Fumaz 2016). The makerspace brand has been derided for allowing the U.S. military to play a key role in its financing (Söderberg & Delfanti 2015), and collaborations between sites and technology corporations through co-sponsored hackathons [7] and other events have

been shown to produce not only prototypes but also entrepreneurial subjects, united by a shared belief that technological innovation will lead to material abundances which increase "the size of the economic pie [for a few] as an alternative to redistributing it" (Irani 2015: 802). Tensions between partners in controlling representation and practices have been noted in collaborations between grassroots innovation movements and mainstream institutions (Fessoli et al 2014) and in conflicts between open and closed worldviews within digital innovation and fabrication networks in the Global South (Zindy & Heeks 2017). While similar tensions have been recorded at library-based SMSs (c.f. Sheridan et al 2014; Slatter & Howard 2013), there remains a lack of qualitative research which examines museum-based sites, especially from a U.K perspective.

This paper explores the circumstances of three colle ctions makerspaces at museums in London, and their relationality to other kinds of SMSs in the U.K., by examining their practices and the geometries of power they reveal. Are collections makerspaces merely stewards of the donors and corporations who brought them into being, shaped by a late-capitalist experience economy where sovereignty is abandoned in pursuit of much-needed funding – or is the reality more complicated? The analysis unfolds as follows. First, conceptual inspiration for the intersection of spaces and practices is discussed through key theoretical approaches that explore the effects of institutionalization and of space as power geometry. This is followed by a brief genealogy of shared machine shops, which I argue can be viewed through four temporal waves of innovation in the U.K., with collections makerspaces emerging as part of a 'fourth wave'. This claim is explored through an examination of ethnographic data gathered during interactions with collections makerspaces at Tate, the British Museum and the Wellcome Collection where I served as researcher-in-residence. Findings are organized according to canonical and distinctive practices observed, and their effects on spatial power geometries between sites, host institutions and funders. In conclusion, I suggest the collections makerspace can be viewed as an experimental – and potentially radical – field site for critical institutional inquiry, where museum imaginaries and hegemonies are being gradually reframed through tactical deployments of peer production practices.

THE MAKERSPACE IN THE INSTITUTION: SPACE AS POWER GEOMETRY

This paper situates itself around the notion that spatiality is a constantly evolving process, woven together through multiple articulations of social experiences, histories and relations coming together in "a situation of co-presence" (Massey 1993: 64). In line with the theoretical frameworks of thinkers like Lefebvre (1991) Massey (2005; 1993), Soja (1996) and Graham (2006) who have written extensively about the fluid and ever-shifting power-geometries of the spatial, I argue that a space [8] (from a public park to a neighbourhood to a collections makerspace) need not be defined only by its 'planners' (those who envisioned and built it) but also by the practices of its 'users' (those who work, make and hack within it). Even the most hegemonic of spaces is in fact a contested and mediated collaboration, its digital and physical imaginaries continually in the process of being reframed through the myriad discursivities, practices and routines of diverse actors. These actors may be humans (e.g. families) or non-humans (e.g. machines), and as actor-network theorists like Haraway (1991) and Latour (2005) and practice theorists like Savigny et al (2001) have pointed out, there is an increased need for social science and STS[9] approaches that integrate non-human actors as mediators, nodes and collaborators into the actor-network milieus of social processes and their corresponding shared

practices. Here, the shared machine shop emerges as a distinct environment that carries its own form of "cosmopolitics" (Latour 2004 via Stengers 1997), overlapping cosmos (worlds) woven together through evolving human and non-human alliances. It is also a potential space for contestations of power relations to occur through the processes of cultural hegemony (Gramsci 1971), where a ruling group attempts to maintain its domination through cultural discourses and symbols. Such discourses can be unpredictable, however, allowing counterhegemonic alternatives to arise in unexpected ways. In such moments of fluidity, even the most seemingly dominated of spaces can also become sites of subaltern resistance.

These critical perspectives suggest there is a distinct potential for the practices of collections makerspaces and other institutionalized shared machine shops to challenge the traditional roles played by their hosts. This is no easy task, however. The discourses of hegemony employed by U.K museums, and their myriad interconnections with British imperialism and colonialism, have been well documented (Delbourgo 2017; Harwood 2013; Fuller 2008; Hall 2005). Historians like Barringer (2006), for example, have traced geographical distributions of the acquisition of museum artifacts in the 1800s to parallel distributions of imperial capital and influence. Meanwhile, governmental efforts to harness the power of public institutions in the Victorian era included attempts to pacify and educate the rowdy working classes by inviting them into the museum for 'civilising', a form of societal self-regulation reinforced by the presence of well-behaved upper-class patrons (Hall 2005; Bennett 1990). Bennett (1990) and Bourdieu (1984) have described how the duality of the public museum as a site of order and the public fair as a site of disorder in this period laid the groundwork for the ways aesthetics and cultural capital continue to be employed as key symbols of economic superiority. As Harwood stated in 2003, "The museum became, and is still, a technical solution to the problem of displaying wealth and power without the attendant risks of social disorder" (377). These institutional discursivities have been similarly portrayed by Foucault and Miskowiec (1986) and also by Bishop (2012), who have written about museums as 'heterotopias', sites of infinitely accumulating prestige made every more powerful through their educative roles as masters of public knowledge and order.

By returning to the potentials for permeability in even the most historically entrenched spaces, however, even heterotopias can be seen as "articulated moments" (Massey 1993: 65) of networked relations that are contested and reworked through the introduction of new discourses. These contestations are especially present in blended sites like collections makerspaces, which are inspired by grassroots practices but also heavily influenced by the internal priorities of their host institutions. Garud et al (2007) describe institutionalization as the process by which a group of collaborating actors leverage resources to transform an existing institution or create a new one – and in the case of institutionally-hosted spaces, building consensus between opposing discourses becomes just as important as between those of other kinds of actors. Research has found, for example, that institutions tend to become more similar over time as a result of their interrelations (isomorphism, via DiMaggio & Powell 1983), and also that despite the hegemonic nature of their systemization, businesses and corporations are deeply affected by their encounters with informal grassroots groups (Fressoli et al 2014). As Seitanidi and Ryan (2007) have found, in partnership relationships of these kinds where both parties are actively, not passively, involved, corporate community involvement or CCI can also become a process of co-evolution. This paper therefore approaches the institutionalization of shared machine shops as a process that carries the potential for transformative dynamism, constructed through

social, cultural and political relations.

A BRIEF SHARED MACHINE SHOP GENEALOGY IN FOUR CUMULATIVE WAVES, FROM HACKLABS TO COLLECTIONS MAKERSPACES

In order to build an understanding of where collections makerspaces sit within the shared machine shop canon, this paper starts with a condensed genealogy of that legacy in four cumulative – and at times concurrent – waves. These waves focus in particular on moments of transformation, in the tradition of Jordan (2016), maxigas (2012), Edgerton (2011) and Smith et al (2016), who have called for critical re-buildings of historical technoscience narratives through examinations of their multiplicities and their absences. The birth of the shared machine shop occurred around the same time that the 'hacker' archetype itself emerged in the 1960s, taking form in the shared voluntary labours of collectivist yet amorphous groups of computer users who enjoyed exploring the limits of emergent technologies at labs at the Massachusetts Institute of Technology and other informal gatherings (Kelty 2008; Coleman 2013). These practices were similar to the 'jugaad' frugal engineering hacks that had already been employed collaboratively throughout the Global South for many years (Ray Murray & Hand 2014; Braybrooke & Jordan 2017), but with a new motivation which originated not from the necessity of limited technical resources, but instead from the leisure power associated with having a surplus of them. By the late 1970s, while the human tendency to engage in technological innovation was also nothing new[10] , the distribution of the first consumer-ready home computers allowed the possibilities for collaborative experiments to hit a new threshold. These developments also allowed artists and tactical media practitioners to explore hacking as a creative and critical practice, resulting in seminal works such as Roy Ascott's 'Terminal Art' (1980), a telematic art network built before the advent of a public world wide web that linked together a group of artists across California, New York and Wales using an early computer conferencing system[11] .

The clearest physical manifestation of the hacker subculture also emerged in the 1970s – the shared machine shop (SMS), or an innovative laboratory for experimentation and learning with open co-creation methods using digital tools (Dickel et al 2014). The idea of gathering spaces for hackers and machines to meet was not exactly 'new' at this time either; it could be traced, for example, to the 'invention factories' of the late 1800s, when a research lab was first built by the inventor Thomas Edison to promote technological innovation and scientific co-creation, inspiring 350 similar sites at research institutes across the United States from 1900-1940 (Holman 2015). In museums, meanwhile, 'wet rooms' had long been set aside for conservators to isolate noxious fumes and use new technologies to work with artefacts. The British Museum in London once housed its spaces for conservators in the same basements it used to preserve some of its artefacts during WWII air raids; in 2015, it launched the World Conservation and Exhibition Centre, marking the first time in its history that conservation staff were able to work with artifacts in natural light. However, the dissemination of the shared machine shop as a public space for peer learning and digital fabrication – not only amongst professionals, but also for amateurs who just wanted to experiment – was something new.

Like the traditions of hacking, this paper argues the unique subjectivities of the shared machine shop and its manifestation of peer production practices in action can be understood from a U.K.-based perspective through four distinct waves of innovation, from radical beginnings in the 1970s (Smith 2014) to divergent iterations by the 2000s (Culpepper 2016, Dickel et

al 2014; Sampsa et al 2014). The *first wave* of SMS innovation can be traced to 1970s London, where the United Kingdom's first SMS sites emerged under distinctly utopian and egalitarian circumstances. In 1976, industrial workers at the Lucas Aerospace corporation united with local labour networks, factories and socialist co-ops to build Community Technology Networks across London, sites that would test technologies relevant for 'socially useful production' over private profit, with innovations ranging from children's play equipment to small-scale wind turbines to disability devices (Smith 2014). The first hacklabs and medialabs that opened across Europe in the 1990s employed similar tactics, building solutions to local issues through autonomous, peer-produced physical fabrication – and, in the case of the medialab, new possibilities for a creative, radical, collaborative internet. A mixture of artist studio, hackspace and Californian 'cybercafe', famous medialabs like Artec and Backsp c (both based in London) helped inspire a new generation of practitioners to explore the implications of computer networks (Frost 2012; Bassett 1999.) High-profile pieces included the Tate's first net art [12] commission in 2000 entitled 'Uncomfortable Proximity', a critical hack by Graham Harwood of the artists' collective Mongrel which lead web users to an alternate mirrored version [13] of the Tate website that revealed its "cultural cosmetic surger[ies]" or self-censorship of less flattering legacies (Harwood 2003: 375).

Second-wave SMSs also started to open around this period and were typically referred to as hackspaces, preferring closed memberships to provide a safe space for those who 'just loved to hack' (Levy 1986). The goal of second-wave sites – many of which still exist today like Berlin's c-base, founded in 1995 – has often been long-term community salience over overt politicization, a fostering of greater public legitimacy for hacker subcultures in light of crackdowns on illegal activities during the mid 2000s (Farr 2009). The *third wave* of the SMS lineage can be defined as related to the period when hacker subcultures became a mainstreamed movement of those increasingly intrigued by the digital, with makerspaces, fab labs and open workshops opening around the world. 2008 has been cited as a key year in SMS history, when a widely-publicised exchange between German hackerspaces and American activists called 'hackers on a plane' brought these sites to the attention of various publics for the first time (Smith et al 2016). It can also be defined as the moment where the practices of 'openness' – that is, the free and agile sharing of ideas, templates, code and designs; the development of tools and systems for locally-distributed fabrication; the emergence of free culture and open knowledge movements around visions for a democratic, user-led commons – truly came into maturity as alternative systems of socio-economic production for shared machine shop communities (Jordan 2016; Benkler and Nissenbaum 2006; Benkler 2002).

The makerspace model, an open workshop with mentors and tools aimed at helping people learn how to make things, is a third-wave SMS variant that has been especially successful, with over 100 sites opened in the U.K. alone (Nesta 2015). Sites employ the term 'maker culture' to democratise shared machine shop traditions while drawing in users interested in creative activities not traditionally found in hackspaces, such as crafting or e-textiles (Meehan et al 2014; Davies 2017). The mainstreaming of maker symbols – such as O'Reilly's widely-read *Make* magazine and its makerfaires, where crowds of 100,000 gather in science fair settings to share projects (400 have been organized since 2012; the White House held its first in 2014) – have inspired a generation of enthusiastic digital fabrication converts, with some dubbing it a 'revolution' (Anderson 2012; Hill 2015). This claim rings a bit hollow in the face of current realities, however, with many sites remaining niche

playgrounds for the already-empowered, alienating less privileged users and dependent on core elements of the capitalist economy, from open markets to global supply chains (Davies 2017; Toupin 2014; Carstensen 2013; Fleischmann et al 2016; Grenzfurthner & Schneider 2009).

Meanwhile, since 2015 a SMS *fourth wave* has started to emerge which can be characterized through its diversification as hundreds of new SMS flavours are witnessed, from makerspaces in universities to mobile fab lab-library hybrids that cross interstitial lands to access users in rural regions (Culpepper 2016; Moorefield-Lang 2015). There are plans for a 'Flotante' fablab, its modules designed by fablabs around the world, which will float along the Amazon River to "better understand the green lung of the world" (UABureau 2016). Sites are opening in neglected urban districts of cities like Buenos Aires and Detroit once known only for their post-industrial decline, such as medialab and art centre Hangar, which sits in a former textile factory in Barcelona's El Poblenou district alongside radical citizen-led cooperatives (Braybrooke 2016). This wave is also defined by an increased institutionalization of SMS practices, with sites like collections makerspaces opening through partnerships between donors, technology brands and cultural institutions, many of whom had already been testing out digital innovations since 1994, when the Natural History Museum became the first cultural institution in the U.K. to publish a public website on the world wide web (Hawkey 2004).

Early reports have lauded the democratizing potentials of museum-based sites for digital making and learning (British Council 2016; Oates 2015). However, empirical evidence remains scarce, outside of few early efforts in the U.S. such as a 2016 survey which found sites affecting the functions of institutions themselves, from new uses of 'wet', messy materials to the introduction of new staff roles (Brahms & Crowley). This research echoes similar efforts in other sectors like that of Chesbrough et al (2016), who found that the open innovation processes of R&D teams had filtered into business practices themselves, in a gradual move from closed to open models. Despite this, an alliance between community, grassroots and institutional actors can be fragile, marked by contrasting priorities (such as entrepreneurship and business skills) to those of more autonomous models. As Smith et al note, "tooling-up" does not necessarily lead to social change, especially when external funder becomes prominent (2016: 104). What, then, is the situated nature of a collections makerspace within the auspices of a large cultural institution? How does it differ from the circumstances of other fourth-wave sites?

RESEARCH DATA AND METHODOLOGY

Addressing current gaps in knowledge by focusing on the practices of U.K-based sites was a primary concern for the project examined by this paper. When the study began in 2015, 34% of sites classified as makerspaces in the U.K. had been founded with a company or organisation, compared to 47% by informal grassroots groups (Nesta 2015). Only a handful of these co-founded sites were located inside an institution like a school or library, and even less inside cultural institutions. Because four such sites were located in London (Tate, the British Museum, the Wellcome Collection, and the V&A, whose digital learning space, the Sackler Centre, was under renovation at the time of the study), the decision was made to base research there. My own interactions with sites began at the Tate Digital Studio, which I first engaged with from 2013-14 while working as design curation lead for the Mozilla Foundation. Together, we built a digital curriculum pack called "Cultural Heritage Remixjam" which introduced open access and co-creation principles to educators in a museum setting, and this is where I first saw peer production practices employed within an institution. These encounters inspired the research on collections

makerspace practices later conducted at the Tate, the British Museum and the Wellcome Collection from 2016-2017, which this paper focuses on.

The Taylor Digital Studio (TDS) is a creative space for digital learning and making at the Tate Britain, one of London's oldest museums, built in 1897 when industrialist Henry Tate offered his collection of British art along with a £80,000 seed donation (Tate 2017). TDS opened its doors in 2013 as part of Millibank Project renovations, becoming a home for transdisciplinary digital programmes that combined art and technology. The Samsung Digital Discovery Centre (SDDC) is in the basement of the British Museum, the first national public museum in the world founded in 1753 (also as a result of a wealthy benefactor offering his collection to the state; this time it was the physician Sir Hans Sloane). The SDDC opened in 2009 through an agreement with Samsung Electronics to build digital learning experiences for young people aged 3 to 19. The most ambitious site of this study, its activities are carefully programmed and engage over 10,000 visitors a year. It is also responsible for the British Museum becoming one of the world's first cultural institutions to use virtual reality technologies to engage users in its collections through a Bronze Age tour (British Museum 2017; Rae & Edwards 2016).
The Wellcome Collection, meanwhile, opened in 1932 and is now the second-richest charitable foundation in the world (Dunjerski 2000), based around a vast public collection focused on the study of medical histories. Its benefactor Sir Henry Wellcome always envisaged bringing a museum, library and gathering space together, but it was not until extensive re-designs in 2014 to meet future visitor demands that the Reading Room (RR) re-emerged as a radical public venue for hands-on exploration (Wellcome Trust 2012). While it is the most "pre-tech" of the sites in this study, there are echoes of makerspaces everywhere in its myriad invitations from facilitators (c.f. Vigour 2016) to co-create and build through learning, making, rummaging and discussing. As part of their public mandates, the sessions and events of all three sites are offered for free.

In employing a multi-site ethnography as the primary method of research, this project was inspired by research that was distributed, iterative and based on collaborations with site users, allowing for immersive engagement instead of distance, a gradual "deferral to subjects' modes of knowing" (Holmes & Marcus 2008: 82; Atkinson et al 2001). In addition to working with primary sites, the research was also enriched by informal interactions, from tours to workshops, at other kinds of fourth-wave SMSs associated with institutions, from innovation hubs to privately-funded cultural bodies. These ranged from iHub's 'Gearbox' open hardware hackspace in Nairobi, Kenya to 'Hangar.org', a medialab and cultural centre opened in 1997 by the Association of Visual Artists of Catalonia in Barcelona. Meanwhile, acting as researcher-in-residence at the primary sites allowed for many moments of casual experimentation through hands-on making and hacking alongside site users, in a setting of co-present collocation (Trainer et al 2016). This included 150 unstructured hours of hanging out and making; participant observation of 20 workshops and public gatherings; action research [14] in the form of digital archive websites and workshops built in partnership with sites; 45 recorded individual and group interviews with site staff (managers, A/V teams, curators, facilitators) and collaborators (external artists, practitioners); and 50 questionnaires with site users (youth learners, adult learners, families) [15]. Interviews, questionnaires a nd participant observation notes were then coded, queried and organized manually into a set of thematic nodes using the qualitative analysis software NVivo. It was through this process that I started to understand that a core theme uniting user practices across sites was their similarity to – and also their distinctiveness from – the practices of other fourth-wave shared machine

shops. The next section of this paper analyses the data with regards to these guiding themes, while reflecting on the ways that the deployment of making and learning practices correspond to spatial politics and flows of power.

ANALYSIS: COLLECTIONS MAKERSPACES, PRACTICES AND POWER

An example of the kinds of activities typically observed at collections makerspaces was "Future Makers: Clay", a two-part weekend workshop in the spring of 2017 which I built the curriculum for in collaboration with site managers at the Samsung Digital Discovery Centre for the families-focused Innovation Lab/ Future Makers series. Inspired by science fiction and speculative design, participants were asked to analyse the British Museum's collection of Korean pottery as if they were aliens from parallel universes who were beholding Earth-made artifacts for the first time. The session started with a brief presentation of the seven Earth-like planets that had recently been identified in the Trappist-1 galaxy, followed by a tour of the British Museum's Korean pottery exhibit, where photos and notes were taken on tablets (provided by Samsung). The group then returned to the SDDC to share their galaxy's versions of pottery with Earthlings. Bringing together a diverse array of crafting materials, from model clay to fabrics to ornamental gemstones, families created their own ceramic artifact. Free glitching apps and design tools were then employed on tablets and mobile phones to 'remix' physical artifacts into digital renderings. The resulting images were projected onto a wall, with participants building a dynamic visual mosaic by adding their own physical and digital creations and then connecting them to others' works using thread and other materials. The result was a colourful, mixed media alien artwork that had been co-designed by all.

Many of the practices observed at collections makerspaces were historically similar to typical making or hacking activities found at other fourth-wave SMSs. For example, all three sites put a primary emphasis on enabling users to co-create and learn in groups. Site facilitators often acted more like peers than conductors, avoiding traditional presentation styles where possible and ensuring furniture, equipment and environments helped build the atmosphere of a "trying-out space" in the words of a TDS manager. Sites were proud of their "inherent dynamism" (Massey 1994, p. 2) as compared to that of the external institutional environment, displaying a non-hierarchical modularity in their workshops and actions aimed at empowering users to also act flexibly. "I think," mused a RR site manager, "watching how people use this space in different moments is fascinating, because it's not a space with overt rules. So sometimes when people come over the threshold, it takes them a while to figure out what they *can* do in the space and what they *want* to do… [the room] is designed to be… egalitarian, there's not the expert, there's not the audience. No one is going to tell you what to do." A TDS manager explained how he felt digital innovation had "always been all about open source, accessible versions of high-end software emerging… this kind of sharing is how so many great things have been made. And that's a big part of the Studio. Reminding us to create new things *together*, instead of being all fancy about it." In user feedback from sessions at all three sites, phrases like "I enjoyed making things with the group / working together was fun / I didn't expect to do this in a team" was common in answer to the question "how did this space feel to you", connoting that for many users (especially those new to the site), spatial engagement also meant spatial interaction.

Building and sustaining a sense of a community amongst site users, despite the limitations of doing so inside an institution traditionally focused more on patrons who donated funds and international visitors who only engaged sporadically, was another core priority for all three sites, much as it has been for other fourth-wave SMSs. As a TDS manager described, the Digital

Studio from the very beginning insisted on loads of collaboration […] bridging between teams […] because we had to bring so many facilitators, artists, technologists, curators, producers together to do any of it." Another TDS manager noted that while her aim had always been to invite a diverse subset of users into the space, in her background in education she had learned the hard way that it would not be enough to "just open the doors and expect the community to come to you." Relationships – and trust – had to be built manually with local organisations and schools, "so we started by setting up as many collaborations as we could. And it's taken a while. It's been slow." SDDC facilitators were also thoughtful in their analysis of user demographics. As one explained in a group discussion: "We do see that while about 70% of visitors to the British Museum are foreigners or tourists, this is not the same for the Samsung Centre… it is much more local, people come over and over, or they heard about it through their schools." The majority of site users also spoke English as a first language, unlike many of those who typically visited the museum's galleries above the SDDC. Staff wondered whether it was the digitality of the room that kept them away, its basement location, or the lack of promotional materials for the SDDC being provided in other languages. "This is really above my pay grade," a facilitator reflected, "but I think the families who come into this room come into museums a lot already… so, who isn't confident to come in yet? I feel like we still need more data on that."

Indeed, while the SDDC's weekday sessions catered to a wide variety of schools across the U.K., many of the parents I spoke with at the site's weekend workshops, echoing similar demographics observed at other kinds of shared machine shops (Nesta 2015), already felt it was valuable to engage with sites of this kind in general. When asked to compare the SDDC to other hands-on learning sites of its kind, almost all of them responded with another site they had been to in London. None said it was their first time at a museum, or that they had travelled from a location outside of the city, except for one family who were visiting from New York. One woman said she and her children spent every weekend rotating between free activities at the V&A and other museums. "I want them to take advantage of the culture here," she said. "Plus, they just love it." SDDC staff were quite proud, therefore, about the launch of a new initiative to engage lesser-served families by providing roaming hands-on digital activities in the main galleries of the British Museum upstairs, in order to draw in new participants who might not enter the SDDC otherwise. At the RR, by far the most publicly-oriented and busy of the sites, a group of facilitators undertook an extensive ethnographic research project in collaboration with external academics when the site opened in order to build a better understanding of user behaviours and needs. From this they built a framework to enable those who looked hesitant to learn and play, "invigilating more participation by staying out of the way, feeling it out" in the words of a site manager. This enabled an informal environment which gave users the freedom to explore, touch and look before settling.

As was the case for many of the other fourth-wave SMSs I spoke to who had opened in partnership with institutions, maintaining equilibrium in funders ite relationships was a key consideration for collectio ns makerspace staff. Due to cultural funds disappearing across the U.K. as a result of increased austerity measures, a trip through the British Museum is a trip through a history of corporate transactions, with names like 'Air Korea' and 'Goldman Sachs' listed aside exhibition titles. The SDDC, for example, was both named and built in the image of its donor, its white cupboards filled with Samsung-only kit. Staff and user opinions on this matter were largely ambivalent; they were aware the site would not have been possible without such a friendship, and expressed gratitude for having been able to engage so many young learners through the project. After all, sponsorship at institutions like the British Museum also means power – for staff, the mandate

to deliver experimental programmes; for funders, the prestige associated with being a part of the arts by association. As a non-governmental public body, the British Museum in particular seeks out a great deal of external support for its research and exhibitions. Under a new Corporate Membership scheme launched in 2014, sponsoring companies were offered a variety of additional privileges, from special "behind the scenes access and invitations" to exclusive opportunities to "entertain clients and staff in galleries" outside of public access hours (British Museum 2014).

One of the most infamous cases of institution-funder relations has been that of the multinational oil and gas company BP (formerly British Petroleum), which regularly donates large sums of money to cultural institutions across the U.K., from the Royal Opera House to the British Museum. In the late 2000s, its sponsorship of the Tate was thrust into the public spotlight due to its negative human rights and environmental reputation after events like the 2012 Gulf oil spill. Platform, Liberate Tate and other protest groups (their activities unhindered by Tate security and other staff, themselves in conflict regarding the relationship) held a series of high-profile occupations of the Tate Modern, which included a 25 hour stint of writing anti-BP messages on the floor of the Tate's Turbine Hall, tattooing CO2 concentrations in the surrounding atmosphere on activists' skin, and pushing through a freedom of information tribunal that exposed BP's sponsorship amounts to its recipient institutions, accusing BP of "using its donations to buy 'cultural power'" (BBC 2015). In 2017, BP ended its 26-year relationship with the Tate, citing only an "extremely challenging business environment" (Khomami 2016). Staff and users across all three sites discussed the opaque nature of these kinds of relationships, a sense that what was deemed possible when it came to digital innovation was often based on the whims of those in ascendancy. As a BM facilitator reflected in a group chat: "In the end, it really does all come down to funding, and power, who has it, what they use it for… unless there's specific funding for digital, a museum this big is not going to prioritise that when they have so many other concerns." Staff and external collaborators across all sites nevertheless expressed the belief that inside their spaces, the motivation had always been to ensure site users themselves had the most power – to reframe their engagements with collections, and even to reframe the museum.

PRACTICES DISTINCT FROM THOSE OF OTHER FOURTH-WAVE SMSS

Other practices and interactions observed appeared to originate from the unique spatial geographies of the collections makerspace, situating it squarely within its environment. The emphasis on good facilitation over the latest technologies, for example, was often stressed by both staff and collaborators. Despite being the most visibly 'high-tech' of all sites, SDDC facilitators felt that the "careful framing of an activity" always trumped the introduction of fancy tools. Relying on the use of new technologies "to the exclusion of old or existing technologies", they asserted, would be foolish. The TDS took a similar approach. "A very interesting bit of learning I had here," a collaborator reflected, "was that you can do deep learning about digital culture with very few tools – it's the concepts and the exchanges – not the computers – that matter." As a space fully dedicated to youth-focused digital learning workshops, the majority of which needed to be booked in advance, the SDDC was especially thoughtful about its employment of the digital, aiming for "clever" integrations that aligned with the U.K. national schools curriculum. Sites also cited the influence of constructivist [16] and hands-on pedagogies for peer-led learning. "Working in e-learning in the 1990s," a TDS collaborator explained, "I really started to understand how teaching approaches are always socially constructed. Hands-on learning… is the most emotionally satisfying, and useful." RR staff described their motivation to "hack" typical power

relationships through Open Platform, a user-led series where anyone could come and hold a workshop or conversation about the RR collections. Indeed, it was during these sessions randomly run on a variety of topics, from artist discussions on dyslexia and creativity to conversations about health and resilience while stitching personal well-being postcards, that the RR really came alive.

The use of remix as a primary method for interacting with museum collections is another legacy that remains distinctive to the collections makerspace and its unique institutional affordances. From an analysis of archival data [17] from over 50 events since the TDS opened in 2006, ranging from drop-in meme-making workshops to digital artist 'show-and-tells' where external practitioners explained their practice and lead hands-on making activities, it was found that 80% of events had employed remix practices to engage with Tate collections. Site facilitators explained almost all of their young peoples' programmes made some use of the collection. "When teens get to choose classical art images and then remix, repurpose, recombine them," an artist collaborator explained, "now that's a very powerful way to change ideas about museums." Another external practitioner who had lead art workshops in the space described her motivation: "We are so alienated from our own culture. That's really interesting but also problematic, and we need to take it back. We need to appropriate it now, not defy it… rebuilding the elements… we think are worth re-creating together." The rich variety of interesting out-of-copyright works available at Tate Britain made its remix-focused sessions especially popular for younger users who regularly engaged with the TDS. At the RR, meanwhile, a manager explained her favourite artifact in the site's collection was a reproduction of the Ripley Scroll from the 1600s. For many years, she said, it had sat alone in the Rare Materials Room due to its fragility and value. But when the RR opened, a reproduction of it was made openly available for people to see, touch, and work with. "It's an amazing moment in our time," she said, "where that kind of thing can be allowed."

Enabling possibilities for youth leadership was another core method employed by sites to reconfigure the traditional hierarchies and elitisms of museum power geometries. Tate Collectives is a leadership programme for young people aged 13-25 who curate events for other young people at the Tate. The TDS has been a primary site for Tate Collectives planning sessions and events. "I remember one of the first youth meetings I'd ever been at," reflected a user who had started volunteering at the Tate as a teen. "There were Jaffa cakes, they were trying to get young people interested, but it just wasn't really possible because we were in a really boring board room. It felt so power heavy. Like being at a business! How can we get young people from disadvantaged backgrounds involved in a place like that? So we needed a room to make them feel more comfortable… and this space came at the perfect time for that, because they really do feel like it is theirs." The SDDC also put an emphasis on finding ways for young people to engage their parents in co-creation during family sessions. In the "Digital Makers: Clay" workshop outlined earlier in this section, the parents started by making it clear to us that in joining a free digital making activity for families, they had not intended to participate themselves. Instead of picking up the Samsung devices on the tables, most began by disengaging from the session entirely, staring intently at their phones – until a facilitator came over to ask them if they would like to make an artifact alongside their children. After a moment of surprise, most parents rose to the challenge.

The last characteristic distinctive to the experience of the collections makerspace, distinguishing its environment from that of other fourth-wave SMSs, was the intricate complexity of the relationship each site had with its mother institution. Unlike a similar partnership at a SMS within an academic institution, for example, where the SMS essentially acts as a hands-on extension of the school's educational mission (for more on

this, see Culpepper 2016), collections makerspaces were viewed by site staff and collaborators as "cutting-edge proof of concept site[s]" that would inspire museums themselves. Invigorating the external institution to employ more open, collaborative methods was a primary motivation. A SDDC facilitator explained their feeling that sites of this kind should act as precedents for new ways of working within the organisation; being at the cutting-edge, he said sites could act as "experimentation labs" to ensure a different future for everyone. A museum collaborator described his continual frustration with the glacial pace of change due to institutional hierarchies: "In terms of what we do at this museum, we're still baby-stepping in terms of technology used innovatively in its actual galleries. Why is it only allowed in this one room? Everyone's using classical methods still, ignoring this… so how do we get the rest of them to listen?" At the TDS, a manager relayed a more hopeful perspective: "We can't remove this room from its surrounding infrastructures. It was built to be a part of the museum. But helping the Tate become more experimental and open, when its departmental structures and architectures don't really support that, is an ongoing project – and an important one."

CONCLUSION

As a new generation of sites for making and learning practices have emerged in the U.K. with a focus on cultural collections, it has become possible to examine discourses of hegemony and reinterpretation that co-exist within the institutionalization process. It has also become possible to build an understanding of their unique circumstances, woven together from overlapping cosmopolitics of traditions, values and cultures. In exploring staff and user experiences at collections makerspaces within the Tate, the Wellcome Collection and the British Museum, this paper revealed evidence of canonical practices that were reminiscent to those found at other fourth-wave SMSs, from co-creation and group learning activities, to maintaining a sense of community amongst users, to the cautious equanimity of funder-site relations. Distinctive practices specific to the time-space continuum of the collections makerspace were also found, from a staff emphasis on good facilitation over the latest technologies, to deployments of remix as a primary method for engaging with collections, to the influence of host institutions. As a result of these practices and their effects on the overlapping cosmos of sites and their institutions, this paper argues the collections makerspace is emerging as a critical field of institutional inquiry situated around tactical deployments of peer production practices.

As a fourth-wave actor in the U.K.'s tradition of shared machine shops, marked by a unique set of circumstances that foster the proliferation of both hegemonic and counterhegemonic discourses, the collections makerspace both perpetuates and reframes the legacies of its host institution. Through the use of experimental practices and concepts, the cosmopolitics of values and priorities between sites, funding bodies and institutions are always being renegotiated. In discussing a project in collaboration with an indigenous community from Australia, an artist and Tate collaborator explained to me how they had described their precolonial tradition of continually remaking their society's shared 'jukurrpa' (dreaming) histories through the creation and recreation of specialized paintings that depicted these traditions, the cultural expertise of which was shared collectively amongst the community. "This is the problem with institutions like the Tate," she explained. "They have historically taken our shared culture and they have made it elite, and we're supposed to feel they're now being generous – but I think something powerful about digital culture is it can allow people to make something of their own again. There is something about having these sites in cultural institutions, saying you need to remake

this together with us to help it come alive again […] that's everything. *That's* the change." Perhaps it is in these meeting places of time and space, these emergent-yet-familiar constellations of artifacts and actors and practices, that collections makerspaces can help cultural institutions themselves come back to life, too.

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NOTES

[1] This paper is informed by Yochai Benkler's (2006:60) characterisation of peer production as practices that are "decentralized, collaborative, and nonproprietary, based on sharing resources and outputs among widely distributed, loosely connected individuals who cooperate with each other without relying on either market signals or managerial commands.

[2] A method based on the belief that the role of museums in society needed to become more innovative and less elitist, allowing for new forms of expression and discourse and a redistribution of power (McCall and Gray 2013)

[3] Hooper-Greenhill & Moussouri (2000) describe free learning as a set of pedagogies that are non-sequential, self-paced, voluntary and free in choice, where users co-lead the learning experience alongside facilitators.

[4] A concept first developed by N. Bourriard in 1996 to describe interventionist artworks aimed at building social environments between artists and viewers to collaborate as a 'community'.

[5] Due to spatial and funding constraints, collections makerspaces typically do not carry largescale digital fabrication tools such as CNC routers or laser cutters, focusing more on digital design and lo-fi making tools, from tablets and printers to photographic equipment and crafting materials.

[6] A Living Lab can be defined as a collaborative working environment, usually situated within a city or geographic region, that builds from a private-public partnership to foster local, citizen-led innovations.

[7] While there are many variations, a hackathon can typically be defined as an intensive multiday event where a group of collaborators engage in (usually unpaid) labour for the rapid production of software, prototypes and other digital projects.

[8] Here I refer to Massey's definition of space as a site where the social is "stretched out" (2013: 3), brought to existence through multiple narratives, histories and social interactions that allow it to intersect with time.

[9] Here I refer to Science and Technology Studies.

[10] Evidence of hominid technology usage as seen through the development of stone tools can currently be dated to around 2.5 million years ago, around the same time the genus Homo appeared.

[11]Ascott defined 'telematic art' as art forms that combined computer-mediated technologies to network between individuals who were geographically dispersed while involving viewers as participants. In the 'Terminal Art' piece, participants would be able to "tell the computer to turn up any mentions of giraffes and ice cream… the surrealists

could have a field day." More at http://telematic.walkerart.org/timeline/timeline_shanken.html.

[12] Term used to describe works made in the 1990s-2000s that used the internet as a medium for critical exploration.

[13] Site is still available online as of 2018 at http://www2.tate.org.uk/netart/mongrel/home/intro.htm

[14] By 'action research', I refer to the inclusion of generative or active outputs which are co-designed in collaboration with subjects. This may include the researcher and subjects swapping roles, sharing tools, building things and/or engaging in reciprocal sharing of materials, skills and ownership over the work (Pain 2003).

[15] Interviews were semi-structured around questions examining staff and collaborator perceptions of site practices, interactions and power relations, and ranged from 30 minutes to 2 hours in length. Questionnaires explored user perceptions and experiences, and were filled out and discussed during public workshops and events.Due to the confidential nature of interviews, all names have been anonymised, and titles have been replaced with the following general terms: 2) Site user; 2) Site collaborator; 3) Site facilitator; and 4) Site manager.

[16] Here I refer to the learner-centric approach to digital pedagogy that is based on the belief that learners construct knowledge through hands-on experience. For more, see texts like "The museum and the needs of the people" by George E. Hein at CECA: https://www.exploratorium.edu/education/ifi/constructivist-learning

[17] A digital archive of this data is openly available online as of 2018 at http://digitalstudioremix.tumblr.com.

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REDISTRIBUTED MANUFACTURING AND MAKERSPACES: CRITICAL PERSPECTIVES ON THE CO-INSTITUTIONALISATION OF PRACTICE

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Increasing digital connectivity and an evolving producer-consumer relationship has enabled contemporary shifts in expectations and experiences of products, production and consumption. Furthermore, the recent growth of shared machine shops has brought about a steady increase in access to the means of production at the local level. The convergence of such emergent digitally-connected technologies has become synonymous with hopes of new post-industrial production practices whereby information on how things are made travel globally, whilst the physical production of things occurs locally, on-demand. At this same time, the augmentation and intersection of ecological issues, technological capacities and economic concerns has given rise to the conceptualisation of Redistributed Manufacturing (RDM); the technology, systems and strategies that change the economics and organisation of manufacturing in ways that enable smaller-scale precision manufacturing, reduce supply chain costs, improve sustainability, and tailor products to the needs of consumers (RiHN, 2017).In recent years, proponents of RDM within academia (including the ESRC and EPSRC), industry (Including Digital Catapult, Innovate UK and the Ellen MacArthur Foundation), and policy (Including Nesta and BEIS) have sign-posted makerspaces or shared machine shops, and the communities who use them, as key actors for the practical embedding and progression of the discourse. The targeted endorsement of RDM at shared machine shops has spurred a significant level of interest, inquiry and tension amongst the communities who use them. As the RDM agenda continues to surround shared machine shops, a tension arises between peer-production practices that do and do not subscribe to the agenda. As the RDM discourse develops, so too does a resultant (un)privileging of particular materials, tools, techniques, and personas. The paper questions for what purpose individuals and communities within shared machine shops are engaging with the RDM agenda. In doing so, providing a case study analysis of how material flows, technical attribution, subjective experiences and context become shaped, unraveled, imagined, governed and institutionalized across peer production communities in relation to external agendas. Through a cross-comparative analysis, this paper will introduce and evidence the dominance of a digitally-legible assemblage of practices across UK shared machine shops in relation to the emergence of a digitally-dominant peer production technomyth. Advancing insights into the shifting hierarchies of the economic, environmental, and social concerns of RDM advocates and how such negotiations and co-constitutionary practices play out in relation to shared machine shops

Keywords: redistributed manufacturing, makerspaces, peer production, digital fabrication, networks

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INTRODUCTION

The convergence of emergent digitally-connected technologies and peer production practices has led to aspirations of post-industrial production practices whereby information on how things are made travels globally, whilst the physical production of things can occur locally, on-demand.

At the same time, ever-increasing labour costs abroad, high transportation costs, sensitivity to global production trends, material scarcity, complex supply chains and increased risk have renewed the

focus on the social and environmental impact of manufacturing and its externalities (Policy Connect, 2015). The augmentation and intersection of such ecological issues, technological capacities and economic concerns has given rise to the conceptualisation of Redistributed Manufacturing (RDM). This is an intentional reconfiguration of the distribution of manufacturing, which seeks to utilise emerging digital standards and practices to transition towards a more sustainable and resilient industrial landscape.

Emergent RDM discourse advocates a transition towards a more sustainable industrial landscape through a recalibration of existing infrastructure and practices (Stewart and Tooze, 2016). From creative commons licensing, to machine sharing, to open APIs; RDM agendas have looked to develop and direct the technical, material and cultural capacities of emergent decentralised production practices in ways that question and restructure how products are manufactured, how waste is managed, and how cultures of consumption operate (Tooze et al., 2014; Corbin, 2015; Policy Connect, 2015; Dewberry et al., 2016). This shift away from globally fragmented supply chains towards more locally oriented, responsive production ecosystems would affect not just products and material flows, but also the distribution of risk and consequence, reward and value (Stewart and Tooze, 2016).

In recent years, proponents of RDM within academia, industry and policy have sign-posted shared machine shops, and the communities who use them, as key actors for the practical embedding and progression of the RDM agenda (Kohtala, 2015; Prendeville et al., 2016). From the networking of digital tooling and the sharing of production waste solutions, to the normalising of certain artefacts, projects and practices – shared machine shops have been positioned as demonstrative sites for RDM proof-of-concepts (Tooze et al., 2014; Distributed Everything, 2017). It is our observation as participant observers within these communities of practice and academic interventions that the targeted endorsement of RDM at shared machine shops has spurred a significant level of interest, inquiry and tension amongst the communities who use them.

As the RDM agenda continues to surround shared machine shops, the tension that arises is between community-based production practices that do and do not subscribe to this RDM agenda. Through a secondary analysis of a national survey dataset and a critical reflection of initial academic programming, this paper will consider how, when and to what impact emergent techno-myths and corresponding national agendas get taken up within shared machine shops. In this paper we will argue that over time, a process of co-institutionalisation has occurred between a digitally-dominant narrative of peer production and a growing national RDM discourse. We will explore how, as individuals and communities find ways to engage within this process of co-institutionalisation, particular hierarchies of technical, material, social and knowledge relations have begun to emerge from within UK shared machine shops.

SHARED MACHINE SHOPS AND THE TECHNOMYTH OF DIGITAL PEER PRODUCTION

In this section we will explore to what extent the emergence of shared machine shops across the UK, and the celebration of particular technosocial practices within them, is privileging a distinct assemblage of technical, material and social actors from the wider arena of community-based production. Through analysing the open dataset of UK Makerspaces completed by Nesta in 2015, we aim to illustrate the technological and material realities that such a technomyth has begun to engender within UK shared machine shops. We will conclude this analysis by asking to what extent the marrying of shared machine shops, and the peer production communities who use them, to notions of digital fabrication so closely may ultimately prompt the homogenisation of culturally complex sociotechnical practices into technologically deterministic modes.

Shared machine shops have been heralded as 'occupied factories of peer production theory' – as sites for the realisation of a fourth industrial revolution wherein emergent forms of peer production[1] and grassroots digital fabrication[2] can take hold of previously inaccessible production power towards more democratic ends (Dougherty, 2012; Anderson, 2012; Journal of Peer Production, 2014). Dale Dougherty, founder of Maker Media and token 'father of the Maker Movement' reinforces this emerging assumption, explaining it is through the democratisation of digital tools, that 'making' has become a universal element of human identity (Dougherty, 2012). This growing narrative is also commonly placed within academic writing on the topic; for example, when Taylor et al. describe 'makerspaces' as the most visible manifestations of an emergent maker culture, as "they provide communal facilities in an openly accessible space, giving access to digital fabrication and open electronics, which have been collectively hailed as enabling a revolution in personal manufacturing" (Taylor et al., 2016). The wedding of those peer production practices found within shared machine shops to digital fabrication technologies continues to circulate across the Western world – from academic journals and conferences[3] to popular technology publications and outlets[4]. In echo of Braybrooke and Jordan, we argue that in this way the maker movement and it's digitally dominant narrative has become a neatly-packaged and widely disseminated way of understanding a myriad of peer production practices presently bubbling up from within shared machine shops throughout the Western world. In keeping with McGregor et al., Braybrooke and Jordan refer to such a phenomenon as a 'technomyth' whereby technologies are 'narrated' in ways that create a larger story about society whose key component is a determinism of our experiences of the world through our experiences of technology (2017). Advancing from McGregor, Dourish and Bell argue a technomyth acts as a foundational story by which a mythical future is constructed and then predicted simply by inventing it (2011). Dourish and Bell evidence the self-fulfilling nature of the technomyth through an exploration of the narrative that drove contemporary practices surrounding ubiquitous computing in the early 1990s. In this analyses Dourish and Bell argue that the techno-tale of progress which surrounded ubiquitous computing in the early 1990s became itself foundational to scholars in computer science and related fields – framing one's understanding of ubiquitous computing as a transformational force which would "change social relations, social order and daily life" – thus, in turn, shaping future innovations akin to this image (2011, p. 3).

We wish to argue here that the importance placed upon digital fabrication technologies within such narratives of the revolutionary nature of peer production has begun to form a technomyth about peer production communities and the sociotechnical practices that constitute them; a technologically deterministic narrative wherein computer-controlled and Internet-compatible digital technologies become a definitive frame.

ANALYSES OF THE OPEN DATASET OF UK MAKERSPACES

The open dataset of UK makerspaces, completed by Nesta in 2015, proves a useful mechanism for revealing the types of materials, tools, and users characteristic of shared machine shops across the UK[5]. An analysis of the dataset makes clear that shared machine shops across the UK vary greatly from one to the next. They are formed of diverse communities that consist of a broad range of social actors, from machine manufacturers and material developers to individual practitioners and special interest hobby groups. They are home to a diverse set of tools and technologies, from 3D printers and engineering lathes to jacquard looms and potters wheels. They can accommodate a rich palette of materials, from recycled plastic filament to clay, stone and glass. Yet, what also clearly arises from the dataset is a distinct pattern; a specific subset of material, technological and social actors that hold the foreground across the network of spaces – playing a lead role in shaping the practices that flow

within and between these spaces.

Through reflecting on these foregrounded practices, we hope to make tangible the way in which the pervading technomyth of digital peer production has begun to engender within UK shared machine shops. To better illustrate this argument, we share a summation of the Nesta dataset through three interrelated analytical frames: tools, materials, and users.

Tools

There are 16 unique production technology categories represented across the 97 shared machine shops surveyed in the dataset. These categories include: digital fabrication, woodwork, electronics, computing, fabrics, metalwork, plastics, printmaking, photography and film, ceramics, fine metalwork and jewelry, audio and music, science and chemistry, painting and graphic arts, sculpture, and glass. When measuring the relative prominence of each category, a significant disparity can be observed between the number of spaces that cite having the most prominent categories – digital fabrication (62 sites), woodwork (54 sites), electronics and computer (50 sites) – and the number of spaces that cite having the least prominent categories – glass (2 sites), fine metalwork and jewelry (7 sites), and ceramics (7 sites) (refer to table 1, section 1). Furthermore, an analysis of the tools found across the 97 shared machine shops surveyed reveals a total of 185 uniquely different tool types. When measuring the relative prominence of each tool, the prominence of digital fabrication technologies becomes clear as 47 sites house 3D printers, 43 sites house laser cutters, and 30 sites house CNC milling / routing machines. Whereas only 9 sites house welding equipment and only 4 sites house potters wheels (refer to table 1, section 2).

Materials

There are 16 unique material categories represented across the 97 shared machine shops surveyed within the dataset. This includes; wood and derivatives, paper and card, plastics, electronics, fabrics, yarns, paints, inks, metals, ceramics, clay, stone, chemicals, biological or organic, glass, and resins. When measuring the relative prominence of each category; the most cited material categories are wood and derivatives (58 sites), paper and card (56 sites), plastics (52 sites), and electronics (51 sites); and the least prominent are biological or organic (7 sites), glass (1 site), and resin (1 site) (refer to table 1, section 3). Again, note the significant disparity between these two poles.

Users

Out of the 97 surveyed shared machine shops in the dataset, 60 spaces contributed gender-related data. From these 60 spaces 55% registered a membership that was equal to or greater than 70% male. Only 18% of spaces that contributed data cited a membership that was equal to or greater than 50% female (refer to table 1, section 4). Furthermore, out of the 97 surveyed shared machine shops in the dataset, 49 spaces contributed data relating to the representation of ethnic groups across memberships. From these 49 spaces 96% registered a white majority, with 78% of spaces citing a membership that was equal to or greater than 80% white. For all other ethnicities – mixed or multiple ethnic groups; Asian or Asian British; and Black, African, Caribbean or Black British – all but one space cited a minority representation, with most spaces citing less than 20% representation across all groups (refer to table 1, section 5).

Out of the 97 surveyed shared machine shops in the dataset, 48 spaces contributed data on user-types. User-types include; student, hobbyist, visitor or observer, start up, sole trader or micro-business, corporate or large organisation, teacher, and SME. When measuring the relative prominence of each user-type; the most prominent user-type is hobbyist with 25 sites citing hobbyist as the majority of their membership; and the least prominent user-types include SMEs and Start ups, with 2 sites citing Start ups and zero sites citing SMEs as the majority of

their membership (refer to table 1, section 6). Out of the 97 surveyed shared machine shops in the dataset, 52 spaces contributed data on activity-types. Activity-types include; to socialise, to receive training, to get an introduction to making, to make something specific, to prototype, to make one-off pieces, to network or find a maker/partner/designer, and to do small-batch production. When measuring the relative prominence of each activity-type, the most prominent activity-types are to socialise (21 sites citing this activity-type as the majority of their membership) and to receive training (18 sites citing this activity-type as the majority of their membership); and the least prominent activity-type is small-batch production, with one site citing this activity-type as the majority of their membership (refer to table 1, section 7).

Section 1. Relative prominence of cited production technology categories	
Production technology categories	*Number of spaces citing this category*
Digital Fabrication	62
Woodwork	54
Electronics	50
Computing	41
Fine Metalwork and jewelry	7
Ceramics	7
Glasswork	2
Section 2. Relative prominence of cited tools	
Tool types	*Number of spaces citing this type*
3D printers	47
Laser cutters	43
CNC milling / routing machines	30
Welding equipment	9
Potters wheels	4
Section 3. Relative prominence of cited materials	
Material categories	*Number of spaces citing this category*
Wood and derivatives	58
Paper and card	56
Plastics	52
Electronics	51
Biological or organic	7
Resin	1
Glass	1
Section 4. Gender representation across membership	
Percentage of spaces	*Percentage of membership*

55% of spaces	≥ 70% male
18% of spaces	≥ 50% female
Section 5. Ethnic group representation across membership	
Percentage of spaces	*Percentage of membership*
96% of spaces	> 50% white
78% of spaces	≥ 80% white
69% of spaces	< 10% mixed or multiple ethnic groups
76% of spaces	< 10% Asian or Asian British
68% of spaces	< 10% Black, African, Caribbean or Black British
Section 6. Relative prominence of cited user-types	
User-type	*Number of spaces citing the user-type as a majority of membership*
Hobbyist	25
Students	8
Visitors and observers	7
Sole traders and micro-businesses	3
Start ups	2
SMEs	0
Teachers	0
Corporates and large organisations	0
Section 7. Relative prominence of cited activity-types	
Activity-type	*Number of spaces citing the activity-type as a majority of membership*
To Socialise	21
To receive training or learn a skill	18
To make something specific	17
To get an introduction to making	11
To prototype	9
To make one-off pieces	9
To network or find a maker/partner/designer	3
To do small batch production	1

Table 1. Analyses of the open dataset of UK makerspaces

THE MANIFESTATION OF A TECHNOMYTH

Analyses of the UK makerspace dataset shows how a dominant assemblage of user, tool, and material has emerged across the UK shared machine shop network. The dataset proves a useful mechanism and evidence base to demonstrate tangibly how a

distinct assemblage of social, technological, and material actors has begun to form within and between shared machine shops in the UK, mirroring the dominant technomyth of digitally legible peer production. We argue that the UK's emergent culture of digitally dominant peer production and this increasingly homogenous set of practices are therefore entangled within a cyclical dynamic of producing and being a product of the technomyth of digital peer production.

As this technomyth continues to encapsulate shared machine shops, so too does a vision of future community production predicated upon computer-controlled and Internet-compatible information technologies. In light of this, we argue it is crucial to consider to what extent similar-yet-different open access community-based workshops risk becoming excluded from the mix because the sociotechnical practices and communities they seek to support are outside of those which are digitally legible – reflecting on the impacts this exclusion may have upon the wider UK shared machine shop community. Consider, for example, to what extent those many open access print studios,[6] shared bike shops,[7] sculpture workshops,[8] and open wood / metal workshops[9] that mirror the organisation and governance models of shared machine shops yet remain largely absent from the growing technomyth of digital peer production. Many such sites operate based upon an open access model – each offering full access to workshop facilities and peer-to-peer communities at a cost comparable to those of shared machine shops. Many operate based upon a members-led governance model and shared-use policies whereby members not only share access to the workshop and its facilities, but also skills and technical know-how freely with one another. The core distinction is the communities of practice these spaces seek to support (printmaking, carpentry, blacksmithing, ceramics, and book arts, etc.) and therefore the types of production technologies and sociotechnical practices they house. In light of this, there is a need to deploy a critical lens to the formalisation and institutionalising affect of the digital peer production technomyth. For in contrast to the revolutionary proclamations of the digital peer production, there is growing criticism that such categorisations, in practice, are in fact lending to the systematic homogenisation of a heterogeneous set of cultural practices (Maxigas, 2014; Nascimento, 2014; Braybrooke and Jordan, 2017).

In *Challenging the Digital Imperative*, Wyatt argues 'people who choose not to use digital technologies remind us all that things "might have been otherwise"' (Wyatt, 2010, p. 11). For Wyatt, non-users play a crucial role within digital cultures as they 'sketch out alternative development paths that technologies could have taken' (Wyatt, 2010). We argue that the posing of alternative development paths, and the resultant challenge to technologically deterministic assumptions which occur in tandem, can engender what Maxigas terms *critical faculties* within a community – particularly when made by sophisticated non-users of a community (Maxigas, 2017). As Maxigas argues, even if the overall critique-and-recuperation logic of capitalism[10] cannot easily be challenged, everyday rejection of micro-changes – for example, the non-adoption of commodified technologies by non-users – can possibly help a community bring to light and navigate these problems through the all- important lens of critical reflection (Maxigas, 2017). In keeping with such arguments, we find concern in the growing dominance of the digital peer production technomyth across UK shared machine shops. As the evolution of such technotales have often lent to the homogenisation of heterogeneous sets of cultural practices (Maxigas, 2014; Nascimento, 2014; Braybrooke and Jordan, 2017). We therefore ask: to what extent might a loss in the diversity of users or the heterogeneity of sociotechnical practices that constitute UK shared machine shops lead to a loss in connection between adopters and non-adopters? And what impact might this loss of connection have on a community's critical agency and capacity for reflexivity and reflection?

THE EMERGENCE OF REDISTRIBUTED MANUFACTURING AND FUTURE

MAKERSPACES

In the following sections we will illustrate how the technomyth of digital peer production is aligned with, mirrored by and legitimated through the dominant narratives around the future of manufacturing (Berg, 2016), with both redistributed manufacturing and distributed production proponents championing and depending upon the assumption that digital technology is equal to efficiency and accessibility as well as a redistributive force for the 'democratisation of manufacturing' (Lawton, 2017). Advocates of digital peer production within shared machine shops gravitate towards, take up and support the formalising of a relationship between shared machine shops and redistributed manufacturing. We argue that as this coupling strengthens a co-institutionalisation process occurs wherein both the technomyth of digital peer production and the realisation of redistributed manufacturing practices mature and are formalised. We argue this process is beneficial in terms of its potential to aid in the legitimisation and expansion of peer production practices specifically, and shared machine shops more broadly. Yet, also argue that this benefit is not without danger. For should notions of RDM and peer production continue to mature through the technologically deterministic narrative of digital technologies, so too will an othering process wherein less Internet-compatible, digitally-driven actors and practices are rendered invisible.

The concept of Redistributed Manufacturing does not have a standard and widely accepted definition (Escalante and Rahimfard, 2016). The initial appearance of the term is in the 2013 UK EPSRC (Engineering and Physical Sciences Research Council)[11] RDM workshop report where it has the broad working definition of "technology, systems and strategies that change the economics and organisation of manufacturing, particularly with regard to location and scale" (Pearson, Noble and Hawkins, 2013). Subsequent definitions emphasise 'localised production' (Soroka, Naim, Wang and Potter, 2016), 'customisable production units' (Prendeville, Hartung, Purvis, Brass and Hall, 2016), decentralisation (Harrison, Ruck, Medcalf and Rafiq, 2017) regionalisation (Munguia et al., 2016) and geographic dispersal (Soroka, Naim, Wang and Potter, 2016).

The characterisation of RDM, refers to an increasingly distributed and varied manufacturing ecosystem and 'on-demand economy,' where the factory of the future may be 'at the bedside, in the home, in the field, in the office, and on the battlefield' (Foresight, 2013). These local manufactories and the associated decentralised business models change both markets and supply chains, with wide ranging implications and challenges (Pearson, Noble and Hawkins, 2013), it is in emphasizing these societal impacts that the 're' became part of the naming convention. The understanding of distributed manufacturing itself has been historically fluid, evolving from MacCormack's smaller scale plants serving regional markets (MacCormack, Rosenfield and Sloan, 1994), to decentralised production approaches (Kühnle, 2010), manufacturing at the point of use (Devor et al., 2012), and mass customisation and digital manufacturing (Kohtala, 2015) now being synonymous with orchestration of manufacturing though the cloud and digital networks (Zaki, Theodoulidis, Shapira, Neely and Teple, 2016).

NEGOTIATING NATIONAL / GLOBAL AGENDAS AND INTERESTS

The opportunities of the conceptualisation of redistributed manufacturing, moving toward shipping data rather than materials and producing closer to the point of need is a global one, responding to global imperatives and the opportunity of computational networks. However, the research funding infrastructure endeavoring to facilitate such a shift is itself subject to borders and national agendas, enabling a shift towards more sustainable future distribution of manufacturing in a targeted manner that reflects the interests and perspectives of both the funder and the funded. The EPSRC funded Redistributed Manufacturing Networks were funded in order to stimulate an

academic agenda around these ideas, including both academic and user communities in order to better position the UK to respond to the challenges and opportunities facing the UK's manufacturing industry (EPSRC, 2017a)[12]. The breadth of the challenges and potential impacts of RDM, was recognised by RCUK to go beyond the technological, and an advisory group was appointed that included both the funding body EPSRC and representatives from the ESRC with a focus on the socio-economic implications of changing how and where we make things (EPSRC, 2017b).
There is little doubt the activity and outputs of these six networks (EPSRC, 2017a) affected the discourse on distributed production, both with and without the prefix of the 're'. Collectively the RDM networks commissioned over 35 feasibility studies, ran in excess of 20 events and have published in a range of journals, capturing the interest and efforts of a diverse range of UK academics from multiple disciplines including engineering, urban development, design, sociology, computer science, etc. (EPSRC, 2017b). The RDM agenda alongside recent technology and social imperatives has given new relevance to earlier academic works on the orchestration of production and work, with the joint position paper of the EPSRC RDM networks calling for these historic frameworks and academic works to be adapted and reimagined in order to better grasp and respond to the phenomena of distributed production (Srai et al., 2016).

In framing, reframing and interrogating the prior works on distributed production, stimulating new research with an emphasis on enabling a UK benefit from RDM and developing and delivering targeted interdisciplinary end user research it is clear that emergent RDM discourse both produces and is a product of an agenda for the intentional redistribution of knowledge and capital. This intentional redistribution is in tension and sometimes in conflict with other iterations or possible futures of distributed manufacturing. Although the RDM networks met frequently over their two-year funding period to discuss and align conceptualisations of RDM and the associated challenges, opportunities and enablers it would be remiss to portray them as in agreement, as each network has a distinct understanding, disciplinary lean, and agenda.

SHARED MACHINE SHOPS AND REDISTRIBUTED MANUFACTURING AS A CO-EVOLUTIONARY

The Future Makerspaces in Redistributed Manufacturing network (FMS RDM)[13] set out with the explicit intention to establish the role of makerspaces in enabling a transition to redistributed manufacturing, stating in the proposal that the characteristics of RDM were already established within makerspaces and maker culture. This proposal and pitch framed makerspaces, and shared machine shops more broadly, as being an emerging phenomena akin to the early internet – a networked, distributed and ad-hoc type of manufactory – embedded within neighborhoods and communities, changing the dynamics of who had access to make and manufacture. In recent years, proponents of RDM within academia, industry and policy have sign-posted shared machine shops, and the communities who use them, as key actors for the practical embedding and progression of the discourse, as site within which to 'hothouse' sustainable and innovative new approaches to manufacturing and distribution (Prendeville, Hartung, Purvis, Brass and Hall, 2016). From the networking of digital tooling and the sharing of production waste solutions, to the normalising of certain artefacts, projects and practices that promote redistributed practices – shared machine shops have been positioned as demonstrative sites for RDM proof-of-concepts, the future of work and livelihoods, economic saviors and regional regenerators. Therefore, the FMS RDM bid stated it was "timely to explore and define the potential of makerspaces to become an integral part of UK manufacturing and service industries, and to evolve as key contributors to re-distributed manufacturing in its widest sense" (Royal College of Art, School of Design, 2015).

In the context of the UK it becomes clear notions of

peer production are becoming entangled within and constituted by digital fabrication technologies. Sifting community-based production cultures through a definition of peer production that holds a dependency on digital fabrication and Internet-compatibility and thus generating a highly curated viewpoint of community production that formalises distinct sociotechnical norms. For advocates of this technomyth, the concept of redistributed manufacturing along with its corresponding agenda and institutionalised constituents becomes a useful mechanism in pursuit of the tale.

This resonance between the technomyth of digital peer production spaces and the maturing dialogue of redistributed manufacturing can be seen in an analysis of the tools, practices and knowledges highlighted by authors of RDM discourse (refer to table 2). The descriptors of RDM practices and tools lack specificity, leaning instead towards to the abstract and conceptual (Harrison, Ruck, Medcalf and Rafiq, 2017, p. 3). Whilst the tools themselves remain largely ambiguous, it's important to recognise the benefits of redistributed manufacturing are characterised by sustainability, smaller scale production and shared prosperity, which are not exclusively digitally dependent aspirations. Yet, the USP and value-add within the RDM narrative currently centers around the mass customisation of products and supply chains and remains dependent upon increasing data capture and accumulation – thus favoring future sites of production that are computer-controlled and Internet-compatible.

Citation	Tools	Practices	Knowledge sets
Harrison, Rafiq and Medcalf, 2016	Cyber-physical systems. These include next-generation manufacturing, logistics and supply chain management, smart networks, automation and big data.	Networked machines to leverage collective computing power and interconnectivity with the end goal of intelligent and responsive systems interconnected industrial environments.	The anticipated systems will govern themselves, take preventative or corrective actions without human intervention and coordinate supply chains automatically. Facilitate replicability of manufacturing quality across a network of manufacturing sites by removing communication and distance as an obstacle. Teams are likely to have fewer operators with high technical expertise per member.
Soroka, Liu, Han and Haleem, 2017	Machine tool monitoring systems, network based control systems.	Manufacturing: improved demand forecasting, supply chain planning, sales support, developed production operations, web search based applications, data mining, machine learning, neural networks, social network analysis, signal processing, pattern recognition, optimisation methods and visualisation.	Wide variety of tools, techniques and disciplines could make it difficult if not impossible for a manufacturing (non-IT) SME to implement without expert guidance.

Munguia et al., 2016	Office-friendly 3DPrinting units.	Two different possible strategies: manufacturing close-to-patient, and manufacturing in-the-home.	Resident expert with enough basic knowledge of non-electronics manufacturing and assembly would be “outsourced” to the patient’s home. 3D file integrity checks, 3D printing trials and materials testing before the medical device files are released to the public.
		A strong link between mass customisation and distributed manufacturing was identified in the literature and some cases. Mass customisation would implicate changes on a facility layer which is still driven by the incentive to produce high volumes and cut costs.	The term ‘redistribution’ in this context means a higher involvement of the consumer in the process of design or production.
Ford and Minshall, 2015		On-demand, mass personalisation, localised, flexible and more sustainable production.	impact of 3DP on RDM and vice versa will depend on a variety of interconnected aspects that go beyond the technical performance issues.
		For a decentralised manufacturing system to succeed, the technology must be robust and reproducible and there must be significant process and product understanding.	The relationship between the variation in properties of the starting material, the control strategy for manufacture and the product features must be well understood.

Table 2. A taxonomy of RDM technologies, practices and know-how

The RDM emphasis on cyber-physical systems that can ‘govern themselves, take preventative or corrective actions without human intervention’ (Harrison et al., 2016) has found a human-friendly front within shared machines shops and the technomyth of digital peer production, with both narratives mutually legitimising the other. Moreover, notions of redistributed manufacturing compliment, formalise, legitimise and augment the institutionalisation process that the fascination of peer production amongst shared machine shops has already begun.

This marrying is a technologically deterministic institutionalisation process that, on the one hand, has proven a useful mechanism enabling communities of users to take up and co-opt RDM agendas, informing and shaping the understanding of RDM practices held by the funding bodies through participation in its early definition. On the other hand, RDM and its kin narrative ‘industry 4.0’ sacrifices those cultural and social practices of community production that do not fit within the internet-compatible, digitally-driven techno-normative modes of digitally powered peer production.

The institutionalisation of community production by and through the wedding of shared machine shops and redistributed manufacturing could be considered as predatory. We position the FMS RDM

network as a mediator of this dynamic, delivering a program of work that sought to foreground RDM processes and practices within shared machine shops and to explore, test and validate what relationship between RDM and shared machine shops might be useful, possible, and preferable – informing both the role of the shared machine shop and the definition of RDM.

Although the research program was around establishing the roles of future makerspaces in redistributing manufacturing what it delivered in parallel was a program around futuring in makerspaces, questioning the futures presented and promised for makerspaces to date, and valorising and championing a future makerspace (or shared machine shop) that was connected, networked and capable, moving beyond makerspaces as serendipity engines and building them a formal and post-symbolic role within the future redistributed economy. This narrative of redistributed manufacturing and future integration into the manufacturing and policy landscape, had a resonance with a core set of shared machine shops. While many spaces would attend, discuss and participate within the symposiums and events, a core few took their involvement further – proposing studies, partnering with academics, and reorienting or reframing the activity they already undertook in alignment to the emerging RDM discourse. In this way the programme evolved over time, both in network makeup and in its understanding of what RDM and its enablers within makerspaces was and also what it could and should be.

FMS RDM allowed shared machine shops to self-select and self-identify as aspiring towards being part of the future distribution of manufacturing. This is not to say many weren't excluded, the narrative of RDM favored spaces where design decision-making was evidenced as happening, where the aspirations of the makers within them extended beyond the doors of the lab, beyond hacking and making domestically to making, producing and manufacturing at scale. The types of sociotechnical practices valorised by RDM includes those that build upon the digital distribution of product and process data in a way that is compatible with the creation of goods or services – predictably most often centered around digital fabrication technologies such as CNC, 3D printing, laser cutting, and distributable licensing.

During the final stages of the FMS RDM project, a final study (known to its participants as the 5×7) was commissioned that took the reports and insights generated by the five feasibility studies and exposed them to the critique and feedback of a panel of makerspaces to establish if the insights and experience were familiar to them, how they could inform the practice of RDM within their makerspace, and if the state of makerspace making and manufacturing practice rang true to their primary experience as makerspace founders, managers and users. This taking place two years after the initial Nesta dataset again set out to elicit written responses from spaces themselves, asking them to self-report the occurrence and relevance of the practices identified within their shared machine shops, and asking them about their aspirations and challenges in adhering, or not, to RDM and the associated peer production digitised processes. The participants in this study were selected based on geographic spread and their varying levels of participation in the FMS RDM network[14].

When asked explicitly how the RDM agenda applies to their space and its utility, responses varied from highlighting that "the jargon is exactly what 'makerspaces' run away from," to "[we] can be said to be naturally adopting the characteristics of a redistributed manufacturing ethos though still in a nascent stage," through to "the concept is at the core of what we do" (Corbin, 2018). Even those spaces that did not firmly identify as enabling RDM, did consider themselves to be contributing to a diversification of the manufacturing landscape, "we're also already seeding the metropolitan manufacturing ecosystem," "this vision fits well with our future goals for [our space] and we hope to become a 'hothouse' for RDM," "[we] could certainly be described as a dynamic production environment

capable of creating customisable or multivariant products" (Corbin, 2018). Certain spaces aligned fully their short-term strategies to that of the RDM agenda, "as we have a research interest we are making-real this prediction. We are excited by the potential of these trends so are steering ourselves towards them as goals and select members who share these aims" (Corbin, 2018). Many recognised their own positioning as champions and purveyors of RDM discourse and demonstration, "[we have] been positioned over the last five years to be at the forefront of this 'new' wave of thinking. We've been highly active in propagating that concept and are now recognised as being key stakeholders … in how this will develop over the coming years" (Corbin, 2018). At multiple points RDM was highlighted as a stabilising force for shared machine shops, a raison d'être that could take a somewhat fragile business model and provide bread and butter income. For some spaces the research itself provided an income generation strategy, for others the validation of existing practices and a name to hook themselves onto proved useful. To this end, survey evidences how where and when RDM is taken up by a shared machine shop it's because there has been a significant amount of agency from within the space to make this happen, with members championing the RDM concept. Respondents noted the challenges in aligning a space's activity in this way, as one put it 'difficulty comes from the peripatetic nature of institutional support. We find ourselves moving from one partner's agenda to the next and losing energy when projects lose funding' (Corbin, 2018). Therefore, we argue that the adoption of and alignment to the RDM concept is a voluntary and active institutionalisation process, a co-option rather than externally imposed.

In regard to the institutionalisation of shared machine shops, we would argue that the situation and dynamic is not as binary as many would assume. Who and what sets the course is a multi-actor game. Habitual practices and the evolution of such is a process of co-option directed by multiple stakeholders and thus a combination of multifarious agendas. Yes, RDM as a concept was initially developed by academics, universities and research councils and is now of interest to various governmental departments, but the concept itself in this initial form is only that of a kernel – a seed of a concept, and one that is far from fully developed. In many ways, the current fluidity and ambiguity in how both shared machine shops and RDM are defined has allowed those actors involved significant agency in the shaping, defining and co-opting of two concepts – evolving the shared narrative over time in step with the maturation of agendas and visions. RDM is brought to life, realised, twisted, redirected, refuted through real-life practice by individuals, groups and organisations in situ, given their own interests and agendas. We therefore argue that in positioning those who run and use shared machine shops as being unaware of and naive to external agendas (unable to push back, reframe, re-appropriate, take advantage of, etc.) is undermining and discrediting those individuals.

In interrogating the respondents of our study as to how each shared machine shop arrived to an alignment and foci with RDM it became apparent just how 'slippery' shared machine shops are. Respondents reported that the "biggest challenge is always embedding something into the culture of the space" because there exists an inherent tension within shared machine shops as to 'who' – if anyone in particular at all – makes the decisions for a space and its community (Corbin, 2018). The highly decentralised governance and organisation models of most shared machine shops means that the power and influence of any agenda will be limited – with RDM certainly being no exception to this rule. Decisions as to orientation of the space and its practices are driven by "both ideological and economic" reasoning, "100% of the direction is set by the members' interests, and it's just that some of those interests are 'pay the rent'" (Corbin, 2018). Of those spaces that can be evidenced to have taken up the RDM agenda, incorporating it into their operating practices and rhetoric a clear alignment – both in terms of ambition, sociotechnical practices, and everyday financial incentives – can be observed. We therefore argue that where RDM is getting taken

up by shared machine shop communities it is not out of externalised pressures to do so, but rather it is because there has been a significant amount of agency from within the community itself – it is a voluntary, active, and co-optional process of institutionalisation. Therefore, we would like to argue against the narrative undercurrent we find within even critical maker discourse, the notion of the makerspace as underdog, subject to the dominant agency and agendas of institutions. We argue this discredits and undermines the agency and influence such spaces and their communities have within the institutionalisation process itself.

CONCLUSION

In many ways, notions of redistributed manufacturing compliment, formalise, legitimise and augment the growing technomyth of digital modes of peer production that surrounds UK shared machine shops. We argue that the institutionalisation of community production by and through the wedding of shared machine shops and redistributed manufacturing should be considered as a process of co-option that is both beneficial and problematic. On the one hand, institutionalisation could mean that the seeds of change are starting to take root and grow. Consider online sharing platforms such as MyMiniFactory and WikiFab, or public/open copyright licensing models like Creative Commons and the Mozilla Public License reaching the critical mass necessary for them to mature into viable, even mundanely normal, components of the production chain. Imagine informal communal production provisions like shared machine shops, Repair Cafés and tool libraries that become embedded in, understood and supported by regulations and policies. Such promising examples could be understood as cases of evolutionary 'niches'[15] that instigate the restructuring of 'regime'[16] constellations (Grin et al., 2010; Smith and Raven, 2012). On the other hand however, early signs of such institutionalisation processes could also be a foreshadow of potentially transformative agents being mediated, enfolded and ultimately asphyxiated by the very institutional structures they sought to change. Such examples could be seen as yet another display of incumbent regimes exerting their tendencies towards not systems change, but system stabilisation and reproduction (Geels and Schot, 2007).

We therefore ask what are the potential impacts of such a co-constitutionary dynamic between shared machine shops, a national RDM agenda, and a growing technomyth of digital peer production? Within his analyses of social movements, Hess applies three hypotheses as a framework for analysing technology- and product- oriented movements (TPMs) – two of which we feel are pertinent to this discussion. Firstly, the 'private-sector symbiosis' hypothesis postulates that the emphasis on technology and product innovation leads to the articulation of social movement goals with those of inventors, entrepreneurs, and industrial reformers. A cooperative relationship emerges between advocacy organisations that support the alternative technologies/products and private-sector firms that develop and market alternative technologies (Hess, 2005). This speaks to and compliments the benefits of 'collection action framing' as argued by Söderberg when he states 'it is not obvious which side in a conflict can draw support from a deterministic narrative' (Söderberg, 2013, p. 1289). As Söderberg explains, 'collective action framing' within social movement theory refers to how social movements construct narratives interpreting the world in a way that gives meaning to their struggles. This dynamic recognises the active role of social movements themselves as producers of meaning, not just recipiants of prescribed narratives and myths, but co-constitutors of that meaning-making and narrative framing. Framing can be understood as a process through which spaces of struggle are continually created, contested and transformed (Snow and Benford, 2000), and both RDM and the digital peer production technomyth can be understood as forms of 'collective action framing'. As Söderberg argues, what technological determinism influences is the freedom of maneuver of the political adversary. If a social movement can claim such a position in their

collective action frame, then it might contribute to grassroots mobilisation. The collective action we evidenced through the two forms of survey included above showcases elements of how symbiosis with institutions and formal agendas brings legitimacy and visibility to the 'grassroots causes' and motivations of shared machine shops, acting as a stabilising force to enable greater impact and a common ambition.

While much could be gained, we also need to consider what can be lost through the continued entanglement of the technomyth of digital peer production and RDM agendas within UK shared machine shops. As Söderberg's points out, the literature on collective action framing has been criticised for its relative neglect of how pre-existing cultures influence framing processes (Söderberg, 2013; Hart, 1996). As Plekhanov notes, if we consider how a person who disagrees with the given phenomenon and technomyth may be affected – it is likely that their energy will be lessened by knowing that their resistance is futile, that they and their practice is something which is less legible and less valorised in the context of an emerging homogenous agenda (Plekhanov, [1898] 1940). We see this evidenced in the decreasing visibility of non-digitised making practices evidenced in both survey analyses. As we argued above, we agree with Wyatt and Maxigas, that the importance of retaining a connection to non-adopters should be seen as crucial to a community preserving its analytical capabilities – or critical faculties. Without that, spaces and actors within them may quickly lose the sense of agency that Boltanski and Chiapello (2005) deem crucial when closing their work with a call for 'sociology against fatalism' (Boltanksi and Chiapello, 2005, p. 536)[17].

Using the 'incorporation and transformation' hypothesis within social movement theory, Hess postulates that there is a tendency over time for established industries to absorb the innovations of the TPMs, but in the process they also alter the design of the technologies and products to make them more consistent with existing technologies and with corporate profitability concerns (Hess, 2005). Hess concludes that community demands and development of technologies happen in a *private-sector symbiosis* (Hess, 2005). Even where these movements succeed in pushing a technology to the consumer market, they are recuperated in the process, resulting in 'object conflicts' about their proper design and use (Söderberg and Delfanti, 2015). The academic and community positions on RDM and the varying adoptions, co-options and rejections of it as a term through the FMS RDM project reflects this pattern of object conflicts – going from an outside critique of the consequences of modern manufacturing and global supply chains, to a recuperation as a hopeful narrative of future manufacturing and the implementation of such through an entanglement with shared machine shop communities through tests, trials and studies, and ultimately resulting in increased digital legibility and commodification of both the communities of practice involved and RDM as a praxis. Maxigas argues the process of critique, recuperation and implementation entangles technologies and the communities who use them within an endless cycle of commodification resulting in the loss of trust between users and technologies (Maxigas, 2017). This cycle of co-production and co-option presents a dilemma in considering how users could possibly more critically navigate, even infiltrate, such an endless cycle. As Maxigas argues, in his study of technology-oriented and product-oriented movements, understanding the critiques of users within shared machine shops and their recuperation by commodified means is instrumental for mapping the dynamics between political struggles and the technological, cultural and ethical innovation driving the evolution of capital. Without criticality, mediation and conflict between peer production communities and firms remain highly vulnerable to recuperative logics.

We therefore argue there is a need to retain non-users within peer production communities and a danger of excluding them through the increasingly formalisation and co-institutionalisation of the digital peer production technomyth and RDM agendas. A

loss in diversity within shared machine shops could lead to the loss of connection between adopters and non-adopters. Which could, in turn, result in a loss of critical faculties, agency and awareness. Without a diversity of practice and of community, UK shared machine shops (and the peer production communities who use them) are at risk of losing the ability to remain critically engaged and involved within the co-institutionalisation process. The risk of UK shared machine shops aligning with the digital production technomyth and RDM agendas is that the default model becomes an echo chamber of homogenous adoption. Whilst we are not arguing that diverse communities are immune to technological determinism, a diverse community can generate a better position for individuals and groups to be more critical and recognise the broader relationships in the landscape. There is a need for critical friction, to highlight the edges and tensions between this increasingly dominant assemblage of practices and those practices which are less visible, less digitally legible or less valorised. Critical friction is productive, it provides the opportunity for social movements to self-check, self reflect, be critical and question the wider impacts of their practices. We conclude by reiterating the need to deploy a critical lens to the co-institutionalisation of UK shared machine shops and the peer production practices that flow within them to national RDM agendas. Further research is needed in order to assess what is gained and what is lost, and how we can better navigate the process of co-institutionalisation.

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NOTES

[1] Following Benkler (2013) and Benkler et al. (2015), we define peer production as a form of Internet-mediated open creation and sharing performed by groups that: set and execute goals in a decentralised manner; harness a diverse range of participant motivations; are particularly non-monetary motivations; and separate governance and management relations from exclusive forms of property and relational contracts (i.e., projects are governed as open commons or common property regimes and organisational governance utilizes combinations of participatory, meritocratic and charismatic, rather than proprietary or contractual, models).

[2] Following Smith et al. (2013) we frame grassroots digital fabrication as the confluence of digital fabrication technologies (e.g. 3D printing, open-source and web-based design tools, electronic kits, computer controlled milling machines and laser cutters), new business models (e.g. 'personalised manufacturing'), and grassroots movements (e.g. 'makerspace' community workshops).

[3] Such as Gershenfeld, 2012; Hielscher and Smith, 2014; Journal of Peer Production, 2014; Richterich and Wenz, 2017; University Arts London, 2017.

[4] Such as Anderson, 2012; Morin, 2013; Hagel, J. et al., 2014; Hatch, 2014; Banerjee, 2015.

[5] The dataset was commissioned by an open tendering process in 2014 by UK think tank Nesta (National Endowment for Science, Technology and the Arts). Researchers Andrew Sleigh and Hannah Stewart, both researchers with a personal background within the UK makerspace scene, undertook the work over a period of four months. This consisted of defining the fields or data desired into appropriate questions, aggregating known locations of spaces through desk based research and 'snowballing' the survey through social media and their own networks. The method for the dataset's framing and the research approach was documented through a series of blog posts on the Nesta website (Sleigh, Stewart, and Stokes, 2015), and both the list of questions and an initial dataset

were released as a public beta, evolving in response to community suggestions. The resulting dataset contains validated details of 97 spaces, with spaces primarily discursively representing themselves. The definition of makerspace established by the commissioner and researchers specifically excluded private workshops and studios, and defined it as an "open access space (free or paid), with facilities for different practices, where anyone can come and make something".

[6] For example, East London Printmakers, London Print Studio, and Spike Print Studio.

[7] For example, London Bike Kitchen, Bike Works, and Access Bike.

[8] For example, London Sculpture Workshop, Glasgow Sculpture Studios, and Cyan Clayworks.

[9] For example, Blackhorse Workshop, Building BloQs, and Makers Quarter.

[10] Following Boltanski and Chiapello (2005), Maxigas defines 'critique' as the unmasking of the hermeneutic contradiction between the meaning of institutions and how they work in practice, making it possible to challenge the reality of reality (Maxigas, 2017). Maxigas then defines 'recuperation' as a cyclical logic in capitalism; whereby on the one hand, critique is absorbed into capitalist ideology and practice, and on the other, things that were previously not part of the capital accumulation process start to be valorised. In this way, capitalism answers to critique through restructuring in a way that simultaneously implements, but also neutralises and eventually undermines that critique (Maxigas, 2017).

[11] EPSRC is the UK government agency responsible for funding research and training in the areas of engineering and physical sciences. The RDM networks are part of the EPSRC's funding theme area of the Future of Manufacturing.

[12] The remit of these two-year funded networks, included; advancing thinking around end user involvement and interest in RDM, supporting feasibility studies and actively seeking contributions from a range of experts and disciplines.

[13] Future Makespaces in Redistributed Manufacturing was an EPSRC funded RDM network facilitated by Design Products at the Royal College of Art. This hub specifically explored the possible roles of makespaces, and other similar informal sites of manufacturing could play within a future redistributed manufacturing landscape.

[14] Our analysis of the Nesta dataset used the prominence of practices evidenced through the discursive response to demonstrate the emerging dominance of a set of peer production practices aligned to the technomyth. This later study with curated participants evidences the extent to which spaces legitimise their practices in a manner that is adherent or counter to both the technomyth and RDM agenda. Given the rich data provided by each participants, we have chosen to again use a discourse to analyse the prominence of a variety of perspectives and practices.

[15] Niches have been conceptualized as protected spaces, i.e., specific markets or application domains, in which radical innovations can develop without being subject to the selection pressure of the prevailing regime (Kemp et al., 1998).

[16] In keeping with Kemp et al., we define regime as "the whole complex system of knowledges, practices, processes, technologies, characteristics, skills and procedures, and institutions and infrastructures that make up the totality of a technology" (Kemp et al., 1998, p. 182).

[17] For as Boltanski and Chiapello highlight, "as a century and a half of the critique of capitalism has demonstrated, the two critiques – the social and the artistic – are at once contradictory on many points and inseparable, in the sense that, stressing different aspects of the human condition, they mutually balance and limit one another. It is by keeping both alive that we can hope to confront the destruction caused by capitalism, while avoiding the

excesses that each of them risks inducing when it is given exclusive expression, and not tempered by the presence of the other" (Boltanski and Chiapello, 2005, p. 563).

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ACHIEVING GRASSROOTS INNOVATION THROUGH MULTI-LATERAL COLLABORATIONS: EVIDENCE FROM THE FIELD

Silvia Buitrago Guzmán, Pedro Reynolds-Cuellar

Collaborations with academia, international organizations, governments and civic society are both an opportunity and a challenge for grassroots associations to achieve their mission while maintaining their values and philosophy. Little research has been done on programs leveraging these collaborations to increase capacity for community-based, peer-production and innovation in economically constrained environments. This article presents the case study of a grassroots organization, C-Innova, in its leading role as organizer of two international design summits hosted in Colombia in 2015 and 2016. The goal of these summits focuses on increasing participants' understanding of design and technical skills, while fostering aspects of self-fulfillment and psychological needs. These experiences attempt to support and catalyze the emergence of local innovation initiatives. Both summits were organized and implemented through partnerships with local government, cooperation agencies, universities both local and international and members of civic society. We analyze the success of these collaborations across three dimensions: (1) program's objectives, (2) systemic changes across partners as a result of these partnerships and (3) structural improvements and challenges for C-Innova. We find significant changes across all dimensions, suggesting this as a viable model for grassroots organizations to achieve their goals without significantly compromising their core values and beliefs.

Keywords: grassroots organizations, partnerships, design education, appropriate technology, international development

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by Silvia Buitrago Guzmán & Pedro Reynolds-Cuellar

INTRODUCTION

There is a long tradition in the field of international development that considers both technology development and innovation change as frameworks that can be arbitrarily applied in new contexts. This tendency is well documented in the literature and has landmark examples (Borland, 2011; Kraemer et. al, 2009) that portrait this dynamic. Development projects across governments, multilateral institutions, NGOs and lately, social enterprises, are known mechanisms for this. In many instances, this view has created a culture of assistencialism which included practices that involve a degree of generosity from one agent to another, reflected in the offering of capital, knowledge or scientific advances for the improvement of the underdeveloped (Rist, 2014), that negatively correlates with the establishment of local capacities, crucial among communities to enable them in addressing their own challenges. It is only until recently that this perspective has started to shift towards more inclusive platforms for development that bridge this gap. This absence of critical mass in bottom-up initiatives is one of the reasons why numerous communities are still left in vulnerable situations. According to the World Bank (World Bank Group, 2016), by 2013, 10.7% of the world's population was still living under the poverty line.

A response to this disparity has taken the form of communities organizing themselves, building their own capacity and becoming central players in crafting the story of their development. This

approach is not new, with instances dating as early as the 1960's in the context of the Green Revolution in India where local groups started organizing and addressing development issues through community-driven initiatives. One of the mechanisms that fuelled this revolution was the possibility of taking control over technological change. The impact of agricultural technology for the Green Revolution was significant (Evenson & Gollin, 2003) and since then, technology remains a fundamental aspect of allowing these type of socio-economic dislocations to happen (Smillie, 1991).

In this paper we focus on how these community-based groups establish partnerships in order to meet their goals. Through the lense of grassroots innovation, and using the case study of a Colombian organization, we provide insight into how these partnerships and its branching actions, can support and disrupt local dynamics.

BACKGROUND

In our effort to establish how partnerships can enhance and disrupt actions taken by grassroots organizations in achieving their goals, we start by providing context as to what grassroots organizations are and the role they can play as a mechanism of for development and self-determination. Grassroots associations can be defined as a subtype of non-profit group. Locally-based, autonomous, with a bottom-up orientation and composed of individuals that manifest voluntary altruism as a group (Smith 2000: 18), they use a formal and informal organizational structures in order to accomplish their mission (Smith, 2000). Smith (2000) establishes three defining factors in his definition of these organizations: associative, local and volunteer-based. These elements can be found in several conceptualizations of the term in the academic literature with differentiated emphases according to particular interests when meeting the needs of specific communities (Thake, 2004) and philosophical orientations (Cairns et al., 2006). Through participation and membership, grassroots associations have built networks of social bonds in several neighborhoods and communities all over the world (Smith et al, 2017).

A key element in the dynamics of these groups is their autonomy, which is deeply connected to democratic systems and societies that value difference, acknowledge legacies from different cultures and give importance to the diverse use of public goods. Since grassroots associations are constituted and grow from the bottom up, their autonomy, especially related to external linkages with other organizations, is highly valued. This autonomy, translated in being able to act without having to wait for other decision makers, allows them to react more efficiently to local challenges, opportunities and crises. Nevertheless, collaboration, exchange and sharing of different types of resources, knowledge and skills with external agents is in the very nature of most grassroots associations and is a common response to contemporary contexts (Soteri-Proctor, 2016).

Setting up external linkages implies the establishment of structural connections between different stakeholders. This process begins with the establishment of a relationship at the interpersonal level between individuals, in which perceptions, attitudes, philosophies and trust, play an important role. Although good relationships are not a guarantee of partnership success, bad interpersonal relations are definitely a threat. Negotiating what level of control partners can have over projects and reflecting how such partnerships support the achievement of shared goals are necessary steps for grassroot associations to be able to ensure autonomy and independence (Smith, 2000).

In the negotiation process, dilemmas emerge for grassroots associations; to make part of its principles and philosophy more flexible in order to achieve the apparently universal technological tendencies, which are usually the direction government's' innovation policies are targeting. This action will allow grassroots associations to access supports and benefits that will make possible the continuity of their initiatives and It will grant a larger

scale dissemination, taking into account that the origin of most of grassroots associations the shared perception of social injustices and environmental problems, which have been the result of these conventional innovation models and trends. In other words, insert oneself in the contexts and situations that one seeks to transform substantially. (Smith, Fressoli, & Thomas, 2014).

Regarding what affiliations grassroots associations can pursue, Smith (2000) classifies them in two kinds: polymorphic, that accepts sponsorship from other organizations, establishes general guidelines for action and confers certain levels of control in decision making, and monomorphic, which accept collaborations primarily at a local level and within stakeholders who share a similar status in a given hierarchy. This provides them with freedom to formulate and run their policies, keep control over resources and prioritize autonomy when using external funding (Smith, 2000; Smith et al, 2017).

Partnerships with academic institutions, multilateral organizations, government and civic society are part of the current institutional and social landscape worldwide and may offer the opportunity to achieve grassroots associations objectives. Partnerships have structural advantages such as the prolongation of grassroots associations lifespans/longevity, greater effectiveness in its actions (Wollebæk, 2009) and maximization of resources and skills available in response to the scarcity of financial support. They also offer greater recognition and scale of activities with a multi-actor approach and the construction of a more open and collective decision-making process without this implying losses in autonomy (Berger et al, 2016).

Depending on the actors involved, partnerships can have different characteristics and roles. For example, with regards to collaborations with academic institutions, Stevens, Hayman and Mdee (2013) argue that mediation by individuals who have experience both in academia and in the field is necessary. Referred by the author as *'pracademics',* these actors can transit between academic institutions and grassroots associations, articulating and enhancing collaborations between stakeholders and building upon a dialogue between theory and field data and experience (Stevens, Hayman and Mdee: 2013).

Underlying different types of partnerships is the concept of collaboration, understood as a formal or informal exchange between organizations that seek to achieve a set of objectives that each one cannot fulfill separately. A dynamic process of relationship building with various levels of work that is divided, shared or delegated between the actors involved (Berger et al, 2016). Related literature suggests that effective collaboration needs to be built upon conditions and mechanisms that can support it with common agreements and objectives. In addition, developing a shared organizational identity in order to create a common culture, is also necessary. (Berger et al, 2016; Brinkerhoff 2002; Fox, 2010)

Collaborations can also be described in different forms. Najam (2000) proposes a framework based on preferences and interests of each stakeholder in relation with their resources and goals. When both aspects are synchronized and neither party considers their actions and intentions to be challenged, cooperation emerges. When there are divergent strategies but convergent goals and the parties complement each other in the achievement of a shared end, a complementarity relation arises with the possibility of transforming into cooperation. Najam (2000) also includes two other relations in which there is no place for collaboration; confrontation, a case where players consider each other's strategies and goals to be unethical, and co-optation, where goals are dissimilar but resources align, opening the door for a player to attempt changing other players' preferences in order to achieve a goal. These relations are fundamentally unstable and often transitory (Najam, 2000).

Austin (2000) suggests that the articulation between actors is a multifaceted relation that transforms over time and usually evolves in three stages as a *collaboration continuum*. A philanthropic stage,

when one of the organizations acts as a donor in response to a specific need, which Austin considers a potential starting point for deeper collaborations. A transactional stage, when partners increase their interactions, begin to engage in joint activities and through connections a meaningful relation evolves. Finally, an integrative stage, where organizations work together finding alignment between their missions and activities merging in a single and temporary organization with an identity different from each of the partners (Austin, 2000).

Because of its dialogic nature, collaborative work stimulate a constant exchange of opinions and ideas. Learning and knowledge-sharing processes are at the heart of these interactions developing and progressively building an environment conducive to the emergence of innovation. In other words, collaborative work, and more specifically partnerships, are methodological characteristics of the emergence of innovation and there is an interdependency between collective learning processes and innovation. (Hall et al, 2004). Innovation processes developed at the grassroot level require a deep observation of the local context needs and challenges and a focus on social learning processes and social networks within the community.

Seyfang and Smith (2007) propose a definition of grassroots initiatives as "*networks of activists and organisations generating novel bottom–up solutions for sustainable development; solutions that respond to the local situation and the interests and values of the communities involved*". Understood as clusters or chains, grassroots organizations are a source of innovative diversity that extend the potential for community development and who found in innovation a natural choice. Meeting social needs is the primary function of grassroots organizations; providing services in circumstances where the market cannot. Their ideological commitment seeks to polemicize hegemonic systems and proposes changes in the priorities of communities and individuals (Seyfang and Smith, 2007). In that sense, grassroots associations question the established relation between low-levels of education, poor economic condition and low-levels of creativity. This implies a political dimension of the organization that translates in a vision for the community embodied in the projects they engage in and the way they instill their communities with a sense of self-sufficiency and confidence.

However, this organization model also has critical views, some authors find cracks in Community-based and – driven development projects structures, Mansuri and Rao (2004) from the review of impact evaluation studies and ethnographic studies of this type of projects, ask if community participation improves the targeting of benefits, in this respect and following what is proposed by Conning and Kevane's (2002), affirm that community participation can facilitate access to the necessary information and can ensure higher quality monitoring in the implementation of the programs, optimizing their execution, but, at the same time, there is a challenge in terms of the community's capacity to manage information and control the resources in a context loaded with personal interests and affections in dispute. In the same line, evaluations of community-based targeting mechanisms, like the study developed by Galasso and Ravallion (2002) of an Anti-poverty program in Bangladesh (*Bangladesh's Food-for-Education Program*) affirm that despite the fact that a significant percentage of the poorest population had benefited from the program, the structural characteristics of the communities affected the performance, thus, the most isolated villages or areas with the highest level of land inequality had a lower targeting of benefits. In other words, decentralized benefit targeting processes in which the community participates may be constrained by local inequality. For Mansuri and Rao the sustainability of these community-based initiatives depends on building an enabling environment, in which government commitment, the responsibility of community leaders and a careful and well-designed monitoring and evaluation systems, can prevent projects from being dominated by elites and benefiting the most vulnerable population.

In order to dive deeper into the mechanics of grassroots organizations' partnerships and collaborations we will use the case study of *C-Innova,* an *Innovation Center for Appropriate Technologies and Education* in Colombia. This initative explores and celebrates the creative capacity of communities and the advantages of leveraging traditional knowledge as a component for innovation. Data from two international design summits organized and hosted by this local innovation center in 2015 and 2016 shows evidence of the aforementioned mechanisms, allowing us to offer insight into how partnerships can play an important role in the design, implementation and continuity of projects led by grassroots associations to reach their mission.

Case Study: C-Innova, Innovation Center for Appropriate Technologies

C-Innova is an innovation center with the mission of connecting vulnerable communities with appropriate technology and design. It was founded in 2015 as part of the International Development Innovation Network (IDIN) initiative, an umbrella organization created and operated by a consortium[1] of academic institutions led by the Massachusetts Institute of Technology (MIT) and housed at the Design for Development Lab (D-Lab) at MIT. The organization was created through funding from the United States Agency for International Development (USAID) under its Higher Education Solutions Network (HESN) initiative, part of their Global Development Lab unit.

C-Innova houses a community of close to 200 people most of which have participated in the center's activities. A large percentage of its members are physically located in Colombia with a small group living abroad mostly in Latin America and the US. The center specializes in technology design and design education activities with a strong focus on working with vulnerable, marginalized populations both in the context of poverty alleviation or post-conflict transition. C-Innova operates out of a physical space located in Bogotá, the capital city of Colombia, from which members of the center can formulate, design, establish and operate their projects. Because of its close community ties, one of C-Innova's priorities is to implement design education projects in the form of interventions, workshops or summits that can be held in the field along with communities. C-Innova is also growing a number of projects operated from the communities in order to expand its reach beyond any geographical constraint. On top of that, the center is open to community members who can commute to the city. These actions are possible thanks to numerous partnerships the center has grown including collaborations with city governments, NGOs, public and private universities both in Colombia an abroad and local communities.

C-Innova was created in response to two main needs. On the one hand, a desire of members from vulnerable groups and university students to access an open space where they could work in the design of appropriate technologies. On the other hand, a need to create bridges between academia, industry, government, and members of vulnerable groups approaching technology as a platform for development. The organization was established as a local non-profit by Colombian citizens, and operates legally under Colombian regulations. The organization is comprised by a physical space located in Bogotá, where members from vulnerable communities, university students, research groups and general public are engaged in actively participating in achieving the center's mission. The space includes access to non-digital fabrication, electronics design stations, working spaces and storage. The infrastructure does not include digital fabrication given that these techniques are not easily accessible by the communities organization seeks to serve. Along with the physical space, users have access to technical support, mentorship, professional development, training, funding opportunities, networking, as well as multiple mechanisms to become active members and enroll in projects operated by the organization. The center sustains itself through a combination of activities

that include consulting, product design, grant applications and events. Inevitably, this has led C-Innova to establish a large number of partnerships in order to both achieve its mission and guarantee financial sustainability.

PARTNERSHIPS AND DESIGN SUMMITS AS TEMPORARY MAKERSPACES

One of the main strategies C-Innova has used in order to achieve its mission is the implementation of a model for technology design education created at the MIT D-Lab called the International Development Design Summit (IDDS). The IDDS summit is a two-week to one-month educational experience that combines aspects of co-creative design methodologies, technology creation and community building. The summit serves as a platform to mobilize communities around the idea of addressing one's own development challenges. The main goals of the summit are to disseminate the principles of appropriate technology design, to create technology prototypes that can effectively address development challenges and to activate communities by making them participants of the experience and central to the process of technological co-creation. The model was created in 2007 by Amy Smith, and since then it has been implemented 20 times in up to 13 countries.

The summit is built upon a philosophy known as the *'IDDS Spirit'* comprised by five main guiding principles: *Co-Creation*, *Empathy and Resilience*, *Diversity and Inclusiveness*, *Resourcefulness*, *Hands-On work and Fun*. These principles are embodied and interpreted flexibly by the organizing team of each IDDS. This means that although summits are built upon the same principles, no IDDS has interpreted them in the same way. Each summit gathers between 40-60 participants coming from a diverse range of backgrounds and education levels and connects them with local communities. Summits are conceived and implemented by a local organizing team who acts as a governing entity. Organizing teams submit their summit ideas through a selection process that chooses those who will receive support every year. Support for summits come in the form of partial funding, access to human resources, consultancy and assistance with implementation. As teams build the vision for their summits, other actors inevitably come into play. These actors are usually organizations such as universities, NGOs, governments, industry and self-organized communities. Given this dense network of stakeholders and the fact that summit are built upon a strong philosophy rooted in a unique approach to development, aligning goals, visions and governance becomes a complex process.

The process leading to propose and implement an IDDS summit includes extensive field work with partner communities and other stakeholders. This work includes a number of considerations that go from safety on the ground to needs assessment up to the planning process of continuity strategies after the event is over. In fact, the summit is designed to serve as a catalyzer of previous work from all communities, stakeholders and the organization spearheading the initiative. Also, because these summits require numerous partnerships in order to be deployed, they represent a unique opportunity for grassroots associations to leverage resources, advance their mission, increase their human capital and expand their networks.

IDDS Zero Waste 2015. Cali, Colombia. Structure and background

Starting in 2014, a group of Colombian professionals from the National University of Colombia[2] and MIT started collaborating with the idea of taking the IDDS model to Colombia. With support from the IDIN network in the form of a formal partnership including access to its network of innovators, financial resources and technical support leading to the summit, the team was able to put together an organizing team comprised of volunteers from more than 5 countries. The local team established a formal partnership with a regional university, the Universidad del Valle[3] who provided financial resources, access to communities, and connections with the local government. Because all partners at

this stage were academic institutions, aligning goals, expectations, governance and philosophies was a fairly straightforward process. Through previous work done by the regional university in collaboration with the local government, a formal alliance with the City's government was established through the mayor's office and the Department of Environmental Management[4].

This partnership provided a strong connection with local waste picker associations and brought visibility to the summit. Also, it became strategic in order to get buy in from communities given the particular tendency of waste picker groups in the region to operate predominantly at a local level. Lastly, a thorough fieldwork process of establishing needs and aligning expectations across waste picker groups (communities) was carried out together by all partners. Once a shared consensus was reached, an informal partnership was created with communities. Because these groups lack the legal and organizational infrastructure to be able to enter formal partnerships with other entities, they rely on trusted relationships, previous experiences and referrals in order to establish external collaborations.

Given the fact that a good portion of the financial support for the summit was provided by the IDIN network to the local organizing team, the governance of the summit fell primarily on this team. They laid out an initial vision and iterated over it as partnerships were established. Because all government, waste picker groups and academic institutions differ in vision and approach, aligning expectations with regards of what cost-benefit relation each partner will enter by being part of the summit was a complex process. Academic institutions are primarily motivated by advancing knowledge and providing meaningful opportunities for their students. Governments pursue mechanisms that can make the tasks and processes they manage as efficient and economically sound as possible, while maintaining the quality they provide to citizens. Waste picker groups are driven first and foremost by a desire to increase communal well being across all members including financial benefits, job safety and professional development among others.

The goals of the summit were created through a shared Theory of Change (Weiss, 1995) that combined input mainly from the organizing team. The main objectives were: (1) to provide communities and participants of the summit with exposure to co-creation and design education, (2) to provide a viable mechanism for waste pickers to be technology creators, alleviating investment and making government initiatives geared towards making the waste management system of the city sustainable and efficient (3) to connect both partners and participants of the summit with a global network of innovators as well as with financial opportunities and technical support. One objective that emerged during the summit was the creation of an innovation center as part of the continuity strategy. This agreement became the inception of C-Innova as a grassroots organization.

Following the closing of the summit, C-Innova, the National University of Colombia and the Universidad del Valle, continued to collaborate organizing follow up events, offering technical support to alumni and preparing a forthcoming IDDS summit. Connections with communities were maintained for a period of time after the summit and further work with some of these groups has been done as part of C-Innova's activities. With sponsorship from the IDIN network, C-Innova offered a small *'micro-grants'* program that provided continuity to projects developed at IDDS. The program ran for four months and allowed further product iterations. However, none of these projects became financially sustainable and their development was not further pursued.

IDDS Education 2016. Bogotá, Colombia. Structure and background

With C-Innova established as a legal non-profit organization,a second summit was formulated in initial collaboration with the National University of Colombia. The organizing team was composed

primarily by former members of the IDDS Zero Waste in 2015. A good portion of this team belonged to the core group working in crafting and advancing C-Innova's mission. The theme of the summit was decided jointly with the National University of Colombia based on their mandate to support the advancement of education in the country and their commitment to connect the university with elementary and secondary education. Although the summit didn't have financial support from the IDIN network, access to the human resources, branding, technical support and advice was obtained. Moreover, because the main funder was the National University of Colombia with C-Innova acting as the main organizer, governance was shared between these two institutions.

Because both C-Innova and the National University of Colombia were aligned in their interest of connecting arts education with the theme of the summit, a partnership with a local art school[5] was established. Although this partnership was established primarily to guarantee a space to host the summit, alignment in values and philosophy was necessary in order to guarantee a harmonious collaboration between all actors. Finally, and through the networks provided by both the university and the arts school, partnerships with schools were created. A combination of elementary and secondary, public, private and community-based schools became partners of the summit. Alignment with schools was particularly challenging given their strong positions around education as well as their entrenched politics and management.

A theory of change crafted a shared vision for both C-Innova and the National University of Colombia. The document included the following objectives: (1) to provide communities and participants with the opportunity to experience hands-on, co-creative design methodology applied to the field of education, (2) to provide communities with concrete projects that help advance their academic vision and that are generalizable to other contexts and, (3) to provide participants with project continuity via financial and technical advice.

Following the end of the summit, a number of teams were housed at C-Innova for technical support. Although a shared fund for project continuity was discussed, it was not implemented which resulted in most projects becoming idle or dissolving after their initial deployment. In terms of partnerships, both C-Innova and the National University of Colombia continued to collaborate in advising teams and putting together a proposal for another summit. A handful of partner communities are still connected with C-Innova through projects, technical advice, access to tooling and fabrication space. Because of the eminently transactional nature of the partnership with Estación Arte Viva art school, no further collaborations emerged.

DISCUSSION

In the context of Design Summits, and in particular in the light of the many stakeholders involved, how did these partnerships unfold? In planning and executing these types of summits, objectives and principles were initially proposed by C-Innova focused on the importance of creating and shaping a community around the idea of co-creation and empowerment through design. Partnerships reshaped these principles according to stakeholders interests and visions creating new agreements shared by all actors. This *collaboration continuum,* where different activities and dimensions of relationships are tested on a permanent basis (Austin, 2000), provides opportunities for partners to experience changes at different levels, including shifts in organizational structures and the achievement of shared goals.

Local change and shared program's objectives

Because both C-Innova's and IDDS' goals are aligned in that they ought to connect vulnerable communities with design education as part of a new way to do development work, there is great incentive for achieving objectives from both parties. A quantitative analysis looking at outcomes for

participants in skills and attitudes pre and post summit from the IDDS in 2016, shows an increase in technical skills, attitudes towards collaboration and learning of design methodologies (figures 1, 2 and 3). Although there is no formal evidence for transfer of knowledge across domains, short term change in participants has been observed through further work done in collaboration with C-Innova. In fact, both C-Innova's core team and volunteer base are comprised primarily by IDDS alumni. In this role, alumni have the chance to become facilitators, support product development, design and manage projects among others. These activities are a great opportunity to transfer abilities acquired during summits and help cementing key principles of design, community work and technical skills. This in exchange provides C-Innova with key human capital to advance its mission.

Partnerships in the context of IDDS design summits appear to be an appropriate mechanism to achieve objectives across partners. Along with the analysis presented above, partners also report having reached their target metrics. For example, the DAGMA group included training on how to build prototypes created at the summit as part of the professional development portfolio offered to waste picker associations. Waste picker associations strengthen relationships among them allowing them to organize applying to larger grants and government contracts.

Through IDDS Education in 2016, schools gained access to pedagogical material to be used in the classroom. Projects served as objects to rethink curricula and helped inspire teachers to make changes in their practice. Some of these teachers continued working together after the summit sharing experiences and experimenting with the projects developed throughout the summit.

Changes in organizational structures

Multilateral alliances like the ones described in this paper also represent a unique opportunity for systemic and structural change. Because stakeholders become exposed to new frameworks and philosophies of work, it is likely for them to use this experience to reflect upon their own practice. One example of this comes from the IDDS Zero Waste summit where the Universidad del Valle created a new product design course in their Sanitary and Environmental Engineering department called *"Art, Design and Sustainable Innovation"*. The course focused on new designs for waste pickers transportation carts and was the first interdisciplinary effort at the department combining faculty from design, engineering and social sciences. Being able to update curricula based on new methodologies is the type of impact these partnerships should strive for. Another instance of these type of changes was observed in the context of our government partner. Following the positive outcomes of the summit in increasing waste pickers agency in implementing infrastructure and technology changes within their associations, the DAGMA unit used these results to inform new policy towards making the waste management system of the city more sustainable. The National University of Colombia also integrated the IDDS methodology as part of its extended education strategy. Not only they were part of the organizing team for summits in 2015, 2016 and 2017, but they will be running their own summit in 2018. Finally, the establishment of C-Innova as a grassroots organization represents a significant change in how development is structured and approached in Colombia. Because of its strong critique to assistencialism and its continuous effort for bringing local ingenuity to surface, these organizations constitute a tangible and applied counterexample to traditional top-down development approaches. Although further work in systematizing impact metrics for programs implemented by these organizations is needed, especially in the context of multilateral partnerships, we believe these case studies are showing promising results.

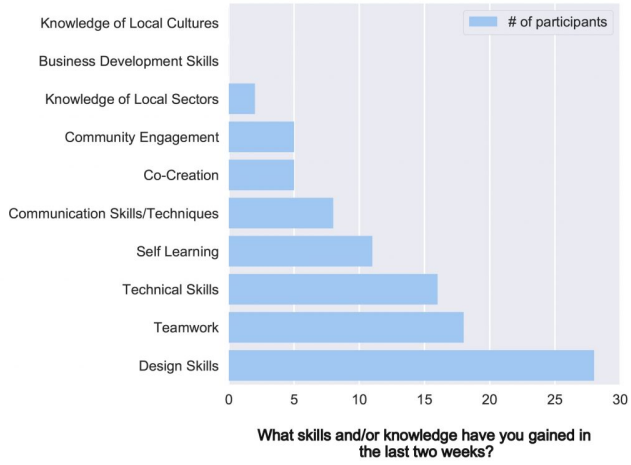

Fig. 1:
Aggregated data from A Qualitative survey fro m IDDS Education in 2016. Data collected pre and post summit.

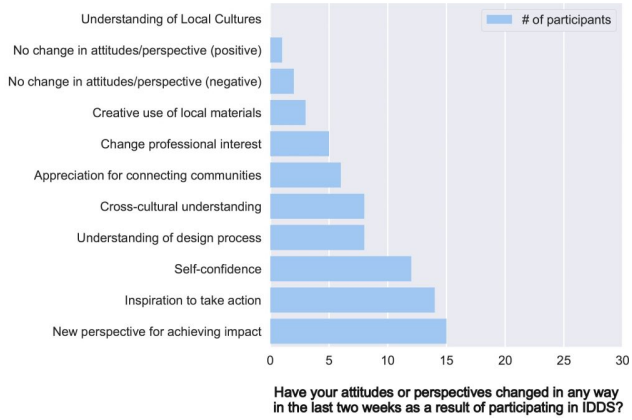

Fig. 2:
Aggregated data from A Qualitative survey fro m IDDS Education in 2016. Data collected pre and post summit.

Challenges

The temporary nature of IDDS summits and the inherent difference in partners goals creates several challenges for grassroots associations entering these type of alliances. Grassroots organizations' main focus are the communities they serve which can make the process of finding shared alignment with partners who hold different agendas complex and draining. A series of interviews carried out with members of C-Innova reveals some aspects of these complexities. As one of C-Innova's members mentioned: *"What IDDS has is that it's like a very strong injection of energy but it dissipates, right? Because relationships are built [more] over time [and] there is very little time to say how specific relationships were built"[6]*

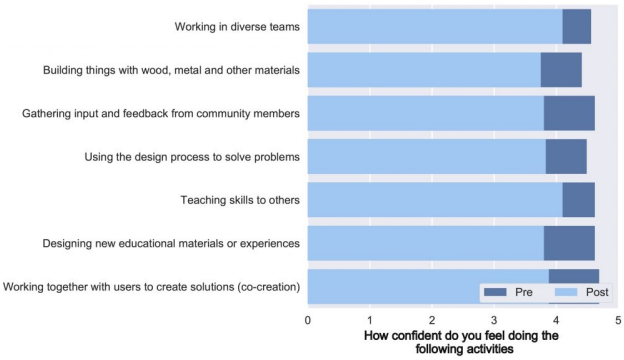

Fig.
3 Aggregated data from a qualitative survey fr om IDDS Education in 2016. Data collected pre and post-summit.

Particularly, aligning objectives with government instances has proven to be a challenging task. Because governments serve public agendas that are crafted prior to enter these partnerships, they are less flexible when aligning objectives and philosophies with other stakeholders. Also, given the inherent culture of politics in the country, these units have become focused on short term outcomes that can render positive indicators during a given mandate. From the perspective of a grassroots organization, ensuring successful alliances with governments given the aforementioned aspects may require choosing partners in government depending on their particular agendas as well as their timing across mandate periods.

Sustaining continuity, keeping momentum and ensuring that projects, collaborations and transfer of knowledge are happening can become a financial burden for a grassroot organization like C-Innova.

Because of the difficulties in guaranteeing financial investment post-summit, the organization is left with the task of continuing the work without economic compensation. Partners may differ in their long term impact vision and, because continuity represents financial investment, they may find continuity to be unfeasible. Exacerbated by the fact that most communities needs surpass the organization's operative capacity, C-Innova's mission and philosophy ends up being disrupted. Is the relation cost-benefit fair when projects are difficult to carry over after the summit? What is the long term impact of these dynamics for communities and participants who partake in summits? Is there a better way to structure governance after the summit? Ongoing research by C-Innova aims to answer these questions. Also, considering partners' long term plans, as well as allocating financial resources for continuity purposes may be beneficial for grassroots organizations to be able to fully engage in further supporting work after partnerships are concluded.

Impact metrics also remain a challenge. Because these partnerships cater to several stakeholders objectives, maintaining a structured pipeline for monitoring and evaluating progress is difficult. Generally speaking, each partner holds metrics based on their expected outcomes. However, having different metrics makes the process of quantifying impact problematic. On the one hand, academic institutions such as universities can measure impact using indicators for knowledge production and transfer as well as public and private resources raised for research development and innovation (Sierra, 2012). On the other hand, C-Innova can measure impact through observing changes in individual and collective capacity building, job creation, improved access to services and facilities, greater sense of community and civic engagement. Being able to share instruments and frameworks for measuring impact across partners is crucial to systematize these experiences.

Finally, although there is a deep sense around the importance of local knowledge and the need to establish strong ties with communities prior to the enter formal partnerships, more work in visualizing this local expertise is required. One reason for this imbalance may be the way governance is established in the context of these partnerships. IDDS summits in particular require financial investment, usually not feasible for communities to provide. Therefore, decision making instances tend to fall under organizing teams which may result in biases when designing curricula and choosing projects to work on during summits. Maintaining a close collaboration loop with local communities is essential to ensure avoiding such biases.

CONCLUSION

Collaboration between entities is fundamental for grassroots organizations to achieve their mission. In this paper we presented two instances of how these collaborations can unfold. Our goal is to provide insight into what advantages and challenges engaging in multilateral partnerships may bring for these initiatives, and most importantly, for grassroots organizations leading these efforts. From our perspective, generating a flexible framework for negotiating and aligning objectives, making sure that principles and philosophies across partners are compatible and acknowledging the limitations some partners may have due to political or organizational factors, are key aspects to the design of these alliances. Having a structure for measuring impact that is shared among all organizations can help understand in detail how these partnerships add value or disrupt the achievement of each partner's mission. Expanding the Theory of Change framework to include input from all organizations is a logical step. Recently, numerous groups working in the field of International Development are using this strategy with promising results (Vogel, 2012). Partnerships also provide a unique opportunity to shift structures and systems by exposing stakeholders to new approaches, methodologies and philosophies of work. The fact that each organization brings to the table networks, knowledge and resources, represents an advantage when trying to capitalize these opportunities. We hope to demonstrate that, if carefully crafted, these kind of partnerships can be

powerful tools for achievement and change across partners objectives and systems.

NOTES

[1]Other universities include Colorado State University, Olin College of Engineering, Kwame Nkrumah University of Science and Technology (KNUST) and University of California Davis (UC Davis).

[2]http://unal.edu.co/">http://unal.edu.co/

[3]http://www.univalle.edu.co/">http://www.univalle.edu.co/

[4]Departamento Administrativo de Gestión del Medio Ambiente (DAGMA) – http://www.cali.gov.co/dagma

[5]Estación Arte Viva La Sabana – http://www.escuelataller.org/index.php/estacion-de-la-sabana

[6]*"Lo que tiene IDDS es que es como una inyección de energía muy fuerte pero se disipa, verdad? Porque las relaciones se construyen más con el tiempo y es muy poco tiempo para decir como que se construyeron relaciones puntuales"* Interview with one of the IDDS 2016 facilitators

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CONFIGURING THE INDEPENDENT DEVELOPER

Tobias Drewlani, David Seibt

In this paper we present results from an 18 month-long online-based ethnography of Project Ara, in which Google managed to enroll thousands of voluntary contributors into the development of a modular smartphone. Our argument is that, within this tension-laden firm-community entanglement, the figure of the "independent developer" emerged as the central mode of organizing development work. In order to demonstrate this point, we make use of the double notion of 'figure' and 'configuration' which we borrow from Actor-Network Theory and Feminist Science and Technology Studies respectively. We present three sets of practices that were central in configuring the independent developer: first, the techniques used by the company to interest and enroll external developers, second, the design and redesign of development tools that both enable and control their participation, and third, the creative strategies with which these externals inhabit the company-led project. We end by comparing the figure of the independent developer to other modes of organizing work in digital fabrication and suggesting some ways in which it might be re-configured beyond scenarios of pervasive corporate control.

Keywords: configuration, user studies, open innovation, digital fabrication

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by Tobias Drewlani & David Seibt

INTRODUCTION: DIGITAL FABRICATION, FIRMS AND COLLECTIVES

In this paper we discuss the "independent developer" as a mode of organizing work that emerged in the complex entanglements of top-down and bottom-up approaches to digital fabrication. We build our account on the case of Project Ara, in which Google managed to enroll a large number of non-company members to voluntarily and creatively contribute to developing a modular smartphone. Our main argument is that, within this project, the independent developer played a central role in ordering the ambivalent relationships between companies, digital design tools, and a large number of unpaid developers. The figure helped to temporarily fold together practices of grassroots development and the organizational control of work and thus obscured the tensions between them. By analyzing how the independent developer was constructed, we aim to recover three of these ambivalences which characterized work in Project Ara and are arguably typical of current entanglements of large firms and grassroots production communities in digital fabrication.

We situate our account within the larger debate surrounding the emancipatory potential of digital fabrication. In both social sciences and popular press, the rise of digital technologies such as computer-aided-design software or 3D printing is often connected to hopes of more democratic modes of production (Anderson 2012; Ferdinand, Petschow & Dickel 2016; Raymond 1999; von Hippel 2005). Hackerspaces, FabLabs, and other community-based design and manufacturing projects, are seen as offering a revolutionary chance to alter power and labor relations (Benkler 2006). However, the increasing engagement of large firms with these spaces and communities casts doubt on their transformatory potential. While bottom-up movements remain important, large companies try to shape and exploit their voluntary contributions in

various ways (Söderberg & Maxigas 2014). This might take the form of introducing different kinds of organizational openness to innovation processes (Chesbrough 2003), establishing relationships with communities (Dahlander & Magnusson 2005), or fostering innovation platforms or ecosystems (Gawer & Cusumano 2014; Ferdinand & Meyer 2017). These entanglements of bottom-up and top-down approaches to digital fabrication give rise to new modes of organizing work. However, when judged against the high hopes of democratization originally linked to digital fabrication, these often appear deeply contradictory. On the one hand, a large number of people are enabled to creatively participate in the development and production of various goods. On the other hand, corporations find new ways of controlling their labor and appropriating its results.

Against this backdrop, Google's attempt to enroll thousands of voluntary contributors into the creation of a modular smartphone is a prime example of the entanglement of large firms and community practices in digital fabrication. More specifically, Project Ara represents an attempt to transfer the platform approach, well known from software marketplaces like the Android or Apple App Stores, to the domain of hardware development. While a small team within Google partnered with a number of other companies to develop the phone's basic unit, developing functional hardware modules (Fig. 1) was left to external developers[1]. Google's hope was that they would create a large number of unique functional modules like gamepads, night-vision cameras, or medical devices in order to make the company's platform more attractive to a wide range of users. In this way, the figure of the independent developer was critical to Project Ara's staggering goal of creating an aesthetically and functionally customizable smartphone that was, as Google put it on their website, "designed exclusively for 6 billion people."[2]

As detailed in the next section, we conceptualize our analysis of the independent developer by drawing on the double notion of figure and configuration as developed in Actor-Network Theory (Akrich 1992; Latour 1992; Woolgar 1991) and feminist Science Studies (Castañeda 2002; Haraway 1997; Suchman 2007, 2012). We believe it is useful to combine these approaches, because they help us to write from the different perspectives of the many actors involved in organizing work in digital fabrication without resorting to a simple top-down/bottom-up dualism. Viewing the independent developer as a figure, we refer to it as at once the *effect* of distributed practices in the socio-material network of Project Ara and a *mode of ordering* the elements of that network in relation to one another. This allows us to observe that, even though Project Ara is initiated by Google, different human and non-human actors contribute to the emergence of what comes to be seen as the naturalized figure of the independent developer. By unpacking the figures constitutive elements and the powerful practices through which they are "figured together—or *configured*" (Suchman 2012, p. 49), we can recover the ways in which it orders the relationship between practices of grassroots development and organizational control of work.

In order to unfold the way in which the independent developer emerged as the dominant mode of organizing work in Project Ara, our paper is structured as follows. After briefly elaborating on the main tenets of our theoretical conception and methodology, we will focus on three ways in which the figure of the independent developer folds together practices of grassroots development and the organizational control of work. We discuss how Google, a large, profit-oriented company, picked up on ideas of grassroots development and indeed started a major hardware project relying on the voluntary contributions of non-company members. We further show how the digital fabrication tools supplied by Google enabled the creative participation of thousands of developers, while simultaneously working as a way of controlling their activities. Lastly, we draw attention to the way in which the often invisible work of voluntary contributors sustained and shaped the company-led Project Ara, and how their exit from the project was

connected to its eventual failure. We close the paper with a discussion of the independent developer's main characteristics as a mode of organizing work in digital fabrication. We will show how it compares to other modes (e.g. the employee, the crowdworker, the user innovator) and point to some ways work in Project Ara could have been organized differently.

Figure 1: A prototype of the Ara phone with customized modules (author: Maurizio Pesce)

USERS AND CYBORGS: ANT AND FEMINIST APPROACHES TO CONFIGURATION

The notions of figure and configuration, as we intend to use them originate in Actor-Network Theory (ANT) and Feminist Science Studies during the 1980s and 90s. In contrast to how these two streams of work have been commonly read, we argue that for analyzing the complex entanglements of large corporations and communities of external developers, they are best taken together. On a fundamental level, both approaches are useful for analyzing such new constellations, because they allow us to think about all actors and power as effects of networks of material-semiotic relations. This enables us to avoid simple dualisms between top-down and bottom-up modes of organizing as well as human actors and non-human means. On the level of conceptual repertoires, we find it useful to combine ANT and feminist approaches because they allow us to bring out different aspects of the relationships between corporation and external developers in Project Ara. Early studies in ANT offer us the conceptual language to describe the construction, stabilization, and orchestration of such relational networks (Callon 1986; Latour 1988; Law 2012[1987]). Feminist scholars criticized these studies for overemphasizing the position of powerful actors like scientists and technology designers (Star 1991). They suggested a different conceptual repertoire that enables us to engage with the agency of marginal actors and their potential to resist, subvert and hybridize. To make this point clearer, we will briefly sketch out how the notions of figure and configuration are positioned within these larger frameworks before showing how we combine them in our analysis of the independent developer in Project Ara.

Work in early Actor-Network Theory was concerned with the question of how non-human actors, specifically technological objects, orchestrate the socio-technical networks into which they are inserted. One important way to answer this question was the turn to a relational semiotic vocabulary that allowed it to talk symmetrically about human and non-human actors (Akrich & Latour 1992). It was in this vein that Steve Woolgar suggested the idea that developing a new technology included what he called "configuring the user" (Woolgar 1991). Working against the metaphor of "machine as text," he proposed that designers, or writers, always oriented their development activities towards anticipated users, or readers, of the technology. Configuring the user included "defining the identity of putative users, and setting constraints upon their likely future actions" (ibid., p. 59). What was materialized in both the physical shape of the machine and its accompanying contracts and instructions was then not the user as a concrete individual, but the user in a semiotic sense, constructed through the designers' activities. In a similar turn, Madeleine Akrich and Bruno Latour noted that a big part of any innovator's work was that of defining and inscribing into the artefact a certain vision about the world in which it was to be inserted (Akrich 1992). Of course, such scripts or programs of action were never truthful

representations of "the user in-the-flesh" (Latour 1992), especially when they were put into new contexts. What Akrich (1992) captured in the notion of de-scription was that actual users might ignore the script, enact it in unanticipated ways, or even change the artefact itself. While both approaches have been widely influential within Science and Technology Studies, work on user configuration and scripts has been picked up most notably in what came to be called User Studies (Oudshoorn & Pinch 2003, 2008). These studies focused, among other things, on the different techniques used by organizations to construct an idea of who the user might be (Akrich 1995; Oudshoorn, Rommes & Stienstra 2004). More recently, this discussion on user representation was opened up to include the cultural work that goes into the very production of people as users as well as the productive activities of these users within the processes of design and production (Hyysalo, Jensen & Oudshoorn 2016; Oudshoorn 2003).

Feminist Science Studies criticized early ANT for focusing too much on the work of powerful actors like scientists, conquerors, and designers and described those studies as "centered, managerialist, and even military in character" (Law 2009, p. 150; compare Star 1991). These scholars preferred writing from the standpoint of the subjugated, because it was more likely to maintain the contestability and non-innocence of all knowledge without buying into claims of radical relativism and infinite interchangeability. In the spirit of generating "situated knowledges" (Haraway 1988) these scholars developed a conceptual language that helps us to engage with always only partially connected communities of the marginal, the rebellious, and the monstrous. In our concrete case they help us to think from the standpoint of the precarious communities of developers outside of powerful companies.

Of specific relevance here is Donna Haraway's discussion of the terms figure and figuration (Haraway 1997, p. 11; see Haraway 1991 for her preceding work on material-semiotic actors). She develops a sense of figures as recurring rhetoric or visual tropes that condense and order whole "universes of knowledge, practice and power" (Haraway 1997, p. 11) in necessarily specific and therefore contestable ways. Much like Woolgar's user, these are not literal representations of any one concrete entity in the world, but rather "performative images that can be inhabited" by such entities. Figures, thus, are always the product of specific worlds and have world-making effects. It is in this sense that Haraway stresses the "contaminated practice" of figuration (ibid, p. 8) as a political tool. Reading the world through different figures, or maps of practice, is what she proposes to do with both her cyborg and modest witnesses (Haraway 1991, pp. 149–182; Haraway 1997).

Haraway's work was picked up and extended as a critical tool for both the de-construction of dominant figures and their re-figuration (Braidotti 1994; Hayles 1999; Kember 2003). We want to draw particular attention to the contributions of Claudia Castañeda and Lucy Suchman in systematizing Haraway's writings in a methodological sense (Castañeda 2002; Castañeda & Suchman 2014; Suchman 2007, 2012). They usefully define figuration as "the simultaneously semiotic and material practices […] by which a concept or entity is given a particular form" (Castañeda 2002, p. 3). A figure, then, is the material-semiotic effect of these practices. It is an entity which, embodied in technologies, texts, visual representations, or bodies holds together materiality and meaning. However, figures are neither stable nor identical with any of their material instantiations. As they circulate through social worlds, as they become differently embodied, they remain mutable and generative of new effects and entities. "Figuration is thus understood here to incorporate a double force: constitutive effect and generative circulation" (ibid.). Hence, by following the process of figuration in concrete, situated practices, researchers can recover a figure's constituent elements as well as their relations and eventual transformation (Suchman 2012). This is precisely what we intend to do in the case of the independent developer of

Project Ara.

MAPPING OUT THE INDEPENDENT DEVELOPER

The independent developer is the figure we chose to follow through Project Ara. We suggest that the independent developer, as a figure, was shaped through and remained generative of novel forms of organizing work in the entanglement of large corporations and communities of external developers in-the-flesh. By attending to the diverse practices that went into its production and continuous transformation, we are able to recover these relations and map out the material-semiotic network of work in the major digital fabrication effort that is Project Ara. In referring to these practices, we use the term configuration, rather than Haraway's figuration, to emphasize two important aspects of our perspective. On the one hand, our use of the term underscores the active contributions of a large number of actors, not only the designers of a company. The goal is to go beyond the simple binary of top-down and bottom-up approaches by presenting a multi-perspectival account without claiming the purity of either perspective. On the other hand, configuration retains the idea of "double force" in that the process of constructing a figure is consequential for all entities implicated in the process and does not only affect the structurally less powerful.

We will analyze three sets of differently situated practices that contributed to configuring the independent developer in Project Ara. Each of the three sets exhibits a particularly important aspect of the configuration, without claiming to present a complete picture of the events in the project. First, we will discuss the material-semiotic practices used by the company to configure the independent developer. We will draw particular attention to the techniques used to construct an idea of who the independent developer might be and how s/he should relate to other elements of the project. We will also discuss how the company attempted to interest actual people in their vision of the independent developer as the central element of a democratized mobile hardware ecosystem, thereby enrolling them into a company-led development project. Second, we will focus on the ways in which a range of hardware development tools, provided by Google and its partnering companies, contributed to the configuration of the independent developer. We will show how a particular version of the independent developer was inscribed into the material shape of these artefacts. As an effect, the tools enabled externals to creatively participate in the project while at the same time functioning as tools of controlling their actions. The third part explores how external developers themselves contributed to the emergence of the figure by enacting it in unforeseen ways. The central aspect here is not that actual people inevitably differ from the vision of corporate actors . Rather, we want to emphasize that their active engagement in trying to act as independent developers elaborated and transformed the figure constructed by the company.

HOW TO FOLLOW THE INDEPENDENT DEVELOPER THROUGH PROJECT ARA

Our account builds on a variety of empirical materials, reflecting the diverse practices and actors involved in configuring the independent developer. Central to following the practices of the developers community was an 18-month-long online-based participatory observation of a group of external developers who took part in Project Ara from its official launch to shortly before its termination. The group, consisting of about ten people, granted us full access to their meetings, documents, and internal communication channels. In concrete terms this meant that in addition to conducting several interviews we were a visible part of the group, affectionately referred to as "the study guys." We joined a series of video conferences, read the posts and comments in their private online forum, studied the documentation they produced, and took part in communications within the group and between the group and other Ara developers. Partly due to the online-based character of the group, all of these activities were readily recorded, which allowed us to

access them later and structure them for our analysis. In the course of our engagement, our role gradually changed from silent observers to active participants. Especially in the later phase, we used this position to share our perspectives and learnings with the group.

To substantiate our account, we draw on the broad range of other data that the particularly open character of Project Ara made available. This included public statements by Google and other actors (such as media and external developers), the phone's technical documentation, recordings of talks and conferences as well as public discussions that were posted on the official website, open forums, and social media platforms. Additionally, we conducted several interviews with the official coordinating team at Google as well as other involved companies and participated in one of the official developer conferences organized by Google. This broad and rich collection of data made it possible to trace the course of the project from its very early stages until its end. It allowed us to enrich our account of Project Ara by studying it from multiple perspectives.

For the analysis, interviews and large parts of the video conferences were transcribed, coded, and together with various field notes ordered along a timeline. By doing this, we were able to trace the re-configurations within Project Ara, how the project evolved over time, which ideas were dropped and which could stabilize. We paid attention to the activities of various actors, including individual external developers, emerging developers groups and communities as well as Google, partnering firms, and the technical and organizational system they developed. This procedure helped us to avoid overemphasizing Google as the central actor in the project. As we will show in the following sections, the path taken was not a linear one, but rather one characterized by the contingent and often conflicting perspectives and activities of various actors.

Our analysis focuses on some of the most important socio-material relations folded together in the figure of the independent developer and leaves out others. It is important to stress that the figure *as an object of empirical research* is delineated, by us as researchers, from the larger (though finite) universe of practice and significance of which it is a part. Thus, even as we speak of the independent developer as a mode of organizing work in Project Ara, we realize that the figure is not first conceived of within this context. In fact, it stems from a much larger domain of practice which is already patterned by asymmetric distributions of meanings, knowledges, and resources. These are not themselves explained within the main part of our analysis, but are simply treated as context.

INVOKING THE FIGURE

In this section we examine the central role of the company in configuring the independent developer. We argue that Google's development team uses a number of techniques to construct an idea of who the independent developer might be and what role s/he should occupy in Project Ara (Akrich 1995; Oudshoorn, Rommes & Stienstra 2004). Some of these practices involve testing the idea with actual developers. Determining to what extent actual developers will meet the company's idea of the independent developer works as a way to prove the viability of the project and helps to guide its further development. Following these internal activities as well as unforeseen developments outside of the company, Google presents its vision of the independent developer to a larger audience of people, trying to enroll them into the company's development project.

The inception of the independent developer is closely tied to Google's effort of constructing Project Ara as a hardware analogue to software development. Even though Google's team claims that Ara is a highly innovative, first-of-its-kind moonshot project, it builds on the well-established cultural repertoire of modern technoscience. This becomes very clear in the many ways in which Ara draws on engrained ways of organizing and

innovating and is in fact framed as a typical Google project. The most consequential of these references to already established practices is Google's explicit strategy to model Project Ara in analogy to its highly successful software platform Android. Working by analogy allows the company to formulate expectations about otherwise uncertain elements of the project, specifically the external developers. The following quote by project lead Paul Eremenko is especially enlightening in this regard:

> "Project Ara is about opening the mobile hardware ecosystem. It's about making the creation of mobile hardware more like the creation of mobile apps. By lowering the barrier to entry. By increasing the number of participants in the ecosystem. By enabling developers to sell directly to the consumer rather than having to go through an OEM [Original Equipment Manufacturer] and by giving developers new hardware design tools that are free and make hardware design more like software development." (Paul Eremenko, 1st Developers Conference, 09/15/2014)

The analogy drawn by Eremenko does a lot of work in determining who the independent developer might be and how s/he might be positioned in relation to the company and its design tools. First, much like the development of software apps, the development of Ara modules should be accessible to a large number of people, requiring of them little prior experience or resources. Second, externals are positioned as independent of large companies, not only in the development of modules, but also in terms of their production and sale. Third, this independence is crucially enabled by making use of free hardware design tools which, to be sure, are provided by Google.

However, even as the translation from software to hardware design offers a first way of envisioning the position of the independent developer within Project Ara, uncertainty remains high. Precisely because such a large-scale attempt at digital fabrication has no direct precedent in the realm of mobile phones, it is unclear whether all the actors will come forth to play their roles as anticipated. This is especially true of the external volunteers who are supposed to embody the independent developer, since they are by definition beyond the company's direct control. Hence, Google sets out to test the viability of the independent developer with actual people. This takes the shape of a series of hackathons which are held over a period of six months across the US. In these events, a total of 212 participants, often engineering students, are invited to develop hardware appliances for an altered version of an existing smartphone, containing additional hard- and software interfaces (see Figures 2 and 3).

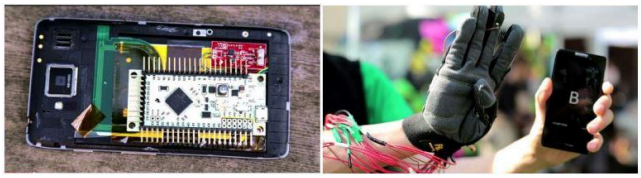

Figure 2: Prototype of a hackable phone[3]
Figure 3: One device developed during the hackathons [4]

Eremenko explained this tool and the rationale behind it as follows:

> "It was […] a hackable version of an existing phone that we loaded up on a truck full with state of the art 3D printing and rapid prototyping equipment, traveled around the country […] and held makathons in a 48 hour format. And we wanted to see: What would the ecosystem produce around an open hardware platform? [O]ur purpose, wasn't to productize. Our purpose wasn't necessarily to make modules. Our purpose was simply to explore what kinds of things people would create. It was an existence proof if you will." (Paul Eremenko, 1st Developers Conference, 04/15/2014)

According to Eremenko, the makathons function as a way of testing out the kind of network that would emerge around a "hackable" phone, without

incurring the cost of having to build the actual Ara phone. Specifically, it was a way of seeing whether someone would come forth to inhabit the figure of the independent developer and if so, who these people would be and what they would create with the tools provided by the company. The existence proof invoked by Eremenko refers then as much to the figure of the independent developer as it does to its ordering effect on Project Ara at large. Thus, the makathons can only prove the viability of "the ecosystem," if there are people to stand as instances of the independent developer, if these people can produce hardware applications with the provided tools and in the allotted time frame, and if their products are judged desirable by the company.

It should be clear, then, that the figure of the independent developer is brought into existence through specific practices of ordering the network elements, like company, tools, and volunteers, in relation to one another. However, as the figure holds these practices together, it simultaneously becomes generative of a new mode of organizing work. Hence, while the independent developer is configured through the efforts of the company, including the provision of certain design tools, the way in which it is taken up by external developers also affects the company's further work. The following quote by the Google employee in charge of organizing the aforementioned hackathons nicely illustrates this point.

> "In many ways, going across the country to the nation's top universities and just ordinary kind of makers and just ordinary people gave us an early glimpse of the kind of things that you guys would care about, like how do we need to create this modular architecture, what kind of interfaces do we need and all of that." (Dan Makoski, 1st Developers Conference, 04/16/2014)

Beyond ordering the work of the actors already involved in Project Ara, the figure of the independent developer also generates new relations that would not have existed in a conventional corporate development project. One of the most consequential of these is formed in the company's engagement with a community-based mobile hardware project called Phonebloks. Phonebloks was a grassroots design project that, like Project Ara, aimed at the creation of a modular smartphone. Started in parallel to Google's then still not-publicized project, Phonebloks gained enormous popularity in different social-media, generating a large community of enthusiasts and supporters. The great success of the project caught the attention of Google's internal team and led them to adjust their plans for Project Ara in general and their vision of the Independent Developer in particular. Viewing Phonebloks as an opportunity to jumpstart their own project, Google's team decided to open up their work in order to enroll the emerging community into the company-led Project Ara. In the first blog post mentioning the project, Google announced the cooperation with Phonebloks, framing it as the necessary complement of their own work:

> "We've been working on Project Ara for over a year. Recently, we met Dave Hakkens, the creator of Phonebloks. Turns out we share a common vision: to develop a phone platform that is modular, open, customizable, and made for the entire world. We've done deep technical work. Dave created a community. The power of open requires both. So, we will be working on Project Ara in the open, engaging with the Phonebloks community throughout our development process […]." (Official blog post, 10/29/2013)

Figure 4: Hakkens' design for a modular smartphone: Phonebloks [5]

Successfully enrolling the Phonebloks community concretizes the company's idea of what the independent developer could look like. At the same time, this new relationship creates a situation in which the company can no longer directly control all activities in Project Ara [6]. The company needs to make sure that the newly found external developers are not only interested in the project, but indeed enrolled into the network (Callon 1986) in a way resonant with the figure of the independent developer. One important way of doing this is inviting the community to a "developers conference" consisting of a series of talks and lectures on all aspects of the project from industrial design to sales. A major part of these presentations lay out Google's idea of the independent developer and its role within Project Ara. By continuously addressing the audience as module developers and by underscoring their central role in creating the revolutionary modular smartphone, the speakers try to enroll the attendees into the position envisioned for them by the company. In fact, Project Ara's innovative potential is framed as resting entirely on the creative work of external developers:

"What new things can I do that I couldn't do before or that I can't do today? Those of you in this room here today and everybody else joining us online you are going to be the ones who are going to answer this question. […] You! You are gonna do it by the modules that you develop, by the modules you create. You! Now it's not gonna be without frustration, […] it's not gonna be without a lot of hard work, but it's you that are gonna make it happen and answer that question." (Kaigham Gabriel, 1st Developers Conference, 04/15/2014,)

The conference's big success, reaching a total of 10,000 people on- and offline[7], marks the point in time at which the figure of the independent developer begins to circulate more widely. While the vision of enrolling voluntary contributors was first discussed within the company's internal team and then tested with a small number of externals, the conference can be viewed as Google's attempt to enroll a large number of new actors into the socio-material network that is Project Ara. Hence, the company occupies a central position in configuring the independent developer and bringing the figure to life. Google's designers use different techniques to construct an idea of the independent developer's identity and position within the project. They then also circulate the figure to externals in hope that it will be picked up in practice.

TOOLS OF CONTROL

The use of the development tools provided by Google is a constitutive part of configuring the independent developer. Without those tools, producing compatible modules is seen as virtually impossible specifically for people that, like many external developers, lack prior experience in hardware design. However, while the tools enable participation, they also regulate it by setting parameters for their user's behavior (Woolgar 1991). As they allow the design of some modules and hinder that of others, the tools can be viewed as an attempt by the company to control the contributions made by external developers. Yet, even though the tools materialize the asymmetric power relation inherent in the figure of the independent developer, such inscriptions (Akrich 1992) can be contested and potentially changed in future iterations.

The tool at the heart of Project Ara's ambitious digital fabrication plans is a software package by the

name of Metamorphosis. The freely available toolkit is supposed to free developers from the need to build physical prototypes, thus making the design of Ara modules more like the creation of software apps. In order to do this, Metamorphosis includes tools for everything from designing the circuit board to performance testing, pricing and ordering modules. In the words of Ara's project lead Eremenko, this is supposed to "alleviat[e] multiple design-build-test-redesign iterations,"[8] and would guarantee the production of modules that are "in essence correct by design." [9] To allow this, Metamorphosis is programmed with all the design rules and standards Google has developed. Standardizing module development in this way is crucial for a project that integrates the distributed activities of developers who are by definition removed from direct organizational control. Even slight deviations, for instance in the physical dimensions of a module, can lead to incompatibility with the phone's main platform, rendering the device non-functional. While the use of tools is thus an indispensable part of the figure of the independent developer, the specific way in which they embody the standards and design rules set by Google also inscribes into the figure the asymmetric power relations between the company and external developers.

The software's user interface illustrates how the development tools both enable and control participation. By presenting the developers with a simple drag-and-drop function for optimally positioning and connecting electrical components, the software allows people with little prior experience in hardware design to create functional modules. On the other hand, this limits the number of building blocks and leaves developers little room to manipulate their inner workings. As one of the Metamorphosis employees explained to a crowd of externals during a conference:

> "So, instead of working with tiny little components, thousands of connections, millions of lines of code, you work with larger blocks that encode the details such as you have heard on all the presentations throughout the day. All the details, they are very, very necessary for the system to work, but not necessary for you to see at every step you design." (Theodore Babty, 2nd Developers Conference, 01/14/2015).

In essence, the software embodies Google's view of the position of the independent developer within Project Ara. While the tool makes it relatively easy to create a module, the software sets strict parameters for *how* to do so, thus enforcing the design rules set by Google. Also, by not offering any way to change those rules, the tool reiterates the division of labor on which the project is based. Everything relating to individual modules should be done by the independent developer, whereas everything relating to the overall architecture of the phone is done by the company.

While this may sound like a perfectly feasible strategy to guarantee Google's dominion over Project Ara, in practice things are more complicated. This is because, even though the tools mediate the design rules set by Google in a relatively rigid way, the rules themselves do not remain static. In fact, the tools need to be constantly updated to reflect both the creative module ideas created by actual external developers and the architectural improvements made by the company. These changes can be traced nicely in the different versions of Google's official guidebook for module development, the Module Developer's Kit (MDK). This document is freely available on the Internet and contains specifications regarding module size, material and layout, as well as 3D models of reference modules, including their software code. As Eremenko proudly remarks:

> "[I]t […] happens to be the first open reference design for a smartphone that's completely freely available on the Internet. So, all of these schematics, all of the drawings and all of the code that we have to date is linked from that URL." (Paul Eremenko, Tech Conference,

> 09/15/2014)

However, as actual developers try to work on their modules, they often find that the current version of the rules does inhibit some of their more creative ideas. In such a case, developers often try to contest the rules, asking the company to change them in the next release of the MDK. This tendency is illustrated nicely in the case of "Flippypad," a concept for a game-controller-module that garnered considerable attention in the early stages of Project Ara (Figure 5). Despite its enormous popularity among developers and press, Flippypad did not adhere to the rules set in the MDK and could therefore not be realized within the larger framework of Project Ara. Yet, when requests from external developers piled up, Google signaled its willingness to *change* the rules, to permit designs judged desirable. The official Q&A page of the Project Ara website stated:

> "Q: Are modules that join two endos or attach a flip screen to an endo supported by the MDK? A: This is not currently allowed by the industrial design language in the MDK. However, the whole purpose of getting a very early MDK draft out was to get developer feedback and adapt. We think some of the concepts out there are pretty cool. And to the extent that they don't compromise other aspects of the design, e.g., structural integrity, we will try and make sure they are supported by the platform." (Project Ara website, accessed 04/24/2014)

This episode illustrates the point that, while the power relation inscribed into the tools is asymmetric, it is neither static nor one-sided. The company might use tools to shape the actions of external developers, but developers can also contest those inscriptions, at times pressuring the company into changing the rules in future iterations. In this sense, even though the tools are a constitutive part of the figure of the independent developer, enabling externals' participation and setting parameters for their activities, the specific way in which they do so is constantly changing as the project progresses.

Figure 5: Flippypad, a creative module concept that could not be realized within the tool's parameters (author: Samuel Herb)

INHABITING PROJECT ARA

In this section we examine the way in which external developers themselves contribute to the emergence of the figure of the independent developer. We want to emphasize three aspects of this process. First, the independent developer becomes an attractive way for actual developers to think about their own work. By embodying the figure in their development activities, they help to put Project Ara into practice. Second, developers "in-the-flesh" never fit the image in all regards. This creates problems for their participation in the project, but it also elicits creative responses on their part, which further elaborate what it means to be an independent developer (Star 1991). Third, while the figure of the independent developer is imbued with asymmetric power relations between Google and the externals, there is no guarantee that people will continue to inhabit the figure. When organizational changes and technical difficulties arise, external developers cease their voluntary contributions and the project as a whole begins to crumble (Callon 1986).

The independent developer, initially envisioned by Google, is put into action when it is picked up by actual developers[10]. By enacting the figure, they decisively contribute to the initial momentum of

Project Ara. This is illustrated by the success of the first Developers Conference hosted by Google. The company later reported 6.800 attendants, 10.000 downloads of the Module Developers Kit and 2660 applications for development hardware[11]. In fact, we find that the way Google rhetorically constructs the independent developer is very appealing to a broad range of people. Externals start identifying with the figure for different reasons ranging from the chance of a monetary profit, to fun, to altruistic motives. As the figure begins to circulate through different media, it gains a performative quality (Akrich 1992). It does a lot of work in enrolling thousands of very differently situated enthusiasts into Google's project. At this early stage, forums are filled with posts like the one below that link being a voluntary contributor in Project Ara to various personal hopes and desires:

> "I'd really love to get involved in the development of Ara modules as I believe it is an incredible engineering feat with a great cause behind it. Empowering the next 5 billion is a staggering goal, but I believe it can be done. The majority of people in my country do not use smartphones and I'd like to assist in developing modules for their needs." (External developer, private forum, 04/20/2014)

However, it soon becomes apparent that for many people there is a mismatch between their ideas and wishes and the independent developer constructed by Google. While people "love to get involved" for one reason or another, most of them lack the knowledge and resources to do so. Remarkably though, this does not result in people questioning the vision of the independent developer or leaving the project altogether. Instead, they engage in the often invisible work of finding ways to inhabit the figure nonetheless (Suchman 2016). On the one hand, this further obscures the asymmetric power relations implied by the mode of organizing work that is the independent developer. On the other hand, these efforts make it possible for voluntary contributors to pursue their own agenda within a company-initiated project.

The first of these elaborations is the departure from Google's original image of the independent developer as someone working individually. Realizing that they cannot pursue the development of Ara modules alone, people identifying as independent developers try to overcome this problem by organizing groups to pool resources and share knowledge. One of the members of the group we followed summarizes this process in a forum post:

> "During the Ara developers conference, it became clear that there were a number of people that would like to either learn more about developing a module or collaborate on the development of one. However, due to a number of varying restrictions, knowledge or access to resources for example, they were unable to do this. This group, now known as [Alphamod], was started during those discussions and here we all are. " (External developer, private forum, 04/18/2014)

The fact that they can only *become* independent developers *as a group* has consequences for how they organize their work. Responsibilities need to be distributed, goals negotiated, video conferences attended. In effect, this means that a lot of the voluntary contributions of external developers to Project Ara does not take the form of developing modules for the smartphone, but of sustaining and coordinating groups of enthusiasts scattered all around the globe. Much of the work they do is that of *becoming* independent developers by reducing the misfit between themselves and the figure. It is this invisible work (Suchman 2016) that allows the company's project to move forward, while simultaneously allowing external developers to pursue their own interests.

Interestingly, it is possible to follow how the mutual shaping between the figure and the people that stand as its instantiations ripples through the material-semiotic network in which they are

embedded. One striking example is its effect on the actual modules that the group develops. While the Ara smartphone was pitched as a revolutionary device that could incorporate all sorts of innovative functionality, our group decided to develop a module that would be *as simple as possible*. Hence, instead of developing the sophisticated hard- and software necessary for something like a night-vision camera, glucose meter or game controller, our group decides to develop a simple button module (literally a module with a physical button on it) without any particular functionality at all. One central reason given for this by the developers is that starting from something so easy would both consolidate the group and facilitate learning for interested individuals.

> "If we started off with something very, very basic [...] that would give us that chance to create a working relationship, a way of working together, a structure and pass on that basic knowledge to as many people as possible." (External developer, videoconference, 04/26/2014)

While creating a basic module is still very much an attempt at a meaningful contribution to Project Ara, it is clearly at odds with the innovative work that Google had intended external developers to do. We can observe here that, even though Google clearly occupies a powerful position in configuring the independent developer, the company's control over actual developers always remains limited. As a figure like the independent developer will always be in need of elaboration in the practices of the people inhabiting it, behavior cannot be inscribed into it "in anything like a complete or coherent form" (Suchman 2012, p. 56).

In fact, there is no way for the company to guarantee that people will continue to embody the independent developer. When the gap between the figure as envisioned by Google, its material instantiations (e.g. in the form of development tools) and the abilities or interests of developers "in-the-flesh" becomes too great, the latter can simply stop their contributions and abandon the project. In the course of Project Ara, several events make developers doubt whether building modules will be technically feasible and whether Google remains committed to building the project in a way that facilitates the meaningful participation of external developers. For instance, even though the independent developer is constructed as someone who uses the tools provided by Google, there are continuous delays in making available both the development hardware and software. Under these conditions, a member of our group concluded in an interview,"some of the more technically minded guys had nothing to focus on, and perhaps as a result they started losing a little interest." Perhaps even worse than the lack of appropriate tools is the fact that Google does not continue to demonstrate and prove their commitment to the external developers as they did in the earlier stages of the project. Following a leadership change within Google's internal team, public statements become rare, one of the developers conferences is canceled and questions by externals remain unanswered. The following forum post by an enraged enthusiast epitomizes the growing doubt of many developers:

"What is the story…ProjectAra Insiders [sic]…Are you going to read the forum? Are you going to respond? Are you going to answer questions? Are you going to acknowledge contributors? Are you going to facilitate small independent developers? Are you going to be truth tellers? Is Google going to do the "right thing". "Do no evil?" I hope so…" (External developer, open forum, 08/20/2014).

Eventually, most development activity ceases. As the figure of the independent developer becomes ever more difficult to inhabit, most people leave Project Ara long before it is officially discontinued by Google. Commenting on the end of the modular smartphone, the final post in our group's internal forum reads "Awww, man. And since all the good-will and enthusiasm has gone after they "went private" I doubt anybody else could pick up where they left off" (external developer, private forum,

09/02/2016).

THE INDEPENDENT DEVELOPER AS A MODE OF ORGANIZING WORK

We have shown how the figure of the independent developer is configured within the material-semiotic network that encompasses the company, the tools, and external developers "in-the-flesh." We have also tried to illustrate how the emerging figure orders the activities of the various actors involved in Project Ara. We will now widen the scope of our analysis beyond this particular case to link the independent developer back to the universe of material-semiotic practices to which it belongs. These are the ambivalent entanglements of large firms and grassroots movements in the realm of digital fabrication and the new working relations they create. In order to do this, we will compare the independent developer to some other modes of work which we typically encounter in the space of digital fabrication. This should serve as a way of contextualizing our findings and summarizing the independent developer's main features.

Let us start from the perhaps obvious but important difference between the independent developer and the employee. It should be clear from the above discussion that these two map out sharply distinguished ways of organizing work. In contrast to the employee, the independent developer implies a non-contractual relationship between the company and developers. The latter do not become members of the organization and are not paid by it. This position of externality extends not only over the development of a product, but also includes production and sale. At the same time, externality in terms of membership and payment does not mean independence in all respects. On the contrary, as opposed to earlier instantiations of the figure, for instance in the gaming industry, the independent developer of Project Ara is only conceivable with reference to a company's development project. It is at least partly configured by the company, which both identifies and enrolls actual developers, and attempts to specify parameters for their action within the project.

The mode of work implied by the independent developer crucially depends on the development tools provided by the company. These tools at once enable the participation of externals with little prior experience or resources and set parameters for their action. However, the relation between external developers and tools is constructed differently than in the case of crowdworkers (Kleemann, Voß & Rieder 2008) or prosumers using parametric mass customization tools (von Hippel & Katz 2002). Instead of carrying out rather atomized micro-tasks or choosing from a range of predefined parameters, external developers are expected to use the tools in creative ways. While the tools are designed and re-designed to enable such creativity, changes to the tools are ultimately made by the company to guarantee the compatibility of modules and platform. Thus, unlike the (digital) artisan (coons 2016), the open source developer (Gläser 2006, p. 264), or the maker (Toombs, Bardzell & Bardzell 2014), externals can neither change nor create derivatives of their tools.

Finally, with regards to the relationship it configures between developers and their products, the independent developer is not any version of the user (Woolgar 1991), the lead user (von Hippel 1986) or user innovator (von Hippel 2005). In the logic of the figure we describe, people develop their products not for their own use, but for the use of others. In fact, modules are supposed to be produced for sale on a platform market regulated by the company and similar in style to the Android App store. In this sense, the independent developer bears some resemblance to the classical figure of the entrepreneur (Schumpeter 1947). The main difference is that this is not a case of creative destruction, but of unpaid, creative labor that benefits the established firm by elaborating its platform. A smartphone "exclusively designed for 6 billion people" [12] ultimately benefits the company that controls the project.

Although, in the end of our story, it does not. Project

Ara was officially discontinued in September 2016. We do not intend to explain why the project failed. We do, however, believe that there is something to be learned from Project Ara when analyzing other digital fabrication projects. As the entanglement of large companies, voluntary contributors, and developer communities become increasingly common in such projects, it is worth considering how work in these new constellations is organized and how it could be organized differently.

RE-CONFIGURING THE INDEPENDENT DEVELOPER?

When it becomes clear that its promise of empowerment and openness cannot be so easily converted into a practical reality, external developers stop contributing to Google's project. But is this all that can be done in the end? To end on such a note would leave us with a rather bleak outlook on Project Ara and similar projects like it. Instead of ending there, we would like to stay true to the more visionary dimension inherited in our notion of configuration: The possibility to imagine how things could be otherwise. Engaging in this practice of re-configuration or what Braidotti calls the "practice of 'as if'" (Braidotti 1994, p. 6), we want to close our account of the independent developer by suggesting a way in which work on a modular smartphone could have been, and could still be, organized differently. The point is not to offer a definitive solution to the tensions between practices of grassroots development and corporate control. The point is to remind us that there is nothing inevitable about the way Project Ara turned out and work in digital fabrication could be organized differently.

Indeed, we find moments of potential re-configuration throughout the project and originating both inside and outside of it. Here we will simply point to two such moments to illustrate how work in Project Ara could have been organized differently beyond pervasive corporate control on the one hand and voluntary developers ceasing their contributions on the other. One of these potential re-configurations lies in the developers' departure from Google's vision of a highly innovative smartphone in the very act of developing modules. We mentioned earlier that, instead of building a highly sophisticated module that would fall in line with the company's expectations, "our" group of developers decided to build a module that would be as simple as possible. While this was done partly because the further development of Project Ara was not predictable and its technical specifications were still provisional, the approach to do something simple points to a different mode of organizing work as well. Importantly, the simplicity of the module was viewed as an opportunity to learn how to work together *as a group.* The goal was to use Project Ara to build a community, to connect to other people sharing the same interests, and to spread the basic knowledge and skills of soft- and hardware development beyond the project itself. In short, this episode can be read as a vision of appropriating a company-initiated project to build a way of working and learning together beyond the goals of the company itself.

A second challenge to the dominant mode of organizing work in Project Ara originated from outside of the project. Dave Hakkens, the founder of Phonebloks, envisioned a very different relationship between companies, design tools and voluntary contributors and therefore a very different mode of organizing development work. In Google's vision of Project Ara both the creation of ideas and the actual development of modules would be done by unpaid externals using the company's design tools to ensure compatibility. In stark contrast, in Hakkens' vision of Phonebloks, only the ideas would be created by the community while the technically challenging work of building the actual modules would be done by companies according to newly established industry standards. In essence, whereas Project Ara was a company trying to enroll external developers, Hakkens envisioned a community of enthusiasts, trying to enroll companies. His idea, then, was not so much that of individual independent developers producing for a company's platform market, but that of a powerful community

of users that could actively influence the industry's R&D efforts to realize their creative ideas. Phonebloks reminds us that meanings and materialities can be figured together in vastly different ways. There is nothing that inevitably binds modular phones or other high-tech products to a platform logic or to the control of a single company.

CONCLUSION

We presented Project Ara as an example of organizing work in digital fabrication and the complex entanglements of large companies and developer communities that are common in such contexts. In order to go beyond the simple dualism between bottom-up and top-down perspectives, we used the concepts of figure and configuration. We showed how different actors contributed to the emergence and temporary stabilization of the ambivalent figure of the independent developer and how that figure in turn became the dominant mode of organizing work in the project. The independent developer was crucial for building the material-semiotic network of Project Ara because it allowed Google to interest external, unpaid developers into Project Ara and to enroll them into a very specific position by providing tools that enabled and controlled their contributions. At the same time, the independent developer was brought into existence in the contingent practices of external developers that tried and sometimes succeeded in following their own agenda. The independent developer cannot, therefore, be described as the strategic outcome of the activities of Google or any other actor in the network. Even though the figure was crucial for holding the precarious relations between these different actors together and made it possible to continue the project besides its many ambivalences. Finally, pointing out the precarious state of such networks, the notion of (re-)configuration reminds us that work in digital fabrication could always be organized differently.

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NOTES

[1] We distinguish the term "external developers" from our notion of the "independent developer" and both from Woolgar's notion of "the user". The term "independent developer" was prominently used by various actors in the field to denote individuals who voluntarily contributed to the company's project by developing, but not necessarily by using products. We use the term in an analytical way to refer to a performative image of organizing work, or what we call a figure. We use the term "external developers" to speak of the developers "in-the-flesh", the concrete people who contributed to module development in Project Ara.

[2]http://www.projectara.com/, accessed 09/12/2015

[3] https://www.youtube.com/watch?v=aSSuIceLP2g&t=0m39s, accessed 07/03/2017

[4] https://www.youtube.com/watch?v=aSSuIceLP2g&t=0m54s ; accessed 07/03/2017

[5] https://commons.wikimedia.org/wiki/File:Phonebloks_open.jpg , accessed 07/31/2017

[6] Indeed, we argue that Phonebloks configured an entirely different mode of organizing work, which was written out of corporate accounts as the project progressed. We will return to this point below when addressing possible re-configurations of the Independent Developer.

[7] https://www.youtube.com/watch?v=IQhbM55F23U&t=0h43m00s, accessed 07/31/017

[8]https://www.youtube.com/watch?v=uj9AcXJ54QQ, accessed 02/19/2018

[9] https://www.youtube.com/watch?v=v2OEKL1w__4, accessed 02/19/2018

[10]Like the members of the developers group that we joined during our research, a typical developer in Project Ara can be described as an amateur in regards to the development of mobile phones. Typically, s/he (though mostly he) had some background and expertise in software and sometimes hardware design and was interested in the Project because of Google's initial promise of democratizing hardware design by providing free tools and lowering the barriers to entering the project.

[11] Paul Eremenko, statement at tech conference, https://www.youtube.com/watch?v=IQhbM55F23U&t , accessed 2018/02/27

[12] http://www.projectara.com/, accessed 09/12/2015

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REMANTLE AND MAKE: A CROSS GEOGRAPHICAL STUDY EXPLORING THE ROLE OF MAKERSPACES AND THE CIRCULAR ECONOMY IN SCOTTISH TEXTILES

Paul Smith, Michael Johnson, Lynn-Sayers McHattie

This paper draws on primary empirical research carried out in two maker spaces based in geographically different sites, one urban based in the central belt of Scotland and one rural based in the Scottish Highlands. It reflects on the ReMantle and Make project, an EPSRC feasibility study exploring the role of maker spaces for the circular economy in the Scottish textiles industry. This research presents an analysis of the project, drawing on methods of visual mapping and Situational Analysis to critically examine the relational and democratic factors for maker spaces in knowledge production.

Keywords: circular economy, makerspaces, textiles, situational analysis

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by Paul Smith, Michael Johnson & Lynn-Sayers McHattie

INTRODUCTION

Realising a circular economy requires consultation and collaboration with a broad spectrum of stakeholders if we aim to develop robust, sustainable solutions to issues of global waste. In the context of the textiles sector particularly this includes manufacturers, designers, higher-education institutions, small to medium enterprises, policy makers, and citizens, all of which are necessary to explore sustainable, circular material futures. The complexities of the material waste issue itself, and the many actors needed to develop responses to it, results in tensions and conflicts when faced with developing practical solutions. Rather than repress ideological collisions and tensions faced in taking theory into practice from multiple perspectives, the research discussed in this paper aims to bring them out in a democratic forum based on practical and theoretical knowledge.

The research presented here explores design innovation approaches, in collaboration with academics, designers, manufacturers and policy makers, to tackling the issue of material waste. In two cross discipline 'Re-Make-a-Thon' workshops, it explored different notions of value in material waste and strategies for implementing a circular economy approach from multiple perspectives. The workshops applied theory in practice using waste textile material from local manufacturers and the tools and resources in a maker space to uncover practical issues to implementing circular practices through hands on experiments, live design briefs and multi stakeholder debate. A Showcase exhibition and Roundtable discussion of the project at its end widened participation further to include citizens and opened up the research to deeper discussions around the social and policy implications of circular practices, and more focused, systemic issues in implementing closed loop practice. The project was part of a bigger research project entitled 'Future Makespaces in Redistributed Manufacturing', a two-year research project based at the Royal College of Art and funded by the Engineering and Physical Sciences Research Council (EPSRC), which explores the role of maker spaces in redistributed manufacturing (RdM). Our study aimed to investigate how we can use maker spaces to cultivate cross-institutional circular thinking and provide resources to develop circular design knowledge and practice. This paper focuses on the

Roundtable discussion at the culmination of the project and aims to uncover the roles of individual actors in the study, their agency, and the role a maker space played in defining and mediating roles.

This paper begins with a summary overview to the circular economy, the maker space movement, and democracy in design. We go on to discuss the methodological approach taken to construct our research, describing the key methods and mode of analysis. Following this, we present the project's participants, activities and outcomes as a narrative case study. The context of each of the key participants involved in the project and that contributed to the workshops are introduced, which allows us to explore how the agency of actors and, in some respects, power relations was recalibrated in the context of the project. This is done through examination of participant responses and our own observations, analysing the roles and discourse throughout the final stage of our project, namely the Roundtable discussion.

Our analysis of the project is argued to demonstrate how future maker spaces could be sites for collaborative material experimentation and democratic spaces for peer produced knowledge. Spaces where institutional norms and agendas collide, strategies for addressing complex issues from a multiplicity of perspectives develop, while simultaneously providing educational hubs for experimentation and learning. In summary of the paper we ask: what role did the maker space play in the development of approaches to implementing the circular economy? To what extent did it contribute to a more democratic exchange between the tensions and conflicts of different institutional perspectives?

IMPLEMENTING THE CIRCULAR ECONOMY

Positioning the issue of waste

Across the globe, societies, in the main, live in a 'throwaway and replace' culture. In Scotland alone, statistics from 2015 show that 46.6% of household waste, equivalent to 1.5million tonnes, went to landfill (SEPA, 2016) with almost half of the non-land filled waste being incinerated. Internationally the issue is even greater with some 10,000 tonnes of solid waste deposited on landfill sites in places such as Laogang in Shanghai, China, and Mexico City's Bordo Poniente (Hornweg et al, 2013). In 2010 global levels of solid waste hovered around 3.5 million tonnes per day and this is predicted to rise to 6 million tonnes per day by 2025 (The World Bank, 2013). Our growing population and demand for new products has placed huge pressures on our planet's resources. The problems associated with the current global trends means we urgently need innovative new ways of thinking about how we make and consume products, and the circular economy has been claimed as one such way.

The Circular Economy

The circular economy is a framework and an alternative way of thinking that can help address complex issues around material waste and linear models of resource use. The term is antonymous to the linear economy, defined as 'converting natural resources into waste, via production' (Murray et al, 2015). A linear system affects natural environment by reducing natural capital through extraction, use and disposal, and degrades remaining natural capital though pollutants. In opposition to this, a circular economy aims to reduce the amount of new natural capital extracted and reduce the impact on remaining natural capital by keeping materials in productive use for longer, thus reducing 'waste' and the need to pollute through industrial processes (The Ellen MacArthur Foundation, 2013). The three Rs of Reduce, Reuse and Recycle have become central to the concept.

In a circular economy the waste from factories would become a valuable input into other processes. Rather than be discarded when they break or fail or become perceptibly obsolete, products could be repaired, reused or upgraded (Preston, 2012). The circular economy is beyond design and waste

management, as it fosters new business models that take account of provenance, longevity, impacts and end of life (RSA, 2013); therefore, partnerships and collaboration in the circular economy will be crucial. In the move towards a more 'circular' future, knowledge exchange will be essential to support joined-up thinking, to connect all stakeholders involved in the lifecycle of material journeys and new supply chain models. Transparent democratic exchanges between all stakeholders will be required if we are to tackle the issue constructively.

Scottish Textiles

Within the UK textile sector, there is increasing awareness of the requirement for new textile initiatives to be linked with the concept of the circular economy (Earley and Goldsworthy, 2015), but there is a lack of innovation tools, practical knowledge and accessible evidence available to provide support. Within Scotland specifically, Scotland's Zero Waste Plan and Circular Economy Strategy set the trajectory for the future of the Scottish economy and environment with a focus on resource efficiency and new innovation. The vision focusses on lower rates of consumption in the economy, less waste, and more value added to resources. In addition, the Scottish Textile Strategy highlights innovation, sustainability and efficient use of resource as key to its ten-year plan. However, the Scottish textile industry, while supportive of the circular economy lacks visible action. Research has found that 'there are few reports related to circular economy innovation in textiles in Scotland and evidence of closed-loop manufacturing' (Wilson, 2015: pg. 1).

Recently, research commissioned by Zero Waste Scotland, Scottish research and policy organisation, investigated innovation in the academic and industrial landscape for Scottish textiles. The research shaped the zero-waste work plan for 2014 to 2016, a plan that foregrounds three key objectives: sustainable fibre processing; showcase and pilot CE models and resource efficient good practice; and seek greater engagement of industry with academia.

With the Scottish textile sector estimated to be worth £956 million to the Scottish economy, and with an ambition to grow by 50% by 2020, there is a significant drive to invest in the circular economy in Scotland as a growing industry, and a substantial opportunity for intervention to help support the transition.

MAKER SPACES

Definition of a Maker Space

Maker spaces are open access workshops that transfer knowledge and technology to citizens. They play a part in establishing social and ethical actions, they can be places where ideas can find a place to experiment and explore alternative ways of doing things. Maker spaces, far from being places of just developing innovative products, are places where design and material engagement play a role in ethical and social interventions, and where alternative thinking propagates (Shea, 2016). The spaces allow academics and citizens (including entrepreneurs) to network, exchange ideas, and learn. Maker spaces are typically independent, community-based efforts. They are responsive to local issues and can exist to provide support for innovation and enquiry where there is no current local provision. Within these physical hubs, technology, skills, ideology and education can come together to explore and experiment with new ideas and possible futures. Maker spaces are 'socially shaped' entities, reflecting their time and place in both technological and human terms (Kohtala & Bosqué, 2014). For our study we were interested in the role these spaces of experimentation, education and democratic production could play in furthering a circular economy.

Politics of Maker Spaces: Activities and Ideologies

Maker spaces often build strong associations with different communities and organisations. These

associations 'flavour' the spaces, which can guide and influence the type of activities and ideas that occur and propagate. A brief review of some of the types of maker spaces currently in operation gives a feeling of how these spaces differentiate from one another, their associations, and the politics at play across the global network of open access spaces. Some maker spaces have developed to respond to specific interests, movements and theories or to fill a gap or niche. Feminist maker spaces, for example, are for some seen as a counter culture to the traditional form of maker space ideology of openness, to one of boundary and safety (Toupin, 2014).

A common view of maker spaces is one of inclusivity, democracy, openness, and sharing, yet a brief exploration shows them to be highly diverse political entities. Social barriers can disrupt open sharing and normative behaviours, which have prevented some groups from engaging with social groups outside their own. Sharing is an almost universal virtue of maker spaces, considered part of the complete ideology of maker spaces and related to open availability of technology, information and the distribution of agency. Research has shown however that knowledge forms in small groups and is normatively shared locally in maker spaces, yet 'lateral' knowledge sharing has been exceptional (Wolf et al, 2014). People who engage with maker spaces are less likely to openly share what they are doing with those outside of their local group. This social barrier to sharing is a characteristic of maker spaces that conflicts with the open sharing ideology that is supposed to fundamentally underpin all their activities. In some cases they have become places for like-mindedness to propagate where similar views circulate and strengthen a particular position. In this social act the people of maker spaces can shy away from conflicting views, instead becoming niche and narrow.

For our study it was important to recognize the politics at play within the spaces we ultimately created as part of the project; the time and place of the project, and the way this influenced the outcomes. By purposefully inviting different perspectives and conflicting views into our project, and by siting it in a maker space, we hoped to allow relative 'strangers' to share and exchange their views and democratically create new knowledge.

DEMOCRATIZATION THROUGH DESIGN

When considering the complex implications of establishing a circular economy, this raises the challenge of assembling multiple actors, and aligning their interests, to collaborate and cooperate in very particular ways for very particular values. This requires a broad cultural shift towards circular thinking that is difficult to expect through enterprise and innovation alone. Therefore, we argue that any consensus on values of eliminating unnecessary waste is not done just through collaboration, but a democratic process.

There has been growing recognition of design innovation having the capacity to deliver constructive and creative democratic processes. Von Hipple (2005) recognises the 'democratization of innovation' to mean 'that users of products and services […] are increasingly able to innovate for themselves.' Such principles have long been recognised through Participatory Design, which 'started from the simple standpoint that those affected by a design should have a say in the design process.' Such a process was strategically guided by 'the consideration of conditions that enable proper and legitimate user participation' as well as 'making the participants tacit knowledge come into play in the design process' (Simonsen and Hertzum, 2012:103). In this way, the process of constructing the problem with participants is as important as the production of an artefact (Bredies, Chow and Joost, 2010:164). Such 'democratization' of the design process has only recently been folded into the wider discourse of co-design as its principles sat in contrast to the 'existing power structures' of most organisations (Sanders and Stappers, 2008).

It is the implications of existing power structures that this paper, through analysis of our project,

sought to investigate through a Foucauldian relation of power to discourse. Foucault (1980) presents power as 'the total structure of actions' bearing on the actions of individuals who are free (Foucault, 1980:220). Hindess (1996) interprets this freedom as 'those individuals whose own behaviour is not wholly determined by physical constraints […] those who are in a position to choose, and [exercising this power] aims to influence what their choices will be' (Hindess, 1996:99). Foucault relates the exercise of power to 'the instruments, techniques and procedures that may be brought to bear on the actions of others' (Foucault, 1980). Hindess suggests that 'the forms of power may be remarkably heterogeneous', and that some will be concentrated and hierarchically organised, while others will be socially dispersed (Hindess, 1996:100). He summarises how, from this perspective, 'power is everywhere and it is available to anyone' and as a result 'its use may be analysed in terms of the most varied instrumental and evaluative considerations' (Hindess, 1996:100).

From the perspective of collaboration, part of the 'instrumental and evaluative considerations' is through the things representative of discourse used to enact the will of institutional actors. For manufacturers, usually these are implemented for the purpose of achieving efficiency or administering quality control. For leaders, this focuses on the capacity to motivate action in alignment with a wider strategic plan. Discourse represents these instruments or procedures as *ways of speaking*, proliferated and repeated across networks of actors to bring about action, which inform the models by which we work and become ways of *infrastructuring* (Simonsen and Hertzum, 2012). As Hayes describes, we develop our own conceptual models about how organisations function, and use these models to guide us, interpret what we see, and decide how to act (Hayes, 2002:72). The challenge we identified for the circular economy was to develop a democratic discourse around a model for circular thinking strong enough to develop and replace existing wasteful modes of production.

Design carries significant potential towards meeting this form of challenge, with a practice that can engage such a discourse, unpacking each actor's various models and make them an *explicit* part of understanding, debate and decision-making. Of core interest for this paper is when such models become *things*, matters of concern (Latour, 2005), 'a contested gathering of many conflicting demands; a disputed assemblage that will divide and congregate and will engage new assemblies of humans and non-humans' (Yaneva 2009, 284). When the knowledge across collaborators in the design situation needs to be gathered and represented, through modelling, a congruence of meaning becomes strained along the associations and implications made. This paper aims to understand these strains by reflecting on the learning developed through the project, and analysing the discourse facilitated with key participants as stakeholders.

METHODOLOGY

The methodology for this paper follows three key stages: presenting the case study of ReMantle and Make through a key narrative of learning; presenting the design and facilitation of the project Roundtable discussion; and the analysis of that discussion using *situational analysis*. Here, we briefly introduce the process of discerning the case study and applying situational analysis, while the Roundtable design and facilitation is presented within the case study and analysis sections.

Case Study

A case study approach is applied to our project as it can deal with multiple causation and complexity (Bell, 2005) and can help critically evaluate design practice for "universal ideas to be extracted" (Breslin and Buchanan, 2008, p.38). For the purposes of this paper, case studies are understood as a key method of empirical inquiry that 'investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are

not clearly evident' (Yin, 2009:18). The context of maker spaces linking with Scottish textiles manufacture through circular textiles design was highly complex, specialized and uncertain, aligning assiduously with Yin's conditions for case study research.

The presentation of the case study used key narratives extracted across of the chronology of the project in order to foreground learning from key activities in relation to power structures and the role of maker spaces for circular thinking. This draws on exclusively qualitative data accumulated through discussions, interviews and researcher observation and reflections collected throughout the project. The purpose of the deployment of this data is to provide contextual information about the overarching project from which the final Roundtable activity was delivered.

Situational Analysis

The mode of analysis for this paper is adapted from one of the author's PhD thesis developing an *object-oriented approach* to trace and analyse multidisciplinary design work. The Roundtable discussion is analysed using aspects of *actor-network mapping* (Johnson, 2016), which used the Ecology Map of the project's actors and context of development to then apply situational analysis (Clarke, 2005) to interpret the discussion and controversies across the cohort assembled.

Clarke (2005) presents situational analysis as methods of mapping to support grounded theory analysis, the initial form being situational maps, which 'lay out the major human, non-human, discursive, and other elements in the research situation of inquiry and provoke analysis of relations among them' (Clarke, 2005:xxii). In Clarke's method of situational mapping, the question is 'who and what matters in this situation?' calling on the researcher's (or informant's) experience observing (or participating) in the situation under inquiry. Clarke then suggests the analyst performs a *relational analysis*, 'literally centre on one element and draw lines between it and others and specify the nature of the relationship by describing the nature of that line' (Clarke, 2005:102). This is performed systematically, one selected element at a time.

For the Roundtable discussion, selected lines of discussion would undergo relational analysis drawn on a sheet of tracing paper placed over the Ecology Map, visible underneath. This would all be supported by asking questions on each relation, annotating the stakeholder's interpretations, with the discussion audio-recorded for further analysis. This further analysis would connect related interpretations from the discussion, combined with wider learnings presented from the case study, to produce three key themes on the roles, motivations and power structures influencing stakeholders in circular thinking.

CASE STUDY: REMANTLE AND MAKE

ReMantle and Make conducted practice-led research to produce a small collection of fashion accessories within a circular economy model by prototyping potential future maker spaces for circular textile design. This case study presents the key narratives at each stage of the project to reflect on the barriers and opportunities to implementing closed loop innovation within the textile sector, on what scale it could be possible, and what role maker spaces could have in a sustainable future for manufacture.

Factory Visits

The initial stages of research exploration in our project involved approaching some of the largest textile manufacturing mills and factories in Scotland, such as, Johnsons of Elgin, Begg and Company, MYB Textiles and the Scottish Leather Group. They all supported the research by gifting pre-consumer textile surplus, including leather offcuts, cashmere and woollen selvedge edging, woven fabric, coned yarn and lace.

Key Learning Narrative

While there was an appreciation for the knowledge and quality in the materials each manufacturer produced, there was variation in approaches to waste and reuse. This was observed to depend on how actively they aimed to produce knowledge on their waste, and how ready other stakeholders were to take their waste, often simply for disposal. While the waste outputs were highly varied along the production process, our focus was on high quality surplus textiles in both off cuts and cones of yarn.

Archetypes & Prototypes

Three textiles designers were commissioned to produce what we called circular *archetypes*, which would act as definitive prototypes in response to the design challenge. A selection of the prototype collars developed by participants from the Re-Make-a-Thons were also produced as *archetype* open source garments for exhibition by our project partners, micro-manufacturers Kalopsia, for the Roundtable and Showcase. Our commissioned designers would also develop their own prototypes for exhibition to a highly finished standard.

Key Learning Narrative

This was a vital part of the project, as the experiences of commissioned designers working with the materials alone brought insights into the challenge such materials present for designers. When sharing their experience in the Re-Make-a-Thons, they described the initial frustration of working with surplus materials, needing to deconstruct their traditional way of working through experimentation, and the enjoyment is discovering how to bring such materials to life. Presenting such a mind shift before then asking the Re-Make-a-Thon participants to use the materials was important to enhance the quality of experimentation and prototype outcomes.

Circular Canvas

To explore the circular characteristics of the garments and systems proposed as part of our Re-Make-a-Thon workshops, we developed a model framing the circular life cycle of textiles, known as the Circular Canvas. The tool breaks down the life of a product into five key stages of *origin*, *material*, *equipment*, *use*, and *post-use* (see fig. 1). The tool challenged us to determine for each stage as much information as was available about the impact of textile products. We focussed on the local conditions around a product during its production and distribution, the material processes involved and the equipment needed to make it. We also explored the product in use looking at the systems in place to take a product to market and the consumer roles. Finally we asked questions about post use, or the future lives of the product and the embedded materials.

Fig. 1: ReMantle Circular Canvas

Key Learning Narrative

The initial purpose of this model was for it to integrate as an essential part of the prototyping process, to inform the nature of experimentation by participants. However, the reality was that the materials would lead the nature of experimentation; how participants would explore their properties to gain inspiration. It was only once they had gained

enough confidence to fully prototype a selection of collars that the canvas came into play as a framework to present and reflect upon their garments. This felt a more appropriate use for the canvas as it does not inherently contain the knowledge around a garment, it is the site on which knowledge gained can be articulated and shared, often exposing key gaps in knowledge, and therefore offering insight towards further iteration.

The Re-Make-A-Thons

The Re-Make-A-Thon workshops were one-day, rapid, hands-on design events where participants were set the brief of transforming waste material into a prototype collar. The collar needed to be open source, where the original conception can be hacked or modified to produce a hybrid concept.

The first Re-Make-A-Thon, set in Glasgow, focussed on exploring the possibilities with the surplus material and made full use of the technical capability of the Glasgow Maker Space, MakLab, such as 3-D printing, digital textile printing, digital embroidery and laser cutting, alongside more traditional sewing and embroidery equipment. There were sixteen participants in total, including a range of fashion and textile designers, product designers, academics and students.

The second Re-Make-A-Thon was hosted in a temporary ‘pop up’ maker space in the Glasgow School of Art’s Highland and Islands Creative Campus on the Altyre Estate, just outside of Forres. We were joined by some of the participants from the first Re-Make-A-Thon, and additional craft makers, researchers and design students from the region, to total fourteen participants. To build on our findings from the first Re-Make-A-Thon, we challenged participants to not only think of some ideas for open source designs, but to consider the whole lifecycle of their concepts using our circular canvas tool to guide them and build systems level thinking into their designs.

Key Learning Narrative

The Re-Make-a-Thons were at the heart of the experiment, aiming to present a viable process for designers to come together with surplus materials and find value. Among various insights, the provision of space for designers to experiment together, share knowledge, techniques and ideas in a constructive environment were widely commented as building interest and new collaborations. There was also a keen sense of self-awareness and learning energy among the cohorts where technical knowledge was actively sought, gaps exposed, and creative yet considered solutions presented. The gaps reflected, however, were significant in that many participants felt they could only speculate aspects of the circular canvas, and so participants with technical knowledge would have enhanced such discussions.

While the quality of what was produced was always going to be limited, the diversity of prototypes was very encouraging. Due to the participants openly conversing on their ideas this seemed to naturally vary their chosen experimentation and outputs. More crucially, many participants chose to work further on their concepts after the workshops to prepare more finished items for exhibition. This observed motivation and interest in the process exposed how the project was meeting a gap in many participants’ work practices to be presented at the final Roundtable and Showcase.

Roundtable & Showcase

The project returned to MakLab to set up a final Showcase exhibition and host a Roundtable discussion with our project stakeholders. The Showcase told the story of the project, exhibiting the raw surplus materials that started it all, through to the hands on experiments and the ideas from both Re-Make-A-Thons, and finally the finished open source garments produced by our project partner, Kalopsia, and our commissioned designers.

Eleven stakeholders took part in the Roundtable with the majority of participants not sharing a

common institution or 'place of origin'. Two participants were managers of maker spaces from different parts of the UK. There were independent textiles designers, a circular economy policy advisor and sector manager from Zero Waste Scotland, with only the academic research team and two other participants sharing the same institutional place of origin.

After allowing the stakeholders to walk around the showcase, we all sat down for an intensive 90 minute discussion, facilitated by prompt cards, but very much driven by the different perspectives and experiences around the table. We used the Circular Canvas to frame a simple Ecology Map of the project (see figure 2) to guide our conversation through the stages of the circular approach. The Ecology Map helped us to scrutinise current situations for products in textiles and to interrogate any new propositions created as part of the workshops. We used prompt questions derived from our project insights to bring our knowledge to the table and explore where the participants saw themselves in product ecologies, where they could have impact and what that impact might be. The key learning narrative for this process is the focus of this paper, presented within our analysis.

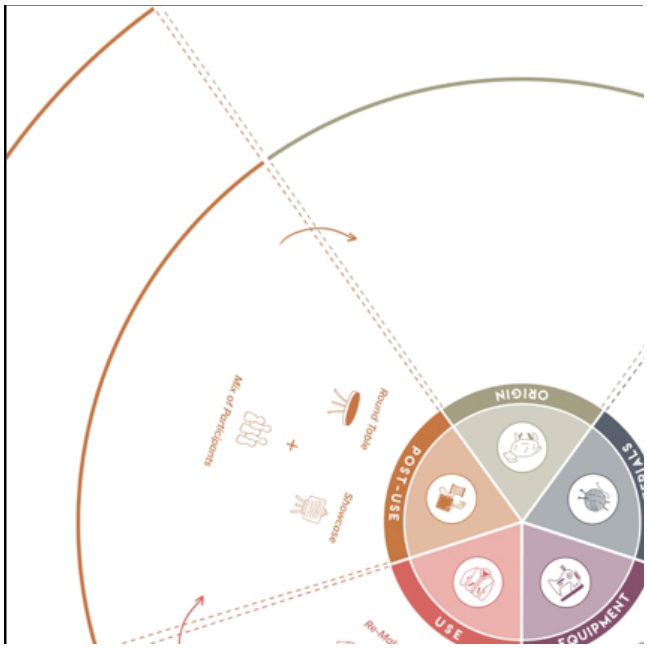

Figure 2. Ecology Map for Roundtable Discussion

ANALYSIS

In this section we present our use of situational analysis: firstly through the mapping of stakeholders who took part in the roundtable element of the research study into the Ecology Map; then secondly, by analysing the major discourses that arose from the roundtable along relational lines, and how they compared to our interpreted findings throughout the project.

Mapping the Participants

We asked participants at the start of the Roundtable to place themselves onto the Ecology Map where they felt they had a role to play in the circular economy and explain their choice as a way of establishing their own view of their role and their institutional background. This began to set out what norms and influences individuals might bring to the discussion. The mapped actors are presented below (see figure 3), referred to by their role and each positioning is annotated with a supporting quote.

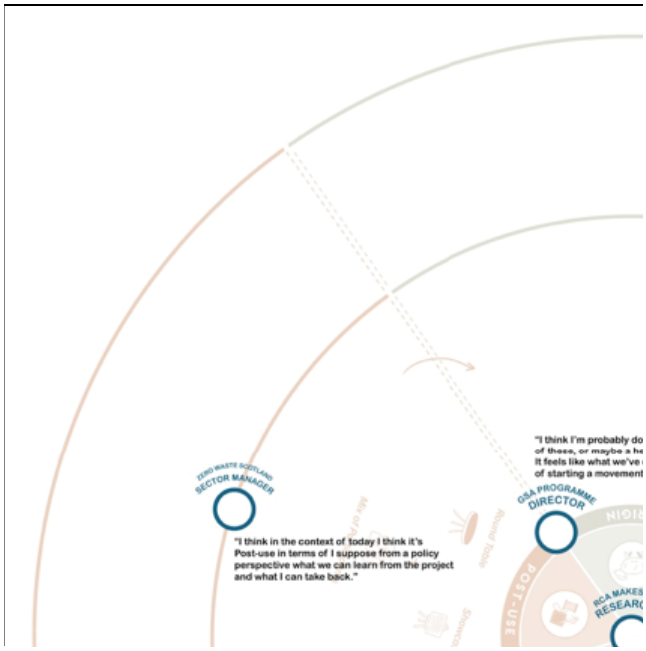

Figure 3: Roundtable Participants Mapped into ReMantle Ecology Map (Johnson, 2017)

Mapping the Discourse

Three prompt questions in particular moved discussion through our circular Ecology Map: Is changing waste to surplus about process or mindsets? Who is best equipped to take on surplus material? Is the circular economy a knowledge economy?' Our analysis maps the key points interpreted from across the discussion, how they relate to the stakeholders involved and how these key points relate to each other in producing key themes on the roles and relationships towards developing circular models in Scottish textiles.

The result of our analysis is presented according to three key themes that emerged. Firstly, much of the discussion centred on *the tension of responsibility and change*; secondly, exposing *the challenge of scale and volume*; and thirdly, providing *space for experimentation and communication*. Each theme is presented with a visual mapping of relations, key quotes from participants, and reasoning for how they frame and constitute each theme.

The Tension of Responsibility and Change

The question that opened discussion, 'Is changing waste to surplus about process or mindset?' was initially separated as part of the creative process for artists and designers, and part of marketing strategies for consumers. Strong discussion expressed the difficulty in propagating the circular economy in textiles due to a lack of education and quality information for consumers. The public can't be expected to change their habits when retailers shift the responsibility of waste to consumers, aggressively undercutting more sustainable models, and fashion advertising "really building vulnerabilities in young consumers". This was proposed as defining the mindset shift:

> "That is getting away from thinking that these prices and practices are acceptable and then realising in fact what we're doing is undercutting our own markets and that is again dangerous." – Kalopsia Managing Director

Responsibility across the stakeholders emerged as a key point of discussion (see figure 4), particularly highlighting the tensions of how responsibility is distributed. The ZWS Sector Manager expressed policy changes that would be meaningful to the public as crucial, such as 'if we could knock 40% off our council tax because our public sector does closed loop textiles.' Conversely, consequences of ongoing ignorance in sustainability issues were cautioned as resulting in unwanted taxes, either on consumers, producers or retailers, in order to force behaviour and process change. Where such penalising legislation would fall would depend on who had power to shift the locus of responsibility. Should the responsibility of waste produced after using an item fall with the consumer or the producer?

> "What if we're all guerilla returners and every time our item has run out or broke down or we were done with that piece of clothing, we just returned it back to the shop where we bought it from?" – ZWS Sector Manager

The group saw responsibility throughout the whole chain of production and consumption, including the retailer, designer and producer, sharing new frames of reference for the textiles industry. The discussion connected such frames of reference to design education and making informed choices that can instil circular practices. The Textiles Embroiderer shared a simple process of providing bags for her students to collect all their bits of waste according to their colour. The issue of the presentation and quality of surplus would arise across the key themes, and certainly emerged within the project activities. However, the particular issue of 'fast fashion' was raised through an example of a fashion designer advocating smart use of disposable materials designed specifically for a circular

economy.

The tension set out in this theme relates to the notion of shared responsibility across the fashion industry clashing with the locus of leadership, and how good decision-making at the start of a process can integrate sustainable practices and still relate to modern consumption.

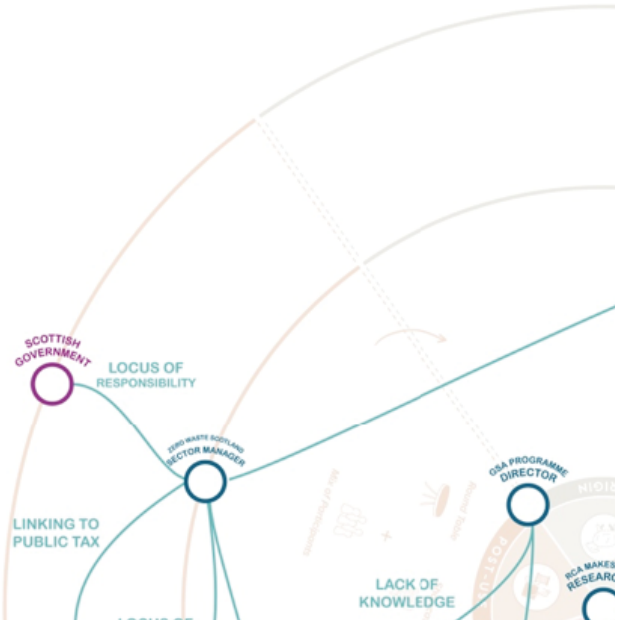

Figure 4: Relational Mapping of 'Tension' Theme, (Johnson, 2017)

The Challenge of Scale and Volume

The second theme exposes the debate expanding on issues around the creation and use of 'waste' or surplus material and how quantity dominates current structures and large-scale thinking, however raising the quality of surplus material was paramount to creative practitioners and seen as a key opportunity. The selection of surplus material for the project seemed to emphasise how surplus waste could be made of interest to designers.

> "This surplus, it's what happens then, what happens next, who's managing that, who's categorising that and cataloguing it. […] unless there's almost a business structure to underpin it, we're going to really struggle to get this into any sort of use and high volume." – Kalopsia Managing Director

> "I do think there's an issue around quantities and experimentation. […] [Manufacturers I approached] were like, 'We need you to take five tonnes of it at a time.' I'm like, 'I can't take five tonnes. I can take two bags, have a play, and then get back to you with solutions and potentially afterwards look at five tonnes, once I know what I'm doing with it.'" – MakLab Manager

The challenge of scale was firmly set out by the ZWS Sector Manager (see figure 5), that the 'Scottish government has decided textiles is not a priority,' as it's felt 'we're very good at designing out waste from our original methods of production,' while major companies 'will not try a new technology unless you can show us that it will process 50,000 tonnes minimum.' As a result, she felt technology should be the focus of innovation towards the circular economy, as well as designers educating manufacturers globally.

> "A garment that Scotland would produce is up to 5% waste. A garment produced in Hong Kong is up to 20% waste. So that's about the industrial process. So what can we as designers and educators, who are going to send out those designers to those industries, what can we impart, teach or learn around that? These are the global challenges." – ZWS Sector Manager

In the context of large British businesses, the Sector Manager asserted 'you will see case study after case study […] trying to close the loop'. However, she claims a textiles techonologist equally will say they're against the boardroom, the design team, or even fashion, where less sustainable materials might dominate the market: 'one year it's polyester. […] that puts up the carbon. If the next year it's

cotton in fashion that puts up the water usage.'' In other words, mainstream fashion is perceived to need to adopt circular thinking, however this would also be subservient to the influences of the market and mindset of consumers. As such, the perceptions of these volumes, and what they mean to the everyday consumer, is expressed as needing to be made more meaningful through design.

The Textiles Manufacturer contributed a story of their waste management as a more flexible, yet systematic exchange. Firstly, what they gave to the project as waste is noted as 'not actually waste or storage, because we actually sell it back and it gets re-spun until they're fibres.' This raises the question of how to make sense of the volumes from a manufacturer's perspective, where it's more about 'bypassing what normal waste routes would be' and 'turning it into something better than recycled.' The challenge for manufacturers is that they can't guarantee how to use their waste, as 'the source material from our surplus is not actually always going to be there.' And so bespoke, creative solutions can play a role, 'like slippers where you felt the whole thing down', responding to surplus, or even learning uses of expected surplus, that could be judged as better usage.

The overall challenge set out within this theme is in facilitating the scaling up of knowledge and creative solutions. This particularly includes how policy, both at governmental and organisational levels, is not exclusive to narrow, high volume technological solutions, but encourages a shared curiosity for small-scale solutions.

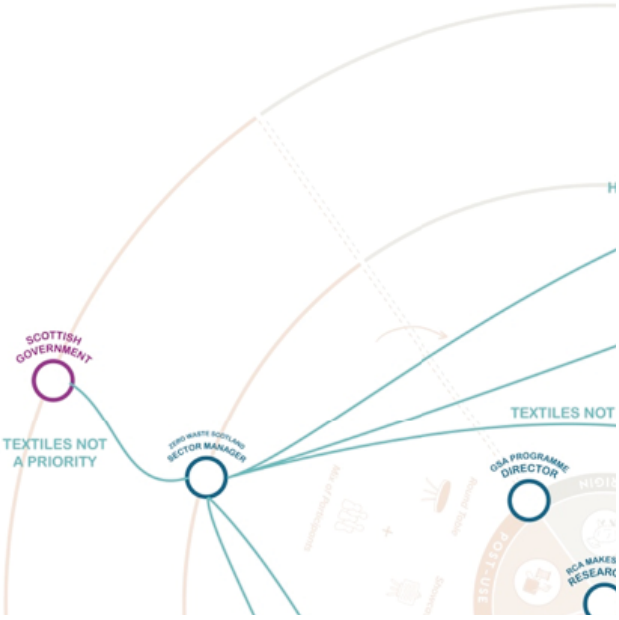

Figure 5: Relational Mapping of 'Scale' Theme, (Johnson, 2017)

Space for Experimentation and Communication

The third theme focuses on the enhancement of maker spaces, and their potential role for contributing a shared space for a circular textiles economy in Scotland. As the challenges of technical processes, material quality, cultural norms and market forces were expressed throughout, the MakLab manager often retorted with opportunities they saw for their operation to intervene (see figure 6).

In response to technical processes of dealing with waste materials, she shared recent experiences experimenting with acrylic, a material they use a lot of, which is a form of plastic that doesn't easily melt down and is difficult to reuse:

> "Recently we've been looking at how we can turn it back [...] re-granulate it and then turn it into a composite that can be added into something else and turned back into something.

> So we have been really pleased with finally finding a solution to this, which is something that we've been thinking about for three years."

This dedicated experimentation towards the reuse of waste material clearly needed time and investment, alongside the wider operations of the maker space, and so this turned her to ask 'where do you find the information?' and 'where do you find people who have already been tackling such problems?' There is a distinct and tangible reason for maker spaces, tackling similar issues of waste that are common between them, to connect and share such knowledge. As part of connecting and sharing such technical knowledge would be another agenda to engage broader communities in contributing, learning and using such knowledge 'at different geographical locations' or 'looking at early years'. Such engagement would ultimately aim 'to change the habits of waste and consumption at the beginning of the process as well.' The uncertainty lies in whether maker spaces could lead this without a consistent approach and systematic sharing of knowledge.

Small exchanges towards changing habits were shared by both the Kalopsia Managing Director and the maker space manager. For Kalopsia, a key policy with their clients is 'when you get products from us, you get the products and the waste, so you're very aware if your pattern is not efficient.' The maker space manager concurs how this is a conversation small makers have all the time, citing how customers request an order without understanding how long it will take and how much it inherently costs. As a result, a major driver towards a circular economy is identified in 'the education of people in terms of much more transparency about how things are made, and about how much they actually cost to make.' Such education is recognised as happening at the point of need, when people make a request for something to be produced, and are confronted, not just with what they value in their modes of production, but what others value as well.

As a result, this theme often overlapped with the previous themes to propose the concept of a *surplus broker*, as a new potential actor in the circular economy in textiles, emerging through the discussion:

"Ideally what you're looking for is someone to have a large symbiotic business that can take some of these waste streams. If you don't know they're there you don't think about it." – Kalopsia Managing Director.

Kalopsia's Design Director drew on existing examples that take on some of the principles of the surplus broker concept, such as the effectiveness of recycling and reuse in Scandinavian countries, who not only 'have all these stations where you return glass bottles, plastic or fabric and everything is labelled and everything is clean and organised,' but everyone knows that you go to these places to give and receive items. This goes a step beyond charity shops or second hand, which select items suitable for resale and dispose of anything else.

The potential for maker spaces in this theme is for them to become a networked space driven by the notion of circularity, brokering knowledge and generating cost benefits in surplus retaining value. Such brokering then connects various actors as stakeholders gaining awareness of the stake they hold; their relevance and relation to such circularity. This shouldn't need to be limited to select members of the public, especially not if such sites demonstrate capacity for diverse technical processes. They become sites for dynamic projects, both addressing local needs, and sharing in global challenges.

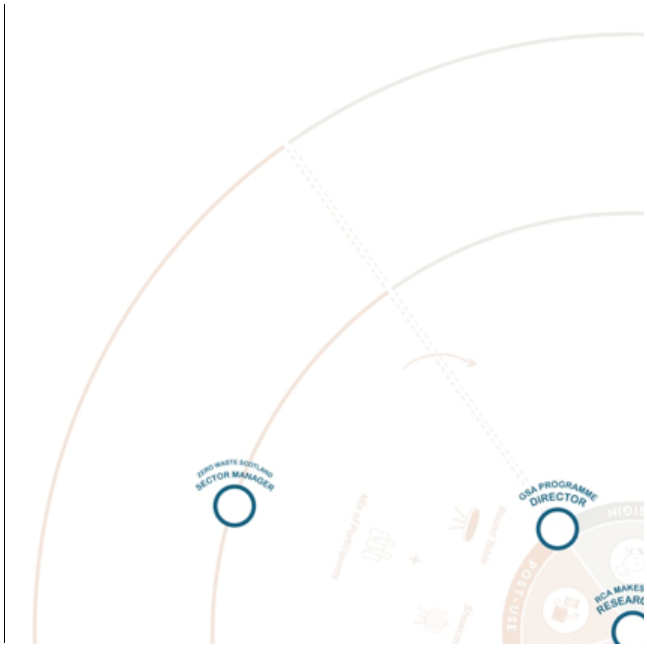

Figure 6: Relational Mapping of 'Space' Theme, (Johnson, 2017)

DISCUSSION

At the outset of this project we asked, what role the maker spaces played in the development of approaches to implementing the circular economy, and to what extent did it contribute to a more democratic exchange between the tensions and conflicts of different institutional perspectives. Reflecting on our analysis of the project roundtable, the participant feedback, and our observations from the workshops, we can begin to assign some meaning to these questions and unpick the role our maker spaces played in democratising the process of new knowledge production. We then make some more general claims about the power of maker spaces to mitigate institutional conflicts outside of the boundaries of the project.

In summary we believe that the maker spaces in this project, although subjective institutions with their own ideas, behaviours and norms, proved themselves to be rich places of open debate, free experimentation with new technologies and, crucially, ideas. Our study brought together the multiple stakeholder views and opinions that are needed to tackle systemic issues like the circular economy. By creating a safe space for debate, institutional and expert knowledge was brought out in a forum where each viewpoint was given the opportunity to contribute to framing the issue from their perspective and contribute to a shared knowledge. We observed that through engaging with the study, opinions were altered and individuals were able to enhance their own knowledge as well as contribute to a new collective body of knowledge. The Roundtable discussion, especially, was instrumental in building new domain knowledge about the issue of the circular economy in textiles at the systems level. We were able to explore the issue from different scales and perspectives, and exchange and debate ideas with the knowledge and criticality of the partner's expertise to ground our exchanges in the real world context. The practical workshops bridged the gap between industry and academic knowledge. By the act of physically creating artefacts, the theory and practice of circular economy are argued to have been tangibly brought together, stimulating debates on quality, value and sustainability. Practical experimentation also allowed a 'safe' trial and exploration of new business models and sharing of best practice in efficient design and production.

From our observations and reflections on the analysis of the project, the key points that have emerged are: maker spaces can be agile facilitators of creative innovation; they have the power to create and broker knowledge between multiple stakeholders in a transparent and open way; and by connecting viewpoints, ideologies and knowledge, they can play an instrumental role in developing approaches that can help to implement solutions to complex issues like the circular economy. These key insights contribute to our understanding of the power of maker spaces and how they can facilitate equality in debates on complex issues.

Facilitators of Creative Experiment

Firstly, we believe our analysis shows that the maker spaces in our project, when compared with, for example, the small creative enterprises or the large producers, can be 'soft ground' for free expression and experimentation. It was the intent of the project to position them as places to 'play' and develop new innovation and so it is not so surprising that this was the case. However, during the workshops and through the Roundtable discussion the role for maker spaces to facilitate creative experiment did emerge as something all the stakeholders identified as a key strength for them. As places capable of agile innovation at a small scale we observe that concepts can be explored safely, and evidence built that can scale out of the maker space and into the wider world.

Connecting perspectives

Reflecting on the workshops it is clear that the project setting was instrumental in bringing the various stakeholder institutions and their perspectives to the fore and uncovering the potential connections. The maker space managers in our project saw themselves, or at least the maker spaces they represent, as facilitators for exchange and knowledge brokers. Capable of connecting experiences to wider challenges as a form of diffuse knowledge producers, able to bring together shared aims from different perspectives to shape issues and distribute knowledge for debate through a network. Maker spaces have their own agendas and politics and this can be largely a product of staff personal ideology. This naturally influences the activities and therefore any concepts that are explored within. While our maker spaces were set up to tackle specifically the topic of the circular economy through experimentation, the Roundtable left open the opportunity for multiple perspectives to both shape the issue and contribute to responses. In this way the maker space played a significant role in connecting multiple viewpoints to generate new knowledge on a topic and, crucially, it enabled the participants to frame the issue from the start, and respond and debate to new ideas.

A Collective Model

One of the significant outcomes from the study was the framing of a gap in the circularity of textile waste and the conceptualisation of a potential solution. The new model, a collective material brokering model, did not exist before the Roundtable and was enabled by the discussion and expert understanding in our project in the maker space. The model focussed on maker spaces playing the role of broker for surplus material in a surplus market place. The idea was in response to the issue of small unreliable supplies of surplus material from large producers that limits its potential for reuse, either by them or smaller enterprise. The idea of circular matching where material is centrally sorted and graded then made available to designers and makers only emerged after the different stakeholder groups at the Roundtable had the opportunity to discuss their own issue with adopting circular approaches and then collectively conceptualise the material broker idea. Our role as an academic institute providing the project space and design innovation approaches in this process cannot be overlooked, and points toward a vital future role for academic institutions as a key partner in supporting any modelling or validation of such concepts in future.

Framing the study

The significance of this study is that it has shown how maker spaces can play a role in bringing together multiple stakeholder perspectives to create new knowledge about a complex societal issue. The maker spaces in our project facilitated both physical experimentation and debate and both were important actors in the contribution to new domain specific knowledge and open debate. Using the skill and equipment of maker spaces enabled a tangible engagement with the technical challenges of a circular economy in textiles. It played the role of broker by connecting designers, academics and material manufacturers to explore challenges through hands on experimentation. It connected multiple perspectives at the Roundtable that

otherwise would not have had the opportunity to layer their knowledge with the knowledge of others, making a significant difference to the breadth of debate and therefore criticality of the issue and any responses.

CONCLUSION

In conclusion to the study, the situational analysis of the Roundtable discussion has shown how maker spaces can play a role in both democratic knowledge production and democratic validation. They played an important role in exposing power relations between stakeholders and to the systemic challenges of the circular economy in textiles. The combination of physical capability for technical experimentation and their openness in inviting stakeholders in to discuss and debate issues position maker spaces as ideal sites for agile innovation. The approach enabled the necessary engagement between academia and industry that has been identified as crucial, yet a barrier to circular economic development and something that has not previously happened in Scotland.

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