D5.2 SOCIAL IMPACT OF DIDIY

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Executive summary

This deliverable presents 14 Digital Do It Yourself (DiDIY) related case studies. It summarises first-hand accounts from interview data and draws preliminary conclusions about the potential impact of DiDIY on creative society. The deliverable demonstrates ways in which DiDIY technologies and global digital capabilities – connected by the internet – enable new forms of creativity and sharing which reinforce each other. The case studies indicate the proliferation of sites of DiDIY innovation and entrepreneurship in communities and communities of interest, and show how these can potentially lead to important social, economic and environmental outcomes.

The deliverable explores how making and digital fabrication projects and companies, online and offline, are challenging attitudes towards technology and materiality. It describes how the culture of local making, particularly through local makerspaces, and global knowledge sharing have potentially beneficial social impacts, from social inclusion to personal and civic well-being. It relates, through case study material, how DiDIY has found a role in bringing creative problem solving and accessible technologies together, to create everything from personal making projects to new business start-ups to citizen-led initiatives that aim to tackle global environmental challenges.

The deliverable concludes that DiDIY is much more than a set of accessible technologies and internet-based information: it is a social and technological phenomenon, fuelled by a new creative paradigm based on the reinforcing effects of new opportunities for creativity and sharing. This is played out through communities and entrepreneurship, manifested in a proliferation of sites of innovation including creative platforms, companies and projects. These developments potentially offer a wide range of possible solutions for problems from environmental to social, educational and economic issues.

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1. Introduction

This deliverable is based on a narrative analysis of 14 case studies selected to represent a cross-section of activities related to Digital Do It Yourself (DiDIY) and social impact. The participants were invited to take part in the research and, during a six-month period in 2016, an interview was conducted with each participant, recorded on video. Interviewees were chosen to represent a cross-section of makers, innovators, entrepreneurs who are closely involved with DiDIY activities, creativity and creative platforms, both online and offline. Interviews with participants feature in a series of DiDIY + Creative Society online videos with a total running time of just under 45 minutes (http://www.didiy.eu/online-videos-didiy-case-studies).

This deliverable considers the potential social impact of DiDIY in relation to the case study information. Work Package 5 of the DiDIY Project (WP5) was designed to consider "how DiDIY may affect social participation in ways that reach beyond the more straightforward applications of these technologies". The principal objectives of this WP are:

- to establish whether DiDIY fosters a spirit of self-motivated creativity and entrepreneurialism that could lead to significant social change;
- to explore how Atoms-Bits Convergence (ABC) technologies, such as 3D printing, offer a significant alternative to previous ways of making things, and the difference they make to social attitudes to material production and consumption;
- to study how DiDIY may help societies to overcome pressing social, environmental and economic issues;
- to explore the relationships between digital cultures, offline making, and digital making;
- to study whether the DiDIY ethos inspires people to bring about changes in their local culture.

1.1 Online Videos

The six online videos explore the culture and ethos of DiDIY in terms of broad social impact and through the first-hand accounts of these leading voices within the field. The videos are themed according to key aspects that emerged during the case study research and during workshop research into maker's motivations. The workshop research included around 135 participants and will form the basis of a further report, D5.3. The six key aspects and titles of the videos are:

- Creativity;
- Sharing;
- Community;
- Entrepreneurship;
- Well-being;
- Glimpses of the Future.

This deliverable follows broadly the same structure, chosen because the research concludes that identifying these aspects is a useful way to think about the creative society implications of DiDIY and is a good reflection of the research evidence that was available. One change has been made. The final video "Glimpses of the Future" focused on engagement with environmental issues going forward, which was a key concern for many interviewees.

This deliverable includes a separate section titled "environment" where these concerns are the sole focus. Comments on the future challenges and direction of research, "glimpses of the future", are in the conclusion.

1.2 An Emerging Phenomenon

As has been emphasized on a number of occasions within the DiDIY Project, DiDIY is an emerging phenomenon that is engaged in a process of dramatic growth and change. Social impacts, on the other hand, may take years to emerge as established outcomes. Within the short timescale of the DiDIY phenomenon it is not yet possible to report very confidently on established and widespread social impacts. However, by taking a qualitative and narrative research approach it is possible to present important indications of potential social impacts through particular and situated examples of initiatives that are currently underway. The case studies give a snapshot of DiDIY related activity in 2016 and demonstrate the broad range of innovative companies, projects and people who are making use of DiDIY related technologies and approaches, often in pursuit of an agenda for change.

1.3 Case Studies

The case studies represent an extraordinary range of new businesses, new ventures and new activity. Taking a definition of 'new', in an organisational sense, as being established within the previous six years, from 2011 onwards, the case studies include two new creative companies (Technology Will Save Us, Harvey & John), two new start-up ventures taking part in the first year of new business incubation schemes (OurOwnsKIN at mv.works, Noook at Central Research Laboratory (CRL)), four new makerspace projects (Machines Room, MAKLab, Barclays Eagle Labs and The Institute of Making), three new online platforms (Wevolver, Fixperts, Smart Citizen), a new global initiative (Fab City) and even a new museum (Derby Silk Mill's Museum of Making). Some of the oldest organisations represented, Maker Faire and Barcelona Fab Lab go back only to 2006 and 2007 respectively, and there are no references to any initiatives established in the 20th Century.

In as far as it is represented by these case studies, this is a 21st century phenomenon and it is this sense of emergence and change, vibrant activity and passionate innovation that characterizes the case studies and the sector. Making and creativity, however, are of course not new. They are among the most ancient and fundamental of human activities. What is demonstrated by these cases is a resurgence of making and creativity in a global digitally connected context with broad access to digital making technologies. Only one participant, artist and engineer Tim Hunkin, could be said to be doing work that is similar to that which he was doing a decade ago; he demonstrates the continuity of making, particularly making that integrates available technology, having witnessed the change from analogue to digital.

Of course DiDIY in a broad sense could be said to have begun with the earliest hackers connecting to the internet, in the 1970s, or in the early meetings of amateur computer makers, such as the Homebrew Computer Club in Silicon Valley, established in 1975. The spirit of DiDIY is definitely in every home-made website created from the early 1990s onwards, and in the sharing of recipes, craft and engineering plans, poetry, music, and so much other creative material put on the World Wide Web by enthusiasts over the past 25 years.

The more particular focus in this deliverable, as across the whole DiDIY Project, is on the emergence of a new creative digital enabling infrastructure. This can be seen in the combination of online creative platforms and access to local making facilities alongside access to lower cost digital technologies, from digital fabrication equipment to technologies for building digital devices and interactive objects. This has opened-up new creative opportunities on a personal and collective

level and these case studies seek to explore some examples of how these opportunities for creativity are being exploited.

1.4 Social Impacts

The tentative conclusion reached – given the important caveat that it is too early to prove social outcomes – is that DiDIY has potential for diverse and widespread social impact. In particular, that it has potential for impacts across a very broad range of targets. The deliverable considers indications of the role that DiDIY can play in:

- fostering creativity, creative agency and creative opportunities to engage with technology;
- supporting the sharing of knowledge and skills and providing access to knowledge networks;
- fostering community engagement and social inclusion;
- promoting entrepreneurship and new business start-ups;
- promoting well-being and personal satisfaction;
- providing a pathway towards a positive environmental agenda such as circular economy and resilience.

This covers a vast impact canvas, stretching from social and economic to environmental agendas. In many cases elements of these different agendas are integrated within initiatives and projects, such as makerspaces and online platforms. DiDIY appears to potentially integrate and deliver, on a human scale and local level, possible routes to counteracting several key frontiers of dissatisfaction with modern life.

Dissatisfaction with consumer culture or with globalization resulting in under-employment, with a lack of creative engagement and agency with technology, with an assessment and test-driven education system, or with material wastefulness and environmental issues are all potential targets of the broader DiDIY agenda represented here. Whilst the range of targets for change is very wide, one key element that the case studies in this research share is a belief in, and commitment to, the value of a process of creative problem solving through making.

2. Creativity

Creativity is the first and strongest potential area of social impact that emerges from the case studies. It figured absolutely centrally in the interviews and was a concern, in many different ways, for all our interviewees. In some of the cases studies, enabling people to create with technology is part of their central vision – for example, DIY technology education company Technology Will Save Us, and open source hardware platform Wevolver. In other cases, there was a clear belief in the power of creativity to meet big social and economic challenges in society. For example, Hannah Fox commented "we need people to see themselves as creative people because we've got some big world challenges" (Fox, 2016) and similarly, Daniel Charny noted "In order to deliver those big changes, like circular economy, we need people to be creative at lots of levels" (Charny, 2016).

How creativity can be fostered by DiDIY was addressed, in many different ways, through the work of interviewees. The importance of creative platforms has been established through previous research in the field of creativity (Gauntlett, 2011, 2015). The need for, and the provision of, good creative platforms, online and offline, was a central concern and clear priority for a number of the initiatives examined here. Within these case studies, creative platforms for DiDIY came in all shapes and sizes, from a well-resourced workshop (Hunkin) to makerspaces able to attract diverse participants and support a wide range of creative opportunities. Several of the case studies are of initiatives that include makerspace facilities (MAKlab, Institute of Making, Machines Room, Barclays Eagle Labs, Derby Museum of Making) and they demonstrate that makerspaces are diverse. They have a wide variety of settings and visions, from those that focus on social inclusion, to entrepreneurship or education, and very often makerspaces integrate a number of aspects of making, or work with a variety of audiences. What they share is an agenda of fostering creative problem solving, often discussed in a context of "playing with ideas" (Clifford, 2016), or fostering a creative environment where "creative people walk in and can feel at home" (Hunter, 2016).

The value of providing a platform for creative collaborations was key. For example, Sherry Huss says of Maker Faire, essentially a platform for sharing making projects, that "creativity is the heart of all of this" (Huss, 2016) and for Bram Geenen, co-founder of open source online hardware platform Wevolver, inspiration came from "realizing that when I wanted to share my chair designs and my knowledge and my 3D files, there was no platform to do so" (Geenen, 2016). Creativity was typically seen as deriving from a process of creative problem solving (Hunkin, Harvey). The role of technicians and support staff, particularly for students, was seen as important (Harvey, Corbin, Ciokajlo, Sherwood, Hunter) but it was also seen as crucial to learning for the maker to experience the process of going through stages of making themselves (Corbin, Koby). The need for scaffolding and the incremental nature of building skills and confidence through small steps were common themes, for example Bethany Koby explained that "seeing the thing you've done successfully accomplished, we see helps create a create a pathway to confidence that then helps them to see how they can be more creative" (Koby, 2016).

Another common theme was the sense that DiDIY could provide creative agency and "empower" makers, which after creativity, was perhaps the most often quoted related concept among interviewees (Charny, Ciokajlo, Clifford, Diez, Fox, Harvey, Huss, Koby, Shepherd). Richard Harvey underlined this point from the maker's perspective, "it's just quite empowering if you figure out [that] the stuff you want to make that's in your head can become a reality" (Harvey, 2016). One potential challenge to empowerment and personal control over creativity was suggested by Charny: "I think there's going to be a big battle on what is creativity and who is using it to sell what, and are

users going to be influencing industry or is industry going to be packaging creativity" (Charny, 2016).

3. Sharing

The second, equally important, route through which potential social impact comes about is the role of sharing. The absolutely central role of sharing projects, knowledge and skills within, and from, DiDIY initiatives emerged very strongly. For some interviewees the main significance of the 'digital' within Digital DIY centred on the potential of digitally enabled communications, particularly the internet, to disseminate knowledge, skills and communicate projects and plans, or build support for initiatives worldwide through dedicated online platforms and networks.

For others, an equal emphasis was placed on shared digital data and digital making technologies. Tomas Diez explains the sharing potential of digital communications coupled with digital fabrication in Fab Labs: "An individual creates a project that could change people's lives on the other side of the world, and being able to have this systematic infrastructure in which that thing could be replicated anywhere in a matter of minutes, I think that that's super-powerful" (Diez, 2016). The role of digital sharing in enabling consumers to engage in DiDIY projects and platforms was frequently highlighted by interviewees. Daniel Charny highlighted the central role of sharing and raised its importance in determining how DiDIY is played out, saying "will digital DIY enable the sharing, and through sharing and open access, enable users, consumers to have more control and maybe impact on ideas like circular economy" (Charny, 2016). For other interviewees there was a belief that sharing, in itself, is a fundamental motivation for makers, for example, Sherry Huss says of those attending Maker Faires "they're here because they really want to share what they're doing" (Huss, 2016).

An understanding of the potential to solve problems through sharing, through open collaborations and via online help, often within specific communities, was voiced at every level. Maker Faire's co-founder Sherry Huss explains that she personally initially came from a more closed media environment but quickly learnt to value the maker ethos of "it's okay to put things out to the community, and then those in the community will help solve problems or move them along or find the right path, and that's a really powerful environment" (Huss, 2016).

Sharing and knowledge transfer were found to be key components of makerspace ethos across the range of makerspace projects reviewed, for example at MAKLab "the tables are big for a reason" (Clifford, 2016) and Liz Corbin at the Institute of Making explains that "our workspace is quite open plan on purpose" (Corbin, 2016). Sharing is the very basis of more formal open source projects such as Wevolver and clearly vital to start-up ventures and creative professionals in order to source technical help, for example makers reported routinely using YouTube tutorials and forums (Harvey, 2016) and sought out specialist technical communities (Harvey, Ciokajlo). Bram Geenen believes that DiDIY projects with an intended beneficial social impact gravitate towards Wevolver's open source platform because originators "who do social good projects, whether it's environmental or for health etc., they have this notion of 'I would love to make myself open source because I want as much people as possible to benefit from it'" (Geenen, 2016).

Several of the initiatives featured or mentioned in case studies operate through online platforms, including Maker Library Network, Fixperts, Wevolver, Open Workshop London and Smart Citizen and dozens of internet-based communities related to making and DiDIY exist, many recently established and growing fast (DiDIY, 2016). The potential social impact of this explosion of information and opportunities to engage is hard to overemphasize, particularly as the general proliferation of shared information via the internet and within DiDIY is coupled to the ethos of sharing and open source from within the maker movement.

Liz Corbin: "There's a certain maker mindset that just wants to be part of the community and kind of that sharing economy, open source ecology" (Corbin, 2016).

Sherry Huss: "It's about a community or a tribe of people coming together that have the same passion, the same values and that sharing of knowledge, that passing it on is really important" (Huss, 2016).

The sense in which creativity and sharing reinforce each other was apparent, as previous research into online communities has shown (Kuznetsov & Paulos, 2010). The evidence from Maker Faires, for example, is that people want to share their creative projects, and sharing inspires others and provides a route to collaborations and knowledge transfer enhancing creativity, building creative confidence and creative problem solving skills. New creative projects are in turn shared to obtain feedback and out of a sense of personal satisfaction and achievement, inviting collaborators, development and contributing to the community shared resource.

4. Community

DiDIY is in many cases a community-based phenomenon, projects being organised through a community site (either online or offline) or within a community of interest, making use of communal resources. Several online platforms and local makerspaces featured as part of our research and the concept of "community" was common within these projects, alongside a clear focus on the benefits a community of users could provide. For example, asking for community help was one path towards product development for some users on Wevolver who, according to co-founder Bram Geenen, seek to "get a community around it, continuously iterate and improve their product" (Geenen, 2016). Smart Citizen is also an example of this type of iterative community development. As Tomas Diez explains, "We have this constant feedback of the usage of the technology in different contexts, and it's allowing us to embed those learning outcomes, and then iterate and improve the platform" (Diez, 2016). In this sense, a community identifying with the project provide a target audience for creativity and sharing, leading to iterative development.

Makerspaces are rooted in community, of course geographically but also through their membership, programme of events, and identity. The core values of makerspaces tend to be defined by the vision of their founders, often working with or responding to the local community. The makerspace within Derby Silk Mill, which forms part of the Museum of Making project, is a recent addition and project director, Hannah Fox, explains how they looked at a number of models but returned to forging their own version, reflecting what the community needed and working through an open co-production process "exploring and prototyping lots of different types of events and activities with our audiences and lots of volunteers". "Making," she adds, "should not be something that is dropped into a community" (Fox, 2016). Dave Shepherd of Barclays Eagle Labs explains that when opening a new Eagle Lab site, he is concerned to find out about existing initiatives, build partnerships and respond to local community, adding that "the purpose is to play into actually what the community wants" (Shepherd, 2016).

Many makerspaces also do outreach work (Connolly, Hurley, Taylor, 2016) – for example in schools and hard to reach communities – and have public access days and events. Some have a specific social inclusion agenda. At MAKLab, for example, there is an attempt to build on the core members who are design professionals, students, makers, independent crafts people.

Richard Clifford explains how they also try to reach out to "younger people, disability groups, older generations, very targeted groups as well, that we – either through a partner or identified by ourselves – people who we can involve in that community, and again, that's about trying to gather common momentum and utilise momentum that design industry and making has, by including a social and inclusion catchment as well." (Clifford, 2016).

We found that in some ways makerspaces are moving towards fulfilling a broader community role and that interest in makerspaces being hosted within civic settings such as schools and libraries is growing very fast. Interest from libraries, perhaps under pressure to re-invent their community role, is strong (Willingham & de Boer, 2015). Work in libraries in the UK is still at an early stage but includes a Fab Lab in Exeter Library (Collyer, 2016) and many libraries hosting digital making workshops and pop-up events (Codegreen, 2017) and exploring possibilities. D5.3 will include an account of a series of pop-up creativity workshops, the Spark Workshops, hosted in libraries, as part of this research. Several case study interviewees have begun to work with schools and libraries (Clifford, Charny, Fox) and others saw the potential: "I think we'll start seeing more and more of these events and maker activities in schools, in libraries, in community places" (Huss, 2016).

One of the many milestones, in terms of a move towards community-based publicly funded digital making, has been the recent establishment of public Fab Labs (funded publicly) as part of a city-wide digital fabrication network in Barcelona (Diez, 2016). Communities and communities of interest provide an identity (perhaps based on a common set of interests, or on identification with the locality, or a peer group such as students), and work as a basis for groups to organise sharing and creativity activities.

5. Entrepreneurship

Entrepreneurship was routinely seen as entirely compatible with the maker ethos of community-based sharing and creativity. The creative problem-solving approach within DiDIY and making, an ethos of exploration and innovation, and access to digital prototyping and new technology expertise, make a start-up culture and entrepreneurship inherently a good fit. Makerspaces where there was more emphasis on social inclusion or positive environmental projects were very keen on entrepreneurship, for example Nat Hunter at Machines Room commented: "We're very entrepreneurial but entrepreneurial in order to somehow make a positive difference" (Hunter, 2016).

Two of the case studies relate to successful new creative businesses that have been built within the last few years based on a DiDIY related vision, or access to DiDIY technologies and opportunities (Technology Will Save Us, and Harvey & John). Two more detail the journey of start-up ventures taking their first steps as a business within new business incubation or acceleration programmes hosted in makerspace environments (OurOwnsKIN and Noook). All the makerspaces we spoke to were interested in the potential for entrepreneurship, although in some spaces said they were more suited to the early stages of open exploration and first prototypes than supporting well developed business proposals (Corbin, Clifford). Others reported that they played an active role in advising and signposting entrepreneurs towards other providers and contacts or routes such as Kickstarter, where appropriate (Clifford, Hunter).

Another key benefit of makerspaces and similar collaborative open workshop environments which we were told about many times is the ability to provide affordable 'messy' studio space for individual self-employed practitioners to get on with their work, particularly in cities such as London with very high property prices. Makerspaces, open workshops and collaborative working spaces can also provide a valuable social and business network, promoting knowledge transfer and business contacts and directly providing facilities. Building Bloqs (http://buildingbloqs.com) in London is one example of open workshop provision for self-employed professionals from a wide range of disciplines (http://buildingbloqs.com/directory). Makerversity (http://makerversity.org) is another well-known example of a collaborative working space in Central London supporting professional makers and maker businesses.

There was some evidence that established big businesses also see the potential for innovation coming from this sector. Intel, for example, is a supporter of the US Maker Movement and Maker Faires, sponsoring the America's Greatest Makers (https://www.americasgreatestmakers.com) reality TV show. Sherry Huss believes Intel understands the potential for innovation through outsourcing and crowdsourcing: "They're really showcasing and helping propel makers by helping them with resources or funding for ideas" (Huss, 2016). Barclays Bank has ambitions to offer a broad platform for makers in the UK, potentially opening up to 100 Eagle Labs over the next few years (Shepherd, 2016) and focusing on entrepreneurship through programmes such as the recently launched "Flight" (https://labs.uk.barclays/flight).

Bram Geenen explains that very many Wevolver users are engineers with "high profile professional backgrounds" and interested in starting new business ventures. Geenen believes that "the whole nature of hardware development, of engineering new products is changing, it's becoming faster, more collaborative, more decentralized" (Geenen, 2016). The case studies suggest that DiDIY is creating and supporting opportunities for independent creative businesses, and that related phenomenon such as makerspaces are providing working space and collaborative working environments, incubating start-ups and enabling skills transfer. As technologies from 3D printing to

drones or robotics become more widespread and affordable, the opportunities for related DiDIY independent creative businesses will also grow.

6. Well-being

Many makers told us that being engaged in a creative way with the physical activity of making enhanced their sense of well-being and happiness, for example by promoting creative problem-solving skills and improving their confidence. Some makers reported experiencing a sense of 'flow', a state of happiness associated with being fully absorbed in the task at hand, which has been the subject of extensive research in the fields of design, management, the psychology of happiness and elsewhere (Csikszentmihalyi, 1992). We asked makers that took part in a series of Makerlab workshops we ran, as part of this research, how they thought making could benefit society. Enhancing well-being was among the most common responses. A full report on these workshops, in which 95 makers took part, is included in D5.3. but – to summarise here – some of the ways in which makers felt well-being was enhanced included:

- reducing stress: "Making can have therapeutic uses. It can help people reduce stress" (Makerlab participant);
- providing a route for self-expression: "I think making benefits society by giving people a means of personal expression, self-expression that is important to well-being" (Makerlab participant);
- improving confidence: "I hope that making can be an enjoyable release of emotion and serve to improve people's confidence, self-belief and understanding of their place in the world" (Makerlab participant);
- enhancing a sense of social connectedness: "By allowing people to feel connected to each other and something deeper. By allowing them to achieve happiness and flow state as an antidote to the stress of modern day living" (Makerlab participant);
- enabling a new outlook: "Builds teamwork, friendships and [helps] share ideas and practices among creative professionals. It makes you see things in a different light" (Makerlab participant).

There is a long history of making, especially craft making, being associated with well-being (Yair, 2011). Making can be employed for specific therapeutic roles within occupational therapy programmes or as part of art therapy programmes, undertaken by health professionals. But making and well-being, in a much more general sense, are related in a number of ways. For example, research from Nesta in 2015 – the *Open dataset of UK makerspaces* – found that socialising was one of the top three reasons why people use makerspaces (Nesta, 2015). Social interaction is an important aspect of initiatives such as Men's Sheds (Men's Sheds, 2017) that provide opportunities for men to meet-up and undertake making and fixing projects together.

As well as social interaction, making can promote confidence, and many of our case studies emphasized this point. Technology Will Save Us, for example, are interested in promoting confidence with technology, and measure confidence as part of the assessment and research they undertake into products, asking whether users could say "I found the confidence", and asking "Has this helped me to find a pathway and to see tech as something I can be creative with, make with as a medium?" (Koby, 2016). Promoting the confidence to undertake making projects is part of the agenda of design education platform Fixperts: "It's about empowering … and creating situations where people have the confidence to… approach a problem creatively" (Charny, 2016).

Making was also recognized as promoting personal self-confidence, more generally, by a number of the makerspaces.

Liz Corbin: "I think people gain greater confidence and sense of impact, it's a lot easier to see your progression in something, in learning a particular craft or skill, you see yourself evolve and you see yourself gain skills and experience and acquiring of new or of a heightened sense of ability and I think that is really rewarding" (Corbin, 2016).

Personal satisfaction in overcoming challenges is another aspect of making related to well-being, and maker Tim Hunkin expresses the sense of both engagement and challenge he felt in "teaching myself to make things well … why I was so persistent, I've got no idea, but anyway, that makes it satisfying." (Hunkin, 2016).

Specific workshops or outreach projects targeting aspects of well-being are also a routine part of some maker space provision. Derby Silk Mill, for example, has undertaken outreach projects testing how a combination of inspiring cultural interest in the museum collection alongside making activities could enhance well-being. Project Director Hannah Fox explains: "We're just working with Derby Hospital currently and we're taking a mini mobile Museum of Making" (Fox, 2016).

Makers told us that engaging with making and then sharing the results of that experience can have positive impacts on a range of important factors for well-being from building confidence to providing a foundation for creative problem solving. Greater access to creative making opportunities and creative platforms where people can share their work and recognise each other as makers therefore has the potential for important social impact. D5.3 will explore well-being from the makers' perspective in more detail.

7. Environment

Making and DiDIY are inextricably bound-up with materiality and therefore environmental issues and initiatives are a major focus for many DiDIY-related projects and technologies. Social and environmental issues, from changes in consumer culture to reducing waste, are themselves deeply integrated, and environmental impacts are also social impacts. Finding new ways to make, locally, using flexible digital manufacturing, with a fixed set of parts that could also enable digital recycling, has been central to the vision for personal fabricators and Fab Labs from its inception (Gershenfeld, 2005).

Promotion of the circular economy is the basis of the Fab City initiative. This is an ambitious global project building on the Fab Lab vision, led by Tomas Diez and referred to by a number of our interviewees (Huss, Hunter, Charny, Diez). "This digital DIY is essential in that scenario, it's essential for local sustainability in which instead of product in – trash out, it's data in – data out". (Charny, 2016). The Fab City White paper explains that the aim is to shift how cities "source and use materials from 'Products In Trash Out' (PITO) to 'Data In Data Out' (DIDO). This means that more production occurs inside the city, along with recycling materials and meeting local needs through local inventiveness. A city's imports and exports would mostly be found in the form of data (information, knowledge, design, code)" (Fab City, 2016). Diez believes that "over the next five years, we're going to see Fab City becoming as mainstream as the Smart City movement".

A common strand among several interviewees was the emphasis they placed on the social relevance of making, rather than making for its own sake. This was expressed as a need to get people thinking about "outcomes" rather than "outputs" (Charny) and for designers to engage with digital platforms and "integrate forward thinking into the platforms through the digital options, the tools" (Charny, 2016).

> Tomas Diez, for example commented "Making for the sake of making is not enough… I hope to see more and more long term innovations that are evolving step by step, learning from the world and being more suitable to solve that world, what the world is asking [for] and not only by creating something and making the world think that they need it." (Diez, 2016).

The direct relevance of DiDIY to tackling environmental problems and enabling a route towards resilience was highlighted by interviewees keen to see making address sustainability agendas. Daniel Charny, for example, reflected that: "There's material but there's also ideas, so the ability to engage with an idea, with a problem and a solution, with an approach, with an attitude, these are ideas and they get into social and they get into sustainable, so when you talk about resilience, it combines these two" (Charny, 2016).

8. Conclusion

As mentioned in the introduction, almost all the case studies featured in this deliverable are relatively new ventures. The question then is why have we seen, within the last decade, an explosion of innovative projects and companies related to making, and particularly making and technology? The background circumstances include the proliferation of internet-based communications and online platforms; it is also true that access to digital making technologies has significantly improved as prices have come down and facilities become more widely available communally, or though bureaus.

DiDIY, however, is much more than a set of accessible technologies and internet-based information, it is a social and technological phenomenon, fuelled by a new creative paradigm based on the reinforcing effects of new opportunities for creative engagement and sharing. This paradigm is enabled by digital communications and technologies but it is driven by what people want to do with these capabilities – which is be creative, share their projects, and solve problems. The desire to be creative, share projects and solve problems is manifested through communities and inventiveness, innovation and entrepreneurship. The proliferation of sites of innovation such as new creative platforms, companies and projects are a testament to this new creative paradigm. There are indications, "glimpses of the future", which suggest potentially beneficial creative society outcomes, addressing a wide range of 'fixes' for problems from environmental and social to educational and economic issues.
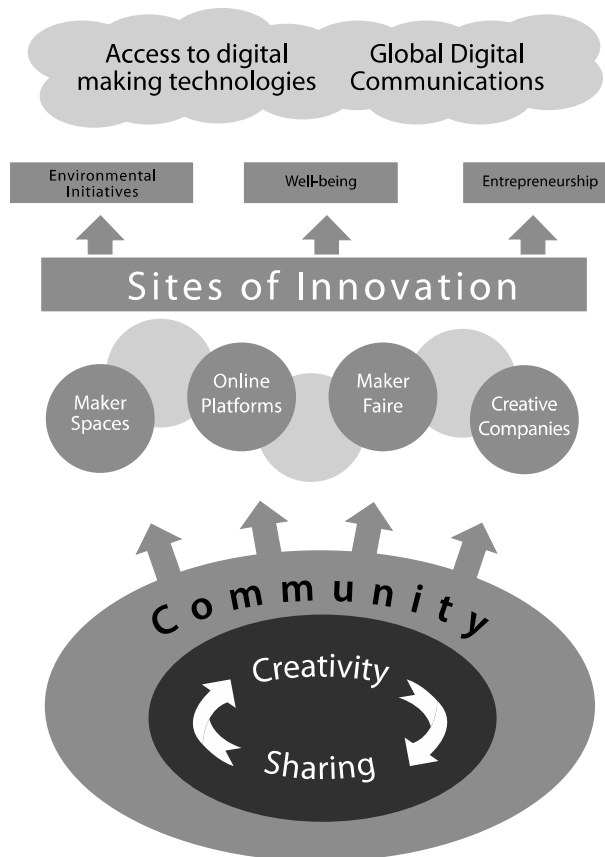

Figure 1 – Generating Creative Society Impacts.

One issue that could stand in the way of realising beneficial social impacts is difficulty in securing funding. Many makerspaces, for example, struggle to find a financially sustainable model from their making activities alone. Public participation projects with integrated but diffuse activities may struggle to find public funding because funds are more often dedicated to narrower target groups.

Makerspaces and Maker Faires are often multi-generational spaces with activities and events for families and schools as well as business and entrepreneurs. Social inclusion and well-being objectives sit side by side with educational objectives through exploration and fun. This sense of integration of generations and audiences, on a local and human scale, plays alongside a narrative of community and democratization that is characteristic of DiDIY.

Another barrier may be the constraining of initiatives to a narrow demographic base. DiDIY is still a relatively new and small phenomenon and whilst it has seen extraordinary growth in a short time, it is not possible to predict whether these activities will become mainstream. Whether every library will have making facilities, whether fixing and repair will become a natural choice, whether local facilities for fabrication and making are established in every community, remains to be seen.

What does stand out is the potential relevance of DiDIY to a very broad range of individuals and communities. Several interviewees reported that makerspaces often have communities with a strong identity, that "come to self-populate based upon kind of the overall mission of that space" (Corbin, 2016). Currently under-served communities could therefore develop facilities that match their own needs and are very different from the kinds of makerspaces we currently see. There is potential for schools and libraries to invent and host many different versions of local making culture.

It seems likely that there will be a general move towards using civic spaces and attracting more public and commercial funding for projects. The challenge once public funding is secured may be to retain the vibrant, sometimes voluntary ethos of projects. As Hannah Fox from Derby Silk Mill's Museum of Making reflects, they need to be "holding true to the community heart of the development" and saying "This is doing it properly, this is how it should be." (Fox, 2016).

9. Case Studies

The following 14 sections of this deliverable present brief accounts of 14 case studies, based on an interview with each conducted in 2016 and additional research material. The 14 cases are presented alphabetically by surname, as follows:

- Daniel Charny, Creative Director, From Now On.
- Liz Ciokajlo, Co-founder, OurOwnsKIN.
- Richard Clifford, Executive Director, MAKLab.
- Liz Corbin, Researcher and Curator, Institute of Making.
- Tomas Diez, Founder, Fab City Research Laboratory.
- Hannah Fox, Project Director, Derby Silk Mill.
- Bram Geenen, Co-founder, Wevolver.
- Richard Harvey, Co-founder, Harvey & John.
- Tim Hunkin, artist and engineer.
- Nat Hunter, Strategic Director, Machines Room.
- Sherry Huss, Vice President, Maker Media, Co-founder, Maker Faire.
- Bethany Koby, CEO, Technology Will Save Us.
- Dave Shepherd, Director, Barclays Digital Eagle Labs.
- Torsten Sherwood, Co-founder, Noook.

9.1 Daniel Charny

Daniel Charny, Creative Director, From Now On.

Daniel Charny is Professor of Design at Kingston University and Creative Director at From Now On (http://www.fromnowon.co.uk). He curated the influential Power of Making (http://www.vam.ac.uk/content/articles/p/powerofmaking) exhibition at the V&A in 2011. He has co-founded a number of leading projects exploring aspects of design and education, as well as the social, environmental and business potential of making; these include Fixperts (http://fixperts.org), the Maker Library Network (http://design.britishcouncil.org/projects/makerlibraries), and CRL (http://www.centralresearchlaboratory.com).

Charny has recently carried out research aimed at bringing the experience of making to a wider demographic. In May 2016, as guest professor with CODE: the co-design research lab at KADK (https://kadk.dk/en), he collaborated in a pilot for the Library Association of Denmark. Called

Fixhubs, this project used a Copenhagen library for a public test of library makerspace formats. Charny says the idea was to test a format that differs from the Fab Lab model, being "lower tech, wider access, closer to craft in that sense" (Charny, 2016). He emphasizes the need to find models that work with different communities and making environments but believes that libraries are a credible arena for making, saying, "if people can see in the library somewhere where they can engage with ideas also through making, not just through reading, that would be ideal" (Charny, 2016).

Charny considers that the benefits of making arise from two conceptual approaches, engagement through making and engagement with making (Halligan, 2016), explaining these as, "using making as a form of engaging people in their community, society … at the same time engaging people with the appreciation of making" (Charny, 2016). The key benefits he cites are "the discovery of making as an option" and by using fixing and repair as an entry point, he notes that "this is a form of discovering self-expression, creating confidence, the ability to create and problem solving" and adds that it is "about understanding that you can think about situations and things in a creative way" (Charny, 2016).

Charny co-founded Fixperts (http://fixperts.org), a project he describes as a "design education programme" but also as a "campaign" (Charny, 2016). Started in 2012, in collaboration with James Carrigan, co-founder of Sugru (https://sugru.com), Fixperts encourages designers to engage with making through one-off repairs for individuals that are then celebrated through short films uploaded to the Fixperts website, allowing others to do the same. The films provide insight and inspiration for makers, showcasing a huge variety of practical, problem-solving design and making processes, often using one-off digital fabrication technologies such as 3D printing. Charny comments that it is the films that are the 'fix' because "it's fixing attitudes" and it is in this sense that he sees Fixperts as a campaign.

Fixperts has proved popular with university design departments and has been incorporated into the curriculum internationally, including, for example, in Shanghai and is a rapidly growing programme, with around 250 films having been uploaded. The films are an example of the way in which internet-based sharing is a fundamental and powerful element of DiDIY. Charny explains how, in developing Fixperts project, "the film format suddenly made it all fall into place and what we share with people is the guideline of how to make a film, so it's the storyboard. Our main tool is a kind of digital DIY, how to make your own film" (Charny, 2016).

> Charny sees Fixperts as a pathway to environmental awareness and building resilience, commenting that, "first of all, it starts with a very direct material experience, and material intelligence, and then material awareness, so through materials is one route. Through making for someone, we focus on real needs, real people and we think making with a purpose is kind of an agenda that we have, with Fixperts".

The bigger picture, though, and the underlying focus of all the projects is a desire to shift design attention away from "outputs" and towards "outcomes", or as Charny says, "to shift designers from thinking, or people from thinking, about the thing but more to think about their impact or what change they would like" asking questions like "Who's it for? What's it going to do?".

For Charny, individuals involved in making for a purpose are engaged in combining ideas with the knowledge and skills of making, it's this combination of imagination and skills that will lead them to ask questions about the relevance of what they are producing and its environmental impact.

> He comments "in order to deliver those big changes, like the circular economy, we need people to be creative at lots of levels and so Fixperts is a kind of maker education approach.

Maker Library Network is a kind of open sharing environment, Central Research Lab is about introducing the principles of positive business, in fact and I think that's the big challenge is to get people to focus on outcomes, not on outputs, for me that kind of captures … all of the projects" (Charny, 2016).

He sees the significance of the digital played out through increased access to digital making technologies and in the challenges of users becoming producers. Two vital future battlegrounds he points to are: creative control within digital platforms; and how designers forge a new mediating role, which he sees as far more important than the capabilities of the technologies themselves. For Charny, what matters is how they are used and what for. He notes, "We've seen 3D printers print billions of Yoda heads and we've also seen them print bespoke skulls" (Charny, 2016).

9.2 Liz Ciokajlo

Liz Ciokajlo, Co-founder, OurOwnsKIN.

Liz Ciokajlo studied industrial design at the University of Cincinnati before moving to the UK in the early1990s. After a number of years working in product and furniture design, and a career teaching product design, she has focused, in recent years, on footwear innovation, gaining an MA in footwear design in 2013 and Co-founding OurOwnsKIN (http://www.bespokelab.co.uk/ourownskin). This is a project that proposes a radical new way of making footwear, by using advanced scanning techniques alongside 3D printing. OurOwnsKIN was one of the first cohort of incubates in mv.works (http://mv.works/about/into-the-wild), a pilot incubation programme run by Makerversity (http://makerversity.org) in 2016.

OurOwnsKIN is a collaboration with artist Rhian Solomon of sKINship and Manolis Papastravrou and combines Ciokajlo's design skills with Solomon's medical knowledge and Papastravrou's ability to translate designs into computational algorithms using auxetics. OurOwnsKIN aims to use the specialist knowledge of the project collaborators to "inform the design of the algorithms used to design 3D printed shoes then put design into the construction. Kind of designing from inside the material out, to make shoes fit, perform better and create a new visual look based on construction" (OurOwnsKIN, 2016).

Part of Ciokajlo's vision for the project was seeing 3D printing as an opportunity for designers to produce locally and have more control. As she explains "I saw 3D printed shoes as being an opportunity to see what's the next thing that we could do to really empower designers to take back their ability to have control over their designs… [so that] you weren't having to make so many compromises, or be so controlled by what the factory was dictating" (Ciokajlo, 2016).

Ciokajlo explains how her background had enabled her to acquire skills and knowledge of digital design and fabrication techniques, from the early days of using CAD, to learning CADCAM as part of her MA, but for OurOwnsKIN it was essential to find collaborators and specialists, particularly in 3D printing. Ciokajlo sought out collaborators both online and offline, through blogging, at conferences and sourcing specialist help, for example via London-based 3D print bureau DIGITS2WIDGETS (https://www.digits2widgets.com). Ciokajlo says of Digits2Widgets "I use [them] as a bureau really, but it's also a great meeting point because they have designers there anyway that are doing some really interesting things with 3D print, so that's a nice community to have conversations with". (Ciokajlo, 2016).

> Opportunities for collaboration and learning from the experience of others was also a large part of the benefit Ciokajlo sees in the mv.works programme, saying: "I was very inspired by the other cohorts, the other awardees. A lot of different ways of thinking about things. A lot of coding that, because I'm very form based and structure, I never had a real desire to learn any code, and because of their projects I got inspired and thought of ways that I would benefit in my own practice by learning code."(Ciokajlo, 2016).

By the end of the mv.works programme OurOwnsKIN had developed to a point where the team was ready to form a company and present ideas and prototypes to the footwear industry. Ciokajlo credits the incubation scheme particularly with helping to improve her "soft" skills, including how to organise and communicate the business concept – she found mentoring particularly useful – as well as the opportunity to develop an advanced prototype. She comments "you need to have something, a prototype and then you can get the conversation started. It's really expensive and difficult to do prototypes of this complexity off your own back". (Ciokajlo, 2016).

9.3 Richard Clifford

Richard Clifford, Executive Director, MAKLab.

Glasgow-based makerspace MAKLab (http://maklab.co.uk) was founded "to allow people to access the latest disruptive technologies" (MAKLab, 2017) and has grown into a wider role. MAKLab now "delivers teaching workshops, community outreach programmes, professional development and accredited learning for a wide demographic across Scotland" (MAKLab, 2017).

> Executive Director Richard Clifford explains the origins of the project "We established MAKLab about four years ago, to tackle inclusion issues and provoke and promote productivity through making, for a very broad range of reasons but really to empower people as much as possible" (Clifford, 2016).

The home page of the MAKLab website reinforces this explicit social agenda stating: "Empowerment through making. We are focused on providing resources for people from all backgrounds, of all ages and all abilities to use making as a tool for social empowerment, regeneration, inclusion, economic growth and social capital." (MAKLab, 2017). Clifford explains that the statement has been refined over time and says "it's less of a mission statement, and more of a summary about the core of what we do, and whilst we have tangents that span very, very wide, that is the fundamental core pillars if you like" (Clifford, 2016).

MAKLab is extending its work to a broader range of environments, recently opening a makerspace in a library in Dundee and collaborating with a Wick High School to launch MAKLab North. The project runs a furniture manufacturing facility in Glasgow, as well as using a mobile MAKLab for outreach projects. Belief in the power of making to promote entrepreneurship, well-being, confidence and self-reliance, particularly in young people and for communities struggling with lack of opportunities and employment is a very strong theme.

The main studio works with a core membership of around 125 regulars, including design professionals, students, makers and independent crafts people but there is a clear determination to broaden engagement to younger people, disability groups, older generations and specific hard to reach communities. Clifford says they are "trying to gather common momentum and utilise momentum that the design industry and making has, by including a social and inclusion catchment as well" (Clifford, 2016).

The ethos recognises the importance of sharing knowledge and skills in an open environment, which Clifford sees as vital, saying: "It's that openness and the tables are big for a reason, so people can gather around about them and see everything that's going on, I think that's very very key" (Clifford, 2016). Clifford credits this policy of openness with encouraging designers to base themselves in the studio, where they can benefit from shared knowledge of equipment, materials, and processes and, he says, "they can turn round and ask and get an answer immediately" (Clifford, 2016). He emphasizes the importance of creativity and playing with ideas, and says that providing a space for creative collaborations and the testing of ideas was key to his original motivation: "I was really interested in seeing what happens if you just give that opportunity – if you give that space, and people can reclaim play, and test ideas with one another" (Clifford, 2016).

> Clifford sees a variety of potential benefits from offering workshops for participants in community spaces such as libraries, noting that: "It can be skills that they pick up through undertaking a workshop for an hour, two hours, or just coming to experience the technologies, and learn about other things people have been working with. But we also align a lot of our work with employability, with social inclusion, with skills exchange between older, experienced crafts people who maybe have been made redundant – or not valuing their skills set – so we can help add value back to the very important skills set. But then sharing that with younger generations and vice versa" (Clifford, 2016).

His focus is on individual empowerment rather than the actual objects produced. He explains: "What they make, what it looks like, how it's made, is sort of secondary, but the power of being able to make is what changes their life, so [our interest] is very much in the person, the individual, the social reason for why they would be doing it" (Clifford, 2016).

His team are less interested in the capabilities of the digital fabrication equipment than the outcomes for individuals. Clifford observes: "We don't really talk about how to push every button on the machine, we talk about 'what do you need the machine to be doing?, what is the actual product you need out of it? - that helps your granny leave the house, or helps your kids with a learning difficulty – what improves their life?" (Clifford, 2016).

Clifford says that MAKLab finds it hard to evidence what they do in a way that fits with traditional funding regimes, partly because it has such a broad-based agenda, integrating different age groups and targeting issues from entrepreneurship to social inclusion. He comments, "financial support to keep doing what we're doing is obviously one of the biggest challenges. Our challenge there is actually that we do too much, our coverage is so broad that a funder might sit in only a tenth of what we do and [they] don't often like to be seen funding outside their remit" (Clifford, 2016).

9.4 Liz Corbin

Liz Corbin, Researcher, Institute of Making.

Liz Corbin works as researcher at the Institute of Making (http://www.instituteofmaking.org.uk) (IoM), a Materials Library and makerspace within University College London (UCL). The Institute of Making was set-up by UCL academics Zoe Laughlin and Mark Miodownik, who act as two of the three Directors, along with Martin Conreen from Goldsmiths. The makerspace emerged from research and public engagement carried out through the Materials Library, initially at Kings College, opening in a refurbished loading bay at UCL in 2013.

It is core funded by UCL and open to the entire UCL community of students and staff, and to the public, through curated events and open days. Any member of the UCL community can become a member and use the space, after attending an hour and a half induction. Corbin comments "for us, inductions have become really important, to bringing people together, especially new members, sharing with them the overall ethos of the space, which is all about sharing and knowledge transfer, experimentation and play, and working with one another" (Corbin, 2016).

Although at any one time there may be several thousand members, the active membership, she says, "tend to be those that have a bit more of a requirement to actually make something in their course; engineers, architects and artists" (Corbin, 2016). Members come in with a wide variety of skill levels and Corbin has been surprised by the initial lack of skill among a number of students, commenting that "quite a lot of them are complete novices, I mean even for those disciplines which are all about making things, like engineers, it's quite surprising … how limited the technical experience they have is" (Corbin, 2016).

Technical support is provided by three technicians, on a rolling basis, generally with two working at any time but Corbin explains that the ethos of the makerspace is that technicians do not actually make objects for members.

> She explains: "What we say is we will give any type of support that we can to that student but we will not actually make that object for them, we will teach them how to work the machine, we'll show them how to order the material, we'll show them how we might go about assembling that piece or, those two components together, but it is our standpoint that actually,

the job of making something is, I mean … you will learn so much more if you're the one to make it" (Corbin, 2016).

A lot of the learning takes place on a peer to peer basis, although technicians do step to help newer members or for particularly complex projects but Corbin believes a lot of skill sharing and knowledge transfer happens without being formally directed.

> She says: "I think the thing about sharing which a lot of people miss is that so much is shared invisibly … it is that non-verbal, just co-existing and sort of seeing the person across the room, what they're doing and you just being in the same environment" (Corbin, 2016).

The ethos of the space is focused on being friendly and inclusive, and operates as a social place as well as a work environment, Corbin observes that "our biggest challenge is making sure that there's a balance between the two and that everyone feels welcome", adding that the ethos emanates from the vision of the founders and is embodied in the core values and reinforced through inductions and the day-to-day operation. She says: "What I've learned is that an open door policy isn't enough, so you can't just say you're open and expect that type of environment to be self-generative" (Corbin, 2016).

Corbin is in a unique position to have an overview of London makerspaces more generally, through her work helping establish Open Workshop (http://openworkshopnetwork.com) London (OWL) a network organization for London Makerspaces. She has documented a wide spectrum of open workshops and makerspaces, more than 40 in London, with a variety of resources and agendas but believes there is commonality. Corbin reflects: "A lot of these spaces are in a roundabout way, being developed to be vehicles for change" (Corbin, 2016). She describes a range of agendas for change being curated through making, makerspace and open workshop communities, from the provision of facilities for self-employed practitioners to work in the city (Building Bloqs), to a focus on critical making and social and environmental impact (Machines Room) or perhaps a desire to see a different kind of educational opportunity, as at the Institute of Making.

Corbin sees both difference and similarities between makerspaces: "I think the community comes to self-populate based upon kind of the overall mission of that space." But what they have in common is a vision of change. She says: "What these spaces are doing is they're changing mind-sets as individuals, and that's just as interesting as how something is made, if you start to begin to see that these spaces are making people and making communities of people that think slightly differently, that want to see change, that want to see more self-sufficient cities, that want to see inhabitants of cities feeling more ownership of where they live, that want to see individuals questioning society more" (Corbin, 2016).

9.5 Tomas Diez

Tomas Diez, Founder, Fab City Research Laboratory.

Tomas Diez has worked with Barcelona Fab Lab (https://fablabbcn.org) from its inception in 2007. He is a Venezuelan born urbanist and is leading the Fab City (http://fab.city) project worldwide. Barcelona Fab Lab was one of the first to be established outside the US, and has given rise to a number of innovative technology projects, such as Smart Citizen (https://smartcitizen.me). Barcelona, as a city, is at the forefront of cities embracing the potential for digital fabrication, recently establishing a network of public Fab Labs.

Barcelona Fab Lab was established within the Institute for Advanced Architecture Catalonia (https://iaac.net), (IAAC) and the intention from the outset, according to Diez was "to not only open a prototyping space for architectural students but a Fab Lab … to work towards the integration of digital fabrication in society" (Diez, 2016). Diez and the Barcelona Fab Lab team have been key collaborators in the development of the wider Fab Lab city network and active participants in global Fab Lab initiatives, for example working with the Centre for Bits and Atoms (http://cba.mit.edu) at MIT and the Fab Foundation (http://www.fabfoundation.org), on developing the Fab Lab platforms and infrastructure programmes, such as the Fab Academy (http://fabacademy.org) and Fab Labs.io (https://www.fablabs.io) (Diez, 2016).

Diez estimates that 30-50 new people a week come to find out about and use the Fab Lab facilities, including those visiting in groups or attending open days. Diez has witnessed digital fabrication becoming widespread in Barcelona, and sees progress being made towards a Fab City model.

> Progress, Diez reports, includes: "a public programme of millions of Euros invested by the city council, opening a new public infrastructure which are public Fab Labs, we see other businesses created around the idea of digital fabrication … so we have now in Barcelona, this whole ecosystem around digital fabrication" (Diez, 2016). He also sees this ecosystem reflected in "high schools embedding digital fabrication technologies, and open source philosophy, and collaborative work" and in businesses and higher education establishments so, Diez comments that, "for people to get access to the technologies and the philosophy of the Fab Lab, they don't only need to go to Fab Lab Barcelona … now they have over 50 options" (Diez, 2016).

Diez co-founded Smart Citizen (https://smartcitizen.me), one of the flagship projects to emerge from the Barcelona Fab Lab. It employs accessible technologies such as Arduino and an internet platform to enable distributed citizen participation projects: "Connecting data, people and knowledge" (Smart Citizen, 2017), for example, to carry out environmental monitoring. Diez reflects on the progress of the project. "We use to say that Smart Citizen came out of a critical design exercise on the top-down Smart City model, but then it has become like a project that is testing and making evidence the potential of open source and again accessible technologies for people" (Diez, 2016).

Prototyped in the Fab Lab and developed through crowd funding and user feedback, Diez sees Smart Citizen as an example of collaborative and iterative product development, he says "it's not you know, a group of gifted developers finding the solution for the world but actually, it's a group of people working together to learn from the world and iterating different solutions and testing them." (Diez, 2016). Beginning with tech enthusiasts, researchers and now city councils, Diez envisages Smart Citizen becoming an "enabling infrastructure" for people, part of a cultural shift towards a more engaged, productive and local focus and away from a highly consumer-based culture. The Fab City (http://fab.city) initiative is a key expression of this vision.

The Fab City white paper (http://fab.city/whitepaper.pdf) calls for the use of city-wide local digital fabrication – promoting local production, based on global knowledge sharing but using locally sourced materials – so that cities are "globally connected, locally productive, self-sufficient cities" (Fab City, 2016). It sets a target of 2054 for cities to be 50 percent self-sufficient on the production of goods, energy and food that they consume. Diez emphasizes the need for an integrated effort towards this goal and is keen to involve business, saying: "this involves an effort not only from the maker movement or the Fab Lab community or the governments, but also with companies and corporations" and has been working with public authorities, and businesses such as Ikea and Nike.

One of the key drivers of this vision is a desire for cities to be uncoupled from the global supply chain and able to manufacture more locally, recovering some autonomy in decision making. The most recent Fab City conference (http://fab12.fabevent.org) in August 2016 was held in Shenzhen in China. Diez emphasizes that Shenzhen, with its flexible, distributed, open source manufacturing capabilities, is a highly dynamic ecosystem for production from which he believes we can learn.

> He cites the idea of modular design, as an example of producing goods in a flexible local production system, where "if something is broken but actually there are parts that can be dismantled and then put into it, open source design can be shared across the world, so you don't actually need to ship everything from Shenzhen, you can produce some things locally and also try to embed the culture of circular manufacturing, meaning giving products a life after death and trying to re-insert trash into supply chains, in order to produce other things" (Diez, 2016).

Diez is impatient with maker movement individual stories of innovation, particularly those of amazing but irrational objects , he remarks "it's cool but that won't create impact if we don't scale-up, work with corporations and we don't work with policymakers, so in order to turn this from a hobbyist anecdote driven, kind of highly individual movement, I think this should be considered as a massive change opportunity" and believes that the focus should firmly be on "real issues" such as "the lack of employment.. or the quality of life" (Diez, 2016).

Diez concludes: "Making for the sake of making is not enough. I think instead of using making [for] personal or individual empowerment, actually it's individual empowerment for a mission, and that mission is to create positive impact in the local environment, but also in the global one, and when an individual creates a project that could change people's lives on the other side of the world, being able to have this systematic infrastructure in which that thing could be replicated anywhere in a matter of minutes, I think that's super-powerful" (Diez, 2016).

9.6 Hannah Fox

Hannah Fox, Project Director, Derby Silk Mill.

Hannah Fox is the Project Director for Derby Silk Mill – Museum of Making (http://derbysilkmill.tumblr.com). It is a site with an extraordinary industrial heritage, as she explains: "the building itself sits on the site of the world's first factory, so the Silk Mill was built in 1721… it was a step change in what was happening in Britain and actually in the world at that time, with a process for fully-mechanised manufacturing off one power source, that meant that there was mass production" (Fox, 2016).

For most of the last 40 years, the Silk Mill has hosted an industrial museum but is now undergoing a process of significant development to reinvent it for the 21st century through the creation of Derby Silk Mill (https://www.derbymuseums.org/locations/silk-mill) – Museum of Making (Derby Silk Mill, 2017). Fox explains how the concept for the Museum of Making emerged from a co-production process by "exploring and prototyping lots of different types of events and activities with our audiences and lots of volunteers, and the sense of understanding the American Maker Movement, thinking about the building as a birthplace of modern making" (Fox, 2016).

A well-resourced makerspace, with digital fabrication technologies including a large scale CNC mill, has been installed as part of the initial re-development phase, giving the project both making facilities, and the community focus to be able to re-invent the space.

> Fox explains: "We created a makerspace and thought, actually let's make the Museum of Making together with our audiences, and see what emerges in that way… So the makerspace was purposed against the development of the project, and it is a community space as well, so we get to test …how a makerspace could work for us and our audiences and our partners, in a much more iterative way" (Fox, 2016).

Fox is determined to focus on what is most useful for Derby and its people, for example, undertaking outreach work, promoting making projects and creative problem solving in schools, and piloting projects to enhance patient well-being in Derby hospital. She is keen to emphasize Derby's position as a high tech engineering city and the home of Rolls-Royce. Helping industry recruit apprentices, providing business incubation space, converting a double decker bus as a mobile museum of making, and promoting arts and science collaborations, are just a few of the projects already undertaken or planned. The museum has also hosted a well-attended annual Mini Maker Faire for the last 5 years.

Fox believes the makerspace should work as a "mutually beneficial environment…we try to encourage that social interaction and social impact through that, rather than thinking about it being transactional, "[it's not] 'you give us money, you get time on this', it's more about how are we doing something together" (Fox, 2016).

Fox emphasizes the importance of making as a multi-disciplinary activity, able to bring together specialists to support innovation and creativity. She views this in the context of the City's innovative past and believes the Museum of Making has a role to play both in re-generation and future sustainability.

> For Fox, the overall vision is about: "re-engaging people with their own narratives and then shaping where we might go collectively as a civic society … I think it's really important that people can understand this and have the spaces and places to develop the necessary skills for our future. The skills to be polymaths, experimenters and inventors and feeling like that's completely part of life." (Fox, 2016).

9.7 Bram Geenen

Bram Geenen, Co-founder, Wevolver.

Wevolver (https://www.wevolver.com/home) is an open source internet-based hardware platform that acts as a project repository and online community, where you can share knowledge and files about hardware engineering projects such as robots, drones or 3D printers. Many hundreds of projects are posted publicly, inviting collaborators from around the world to help develop and test ideas. Bram Geenen is co-founder and explains Wevolver's mission as "enabling anyone, whoever you are, to create technology so that you can learn new skills like engineering, so that you can solve problems that you have, whether it's local problems, or that you want to take up clean energy but also use technology to start your business" (Geenen, 2016).

Geenen has a background in industrial design. He explains that the impetus for Wevolver came from working in his design studio in Amsterdam on 3D printed furniture, all the time collaborating with engineers, scientists and craftsmen but realizing there was no platform to develop and share his chair designs and knowledge. His Co-founder, Richard Hulskes has a background in e-commerce and 3D printing, they started the project together back in 2010. The Wevolver website explains that the "first breakthrough came in 2013 when Wevolver won the Social Tech, Social Change Award from Nominet Trust" (Wevolver, about 2017) enabling them to build a small team of full-time software developers.

> Geenen sees Wevolver as part of a new approach to product innovation. He says: "We also see that the whole nature of hardware development, of engineering new products is changing, it's becoming faster, more collaborative, more decentralized…you can develop hardware better and faster if you just take a different approach, get your product out the door faster, get a community around it, continuously iterate and improve your product" (Geenen, 2016).

Not all Wevolver users are commercial, Geenen explains there are a wide range of motivations "you see the whole spectrum from individual makers who just do it for the sake of making and well, just like the idea of sharing … it's sort of one end of the spectrum, and on the very other end, you have the start-up who thinks like 'okay, I'm going to develop an open hardware project because that gives me this extended R&D department, people all over the world' and also, it's a very good marketing instrument in a way" (Geenen, 2016).

Wevolver projects are all multidisciplinary engineering projects, involving mechanical engineering, electrical engineering or industrial design but they often have an environmental or social impact theme. Geenen believes that DiDIY projects with an intended beneficial social impact gravitate towards Wevolver's open source platform because originators "who do social good projects, whether it's environmental or for health etc., they have this notion of 'I would love to make myself open source because I want as much people as possible to benefit from it'" (Geenen, 2016).

The team at Wevolver try to help contributors to document projects and recognizes that this type of open source hardware development is still very new. Geenen explains some of the difficulties; "for a lot of people it's like, 'okay, I want to share my project but how on earth am I going to do that?', so we help them to do it in a nice way". He believes open source hardware has a strong future but is not dogmatic about this as the only route to product development. The Wevolver platform can equally be used for of the development of privately posted projects. He comments: "There are some cases where it makes sense to do maybe at least your development behind closed doors, or maybe do it forever behind closed doors, in other cases it makes sense to be as open as possible, as soon as possible. For me it's an ecosystem, about creating and innovating" (Geenen, 2016).

> Geenen says that many contributors develop their projects to quite an advanced stage before sharing them: "Too early, people are not confident to share, they feel like: 'I need to get it to a certain point, where on the one hand, it expresses what I want to achieve well enough but also where I've developed it well enough so that it actually makes sense to share' - or that also - 'I've developed it well enough so that now my identity is in there'" (Geenen, 2016).

9.8 Richard Harvey

Richard Harvey, Co-founder, Harvey & John.

Founded in 2011, Harvey & John (http://www.harveyandjohn.com) is a partnership between Richard Harvey and Keivor John. Their extraordinary, one-off creative installation pieces for companies, events and exhibitions often combine the use of digital fabrication technologies with a DiDIY approach to prototyping, making use of skills in invention, design, art and engineering. A recent project is Scent Drops (http://www.harveyandjohn.com/portfolio_page/scentdrop), created for the new Grand Musée du Parfum in Paris, which allows users to experience the 25 ingredients most commonly used in Perfume.

Harvey studied Interaction and Moving Image at the London College of Communication and found the hands-on approach and support of technicians who were knowledgeable across a broad spectrum of disciplines, from software engineering and electronics, to graphics, art and design very helpful. He reflects: "I used to spend a lot of time with the guy who was the software electronics guy … he was great, really helpful and so were all of them actually, the course really pushed you to do new things" (Harvey, 2016).

Starting with creative ideas and using 3D animation to make visualisations, Harvey and John began to build the skills to make their ideas come to life, by seeking out a wide range of technologies and knowledge. Over the years they have made use of a huge variety of technologies and processes, from Arduino and Raspberry Pi, to CNC milling and 3D printing. They have found the necessary expertise and knowledge partly by outsourcing, for example employing skilled individuals with

connections to their local makerspace. They have also had to develop their own expertise in many ways, seeking help from a wide variety of sources, from watching You Tube tutorials to consulting online forums. Harvey comments: "If I've got a software or physical hardware [problem] and someone out there has got that problem, it really helps going online and finding other people that have got the same issues" (Harvey, 2016).

Prototyping is generally done in their Brighton studio, elements of manufacture are then outsourced to specialist suppliers. Harvey believes that his background in making and experimenting, on a trial and error basis, enables him to commission work more successfully. He explains, "because I've had to make stuff myself, I do know…what will work and what won't" (Harvey, 2016). The company now employs a small team of specialists and Harvey believes that this has been key to their success, saying "that's been a real thing that's accelerated us, it's getting extra people in who can specialise and do certain areas" (Harvey, 2016).

The company seeks out technologies that can open-up new possibilities, Harvey recognizes that greater access to affordable electronics and computing in recent years, and to the knowledge and skills to turn creative ideas into reality, has been crucial to their success.

> Harvey explains: "I didn't really know what I wanted to do, I just knew that, I had a lot of ideas and then it started to become reality that I could actually make them happen… often it is that, you already had an idea a few years ago, that you ruled out as impossible and then something comes along and it links back, 'Oh I can do that thing now' and then that goes into a new idea" (Harvey, 2016).

But the technology employed is rarely apparent in the finished piece and Harvey is keen that it is the users experience of the piece that matters. One of their flagship pieces is the Tropism Well (http://www.harveyandjohn.com/portfolio_page/tropism-well), a beautifully elegant installation that pours drinks for guests – and one of Harvey's favourite pieces – he says "how people react to it is really nice, people bow back to it, so it leans for them and they say 'thank you' and lean back, and they treat it like it lives, and I think that's because it moves in such an organic way, it feels like something from nature, so you get a really nice reaction" (Harvey, 2016). Years of experience of making, working through iterations and prototypes, has given Harvey a positive attitude to creative problem-solving and overcoming difficulties.

> He says: "It's still hard but…I think it's quite an optimistic time because there's nothing to be afraid of – you can kind of do anything really you can think of – nothing's too expensive particularly or too hard to do – and even if it is quite hard, there's someone who can help you, or there's some You Tube clip that can figure that out" (Harvey, 2016).

9.9 Tim Hunkin

Tim Hunkin, artist and engineer.

Tim Hunkin (http://www.timhunkin.com) is an artist and engineer. He is famous for his wide ranging and distinctive creative practice including cartoons and automata, the Channel 4 television series: *The Secret Life of Machines*, as well as numerous installation and museums exhibits. His humorous arcade machines have entertained audiences for decades. His current arcade machine work can be seen in two arcades in the UK; The Under the Pier Show (http://www.underthepier.com) in Southwold and in London, at Novelty Automation (http://www.novelty-automation.com) in Holborn.

Hunkin's work combines creative, artistic and humorous interpretation with the practical skills of engineering. His arcade machines are complicated mechanical and computer programmable installations, that have to be reliable and robust enough for public display. He is largely self-taught as an engineer and has spent many years building-up his skills in his workshop.

He explains how he feel creativity is vested in a challenging making "process" of trial and error, rather than in ideas themselves. He comments: "I think the way people look at design and art … they think the creative bit is having the idea, then I don't really agree because I think my ideas are pretty straightforward but each of those arcade machines takes me several months to make and the exciting thing is the journey" (Hunkin, 2016).

Having the creative platform of his workshop, and years of experience with materials and tools, enables Hunkin to creatively prototype as he develops work.

> Hunkin explains: "I cannot think quite how to make a piece in advance, but in the workshop, I think 'oh I've got that tool, I can do it', which I've forgotten about, or 'I don't know how to make this part' and then I find something in the stores, and it's almost like the workshop and the stores are a sort of memory map" (Hunkin, 2016).

Adding "I'll make prototypes before I draw anything. I can't usually draw what a machine's going to look like until I'm half way through making it…it's organic, it's changeable, and if you're making prototypes then that's what you need, you need to be able to work fast" (Hunkin, 2016).

Hunkin has lived through the transition from analogue to digital, initially using cam timers to control motors and graduating to digital components used for industrial automation such as Programmable Logic Controllers but says that although digital technologies have opened up new possibilities "the digital stuff allows me to easily add video and sound to the machine" he still prefers to make things that are "mechanically quite complicated, with a sort of sprinkling of digital intelligence on the top" and adds "I feel it's extraordinarily vast, unexplored territory because in the rush to change, people have kind of ignored that" (Hunkin, 2016).

Hunkin has been involved with the US Maker Movement from the start, saying "there was a naïve enthusiasm about it … I went out to the first two Maker Faires over there and I'd written bits for MAKE Magazine, so I was terribly idealistic about it when it started up" (Hunkin, 2016). He maintains connections to US makers, for example working with a group at the Exploratorium in San Francisco (https://www.exploratorium.edu) where he spends one month a year. He feels less affinity with the more recent preoccupations of the maker movement, with drones and 3D printers, and comments that MAKE has "got a lot more commercial" but he is still optimistic about the longterm ability of people to learn new skills and benefit from making.

He cites his own long and difficult journey towards becoming a skilled engineer, as evidence that it is possible to become skilled through persistence and experience, saying: "I'm optimistic making will flourish in the long term, both because I think it's so deeply ingrained in our brains, but also because it will be possible for people to become just as skilled as they have been in the past… it's

partly because it did take me a long time to learn and I feel proud of all of those skills" (Hunkin, 2016).

He is particularly keen to see the opportunity of practical skills in making offered to children in school, believing that for some children "academic stuff isn't their thing" and that simple tool-use is an opportunity a lot of children no longer get at home. He agrees that initiatives such as the BBC micro:bit, to bring digital skills and coding to schools are fine, but adds that "to me the important thing … you know is that kids can't use a pair of pliers… it's good that now they can add a bit of digital but to me they're still stuck if they can't use basic hand tools…If schools really got their act together and put equal emphasis on practical things as academic stuff, I think a lot of children would be more fulfilled" (Hunkin, 2016).

He finds it harder to find collaborators for his own work with good physical making skills, commenting that: "I can get somebody to do bits of programming for me and it's very cheap, it's really hard to find somebody to come into my workshop and work alongside me on the thing, there's just far fewer people with that skills set" (Hunkin, 2016). It's the combination of digital and physical skill sets that he would like to see promoted saying, "the combination is very useful and far too rare at the moment – I have no helpers who can do both" (Hunkin, 2016).

Hunkin agrees that there is a particular mindset, that both informs his making and influences how he sees the world, a view based on a deep understanding of practical technology.

> Hunkin explains this as an enduring love of technology and the process of making things: "When I go to London, I go round building sites and peer through the windows … I'm much more interested in them than art galleries. It's satisfying because I can look at things and puzzle out how they're made … a completely pervasive way of looking at the world.. which I've found endlessly fascinating" (Hunkin, 2016).

9.10 Nat Hunter

Nat Hunter, Strategic Director, Machines Room.

Machines Room (http://machinesroom.org) is an east London makerspace open to both the public and businesses (Machines Room, 2017). It was founded by regeneration architect Thomas Ermacora in early 2014, and was established to support local technology and creative businesses moving in to the local area; Vyner Street in Bethnal Green, as part of a regeneration project. Nat Hunter is Strategic Director and explains that there are three main types of users. Firstly, local businesses such as architects making models. She explains: "We call the local area The Maker Mile, we've defined it as The Maker Mile. People in the Maker Mile can be organizational members and they will be doing something to do with their business" (Hunter, 2016).

The second type of users are individual freelancers or one-man bands. Hunter says these can be "both highly professional and starting out". They are individual makers using the space as an extension of their studio. Hunter explains that part of the attraction is that, in London: "It's so expensive to get a studio and a studio where you could both use wifi, and have clean working conditions and also chop up a bit of wood". Individual members value the chance for networking, knowledge transfer and support. Hunter explains that "the staff act as conduits. People ask us and then we go, 'Oh so-and-so, he was in last Tuesday, he might be able to help you'" (Hunter, 2016). Hunter says they also try to support new makers "on the lower end of that band, you get someone straight out of university" and, in some cases, training and inductions are exchanged for volunteering within the space, such as cleaning-up. For example, Hunter says they might arrange to "do an hour for an hour swap, so no money changes hands" (Hunter, 2016).

> The third type of users, according to Hunter, are: "The kind of evening class and Saturday band. It's more people who are interested in this world but maybe have a full-time job. They might be learning in order to help their job, or they might be learning also to find out about the world…Sometimes people just want to experience the technology that they read about, or see on the TV" (Hunter, 2016).

Machines Room has a large central space, used to host public events and exhibitions, such as 'Arduino Day', and which also functions as a co-making and co-working space. Hunter says makerspaces have a "personality" that you can read from looking at their programme, typically covering events, workshops, talks and short courses and adds that makers "find their niche… we have a very high ratio of creatively trained people" (Hunter, 2016).

Machines Room is known for its role in supporting critical making. The staff have both technical and artistic backgrounds, and use their expertise to help makers ask questions about what they are making. Hunter is particularly keen that Machines Room contributes to "a dialogue around a vision of the future" (Hunter, 2016). For example, in piloting efforts towards a circular economy and contributing to the process of working out how makerspaces can "help us move from where we are now to the Fab City vision … We are looking for things that are going to improve city living" (Hunter, 2016).

The management of Machines Room is not focused on making a profit but the project does need to be sustainable. Hunter says that membership prices are kept low deliberately but their business model, in common with many other makerspaces, includes a contribution from hiring out facilities for corporate events, for workshops and for business meetings. As with many makerspaces finding a sustainable business model is still an on-going process.

Hunter identifies several networks and communities that Machines Room plays a role within. Firstly, the local community; the Maker Mile network of businesses that, she says, support each other: "Knowing each other means that you can help out and you've got the backbone of, 'Oh I need a so-and-so', you've got a whole square mile with creative technical people" (Hunter, 2016).

Secondly, as a Fab Lab. The space has Fab Lab standard equipment and is part of the very active Fab Lab network and community, for example enabling them to work straight away with new members who have the Fab Academy accreditation. Hunter explains "You got a very familiar kit with very familiar software, with very similar ethos" (Hunter, 2016).

Machines Room also play an active role in the British Council Maker Library Network. Hunter explains the international connections this provides: "There are Maker Libraries in South Africa which is the initial territory, Berlin, Mexico, Istanbul, various places. The idea is that it's an exchange of ideas" and Machines Room has added another layer by developing a Makers in

Residence programme. Hunter explains they plan to have five Makers in Residence per year "and one of them rotating every month who will be an international maker" (Hunter, 2016), creating a community providing international knowledge exchange opportunities.

Hunter is also keen to work with new business models. One example is Open Desk, a company (with offices in Vyner Street) that enables designers to upload furniture designs globally, that can be bought and then made locally – for example through digital fabrication in a local Fab Lab. Hunter explains how they have adapted this model to offer buyers even more choice about how they engage with the manufacture of their furniture. Consumers can choose to be hands-on in the workshop finishing their furniture, so that emotional value is created through the buyers' experience and connection to their product, or consumers can choose to move towards becoming producers and learn to design themselves.

> Hunter explains: "We devised a course, a four-evening course where you could make an Open Desk chair and take it away with you at the end of the course and that was really popular … We're taking that model and giving it stronger roots in a way, giving it some educational roots … What we say is we were going to increase that depth of engagement" (Hunter, 2016).

At the end of the day it is the informal, sharing and friendly ethos, a place with a sense of fun, that Hunter returns to, as among the greatest benefits of using a space like Machines Room. She says: "I think people have a lot of fun here. That's the bit we haven't really talked about. Quite often I think of Machines Room as a playground" (Hunter, 2016).

9.11 Sherry Huss

Sherry Huss, Vice President, Maker Media, Co-founder, Maker Faire.

Maker Faires (http://makerfaire.com) are public events where makers come together to show their projects and share ideas. The Maker Faire website explains Maker Faires as "a family-friendly festival of invention, creativity and resourcefulness, and a celebration of the Maker movement" (Maker Faire, 2017). Maker Faires bring together arts, crafts, engineering, science projects and the Do-It-Yourself (DIY) mindset. Sherry Huss is Co-founder of Maker Faire and Vice President of Maker Media, the company that was spun out of O'Reilly Media in 2013, to focus on the maker movement (O'Reilly, 2013). Huss recounts how Maker Faire originally came into being as "the festival to celebrate MAKE, MAKE the magazine and MAKE the online group" (Huss, 2016). The first Maker Faire was held in the Bay area of San Francisco around the Earth Day weekend of April 2006, a year after the launch of O'Reilly's MAKE magazine (http://makezine.com) in 2005.

Huss witnessed the origins of both Maker Faire and the maker movement and identifies a dissatisfaction with the world of work as an early impetus, saying "folks went to school to become engineers but … they realised … what they were doing is managing people, projects and budgets,

so on their free time, which was the weekends and evenings, they started making" (Huss, 2016). She identifies the major economic recession in 2009 as a turning point that caused "a lot of people to start re-evaluating, a lot of engineers, they were losing jobs – so the question is – 'do I go back to a job that I'm not that happy at?'" (Huss, 2016).

Maker Faires have taken off in a fairly extraordinary way, as Huss reports, in 2015 there were "150 events worldwide, [so it has grown from] from 22,000 people [in 2006] to over 1.2 million people [attending in 2015]" (Huss, 2016). Huss adds that the number of events is growing strongly in the EU "I'd say the EU is probably the most significant growth we've had outside the US, in fact, of 150, about 101 events are in the US, 31 of them are in the EU" (Huss, 2016).

> Huss believes the origins of Maker Faire's popularity is rooted in the US County Fair model that she remembers from her own childhood, where people come "together once a year, usually in the summer or the fall, sharing and showing what they either made, or what they grew, or possibly bring their animals to fair. I think that there are elements of the community coming together, sharing, being a little bit collaborative, trying new things, and actually being excited or inspired by others" (Huss, 2016).

She is keen to stress the inclusivity of Maker Faires, where the spectrum of attendees and makers showing their projects, ranges from complete novices to maker businesses. Three groups she identifies are 'Zero to Maker', these are complete "newbies", then 'Maker to Maker', the enthusiasts showing their projects and, finally, 'Maker Pros', people really thinking about creating or having already established a maker business. Maker Faires, according to Huss, are where the "Maker to Maker and the Maker Pros that are pretty much being very generous with their time and sharing and showcasing to, kind of, the Zero to Maker audience" (Huss, 2016).

> The creative value Huss sees in Maker Faire comes from the cross-pollination of ideas, the conversations and story-telling. She has witnessed this first-hand, reflecting on "the mash-up of all these different things that manifests I think differently in people…when the rocket group meets the robot group, something very interesting can happen that normally might not" (Huss, 2016).

She sees Maker Faires as family attractions adding "there's very few events now that can attract everyone in a family…that passing on, that multi-generational component" is important and the educational value of Maker Faire as vital, identifying making as an empowering activity for children. She says: "We're going to be empowering them, and giving them tools to make better decisions, to function and to kind of create the world that they want to live in, I think a lot of kids don't have that opportunity, and I think it also builds confidence" (Huss, 2016).

Maker Faires have enjoyed support from the highest levels, with a White House Maker Faire taking place in 2014, (White House, 2014) bringing international attention, but Huss admits that Maker Media is still "trying to figure out what is a business model that can actually make this happen" with many Faires "half funded by attendee ticket revenue and half funded by sponsorship". She fully recognises the need for community involvement and approval of new initiatives saying: "We're sort of the steward of this brand… the community owns it and so every decision that we make, we really have to be open and figuring out how it's going to be perceived" (Huss, 2016).

Asked about the future of the maker movement Huss cites the recognition from industry partners such as Intel that the maker movement is a genuine source of innovation and predicts expansion. She says: "I think we'll start seeing more and more of these events and maker activities in schools, in libraries, in community places". She is keen to promote more diverse participation saying: "We are trying to figure out how to get more women and girls in making, and under-served communities,

it's been pretty much a white male world and not necessarily by design, but I also think that these Maker Faires make it much more of a level playing field for more folks to get involved and the barrier to entry is pretty low" (Huss, 2016).

Huss believes the significance of Maker Faire is not vested in the digital, so much as in storytelling, and sharing face-to-face, saying, "even though we live in a digital world and a lot of our attendees have digital devices and are connected digitally, what they're doing isn't necessarily digital in many cases" (Huss, 2016).

She concludes: "Maker Faire if nothing else, is also kind of a by-product of that open source community and DNA…it's about a community, or a tribe of people, coming together that have the same passion, the same values and that sharing of knowledge, that passing it on, is really important" (Huss, 2016).

9.12 Bethany Koby

Bethany Koby, CEO, Technology Will Save Us.

Technology Will Save Us (https://www.techwillsaveus.com) (TWSU) is a company that makes DIY kits and digital tools to help young people and families make, play and invent with technology. Bethany Koby is CEO and co-founder. Started in 2012, TWSU takes a creative approach to technology that stems from the founder's dissatisfaction with educational models.

Both Koby and her co-founder Daniel Hirschmann (TWSU, 2017) trained in the US, Koby as a designer, Hirschmann in physical computing and creative engineering, both went on to teach. Koby saw a lot of educational practice as uninspiring. She comments: "A lot of education is taught, 'copy this, learn it, repeat it' and we felt that tech had this really important opportunity to be taught in a really different way" (Koby, 2016).

Koby identifies three main themes that led to the establishment of TWSU. Firstly, an awareness of the lack of understanding of technology, in society generally.

> She says: "We have opinions about how we actually use technology but we don't know how it works and so we don't have the understanding of actually what we want it to do, in a very kind of fundamental way – because they're black boxes or white boxes or silver boxes – and they don't invite us to do that" (Koby, 2016).

Secondly, as a parent, Koby was keen to see her son "have a relationship with tech, as a medium to be creative with" and thirdly, Koby says "kids are these fearless, curious, creative beings, they want to learn, they're sponges, specifically between the ages of 2 to 11" and the ICT curriculum, centred on coding, covered "a very small spectrum of what their capacity can be" (Koby, 2016).

Coming from a professional practice as makers, creators, and designers, Koby believes that TWSU is in tune with several key current concerns and says "there are a few waves that we're riding". She goes on to explain: "One is around the skills gap – the need in education for kids to learn about how to be creators, makers, have the skills for future jobs – I think that's a wave we're riding. I think another wave that we're riding is around this kind of maker movement – this kind of human need to be productive – whether that be with tech or with yarn, or with craft. Then I think there's maybe another big strand, which is around … education is broken, it is a very archaic system and there are, for maybe the first time in history, education is being disrupted by small businesses, big businesses, everyone's trying to find how to make education something that is joyful and working. Where teachers are empowered and where kids are actually inspired, and not just around test taking and assessment" (Koby, 2016).

TWSU now employs a team of 28, having doubled in size in the last year. They have recently launched a major new product, the Mover Kit, through a Kickstarter campaign (Kickstarter, 2016). All the TWSU kits are designed and packaged, first and foremost, to appeal to young people's interests and hobbies and the company has found, through research, that they are particularly able to reach girls, with 60 per cent of their kits being bought as gifts or opportunities for girls. Koby explains: "We don't lead with the technology, we lead with what you can do with the technology… we see the digital as a tool to bring the physical to life" (Koby, 2016).

Koby is inspired by the teaching and learning philosophies of Jean Paget, Seymour Papert and Maria Montessori, saying "creativity was a fundamental part of their research and empowering young people to be creative problem solvers was the focus of all of their work". She believes that kits help young people to follow a pathway to creative success, emphasizing that "by going through steps and seeing the LED light up, seeing the thing you've done successfully accomplished, we see helps create a pathway to confidence, that then helps them to see how they can be more creative" (Koby, 2016). Whereas a more open-ended approach could be intimidating and a block to creativity. Koby believes that "if kids can be problem solvers, that's a really fantastic skill, no matter what their future might be" (Koby, 2016).

Koby is proud that TWSU were among the partners in the BBC micro:bit project, saying their expertise was in "the user centered approach to design and development, so we essentially, in the process, represented the 12 year olds". She is pleased with the way that the micro:bit has turned out to be "a little friendly board that begs for you to want to interact with it," (Koby, 2016) adding that it is a flexible platform that has been given away to a million 12 year olds and says "importantly … they are the young person's, they are allowed to take them home" (Koby, 2016).

By working with learning partners including The Prince's Trust, Code Club and Scouts, TWSU is able to reach diverse audiences.

Koby sees TWSU as pursuing the goal of: "An agency led, inventive, creative, exploratory world of understanding tech, not an assessment driven point of exploring tech … kids having fun with tech in a really productive, creative way, how could that be bad? Why would that be something we didn't want to happen? Kids finding agency and passion is super important, finding the thing that you love about technology is exciting" (Koby, 2016).

9.13 Dave Shepherd

Dave Shepherd, Director, Barclays Digital Eagle Labs.

Dave Shepherd is Director for Barclays Digital Eagles and Eagle Labs (https://labs.uk.barclays). This is an ambitious programme from Barclays Bank which aims to open a large number of 'Labs' - potentially up to 100 over the next few years (Shepherd, 2016) - in locations across the UK, sometimes in decommissioned and re-purposed bank properties. Barclays programme for Eagle Labs emphasizes tailoring each Lab to the local community, for example seeking appropriate local partners such as universities, local authorities or companies already involved with supporting maker businesses (Barclays, 2016).

Shepherd explains that the plans for Eagle Labs grew out of the Digital Eagles initiative which was, he says, "essentially this idea to help our colleagues to get more digitally savvy with what has become known now as, I suppose, 'the digital revolution'"(Shepherd, 2016). Shepherd explains the origins of Digital Eagles as: "In branches, to help us become digitally savvy and digitally confident, we would do things like 'code playgrounds' where we'd invite kids into branches and get our staff to teach kids how to do code" (Shepherd, 2016).

The need for staff to understand digital technology, in order to help customers, particularly older customers drives the programme.

> Shepherd explains: "In the tech world you get hand-me-ups. So, we were finding older people who'd been given the old phones from their grandchildren, and they were coming in with the iPhone 4 … and saying 'can you help me with this?'... we worked out the best way to learn the stuff is actually to teach it" (Shepherd, 2016).

Shepherd sees Eagle Labs, as a step on from Digital Eagles and as meeting several objectives. Firstly, operating as community makerspaces with digital fabrication technologies, such as laser cutters and 3D printers, that can be rented by the hour. Shepherd clearly sees the potential of these technologies for SME businesses and part of the attraction for Barclays is that staff, particularly Relationship Managers, get on the same page as potential new customers. Shepherd comments "We wanted get our staff onto the front foot as everybody in the UK now is starting to wake up to what a makerspace can actually do" (Shepherd, 2016).

Beyond the central offer of a makerspace, which Shepherd admits won't make any money in itself, the ambition is for business incubation; renting out space and supporting new business on the one hand, and meeting corporate social responsibility (CSR) goals on the other. The CSR comes about through local education and school partnerships, for example, teaching digital skills such as coding. Barclays is a partner in the BBC micro:bit programme and runs extensive 'Code Playgrounds'.

Shepherd is happy to see each Eagle Lab influenced by its community, by the premises and partners. For example, Shepherd says that in Bournemouth – where the Lab is located in an ex-corporate suite in an office block – as opposed to the Brighton Lab – which is on the Preston Road High Street in a dis-used branch – the user profile differs. He says of Bournemouth: "The footfall we get here is as a result of bookings through the internet, whereas the bookings that we get in Brighton are people just coming in through the door" (Shepherd, 2016).

> Shepherd adds: "It's not anything you could copy and paste across and have a stamp of exactly the same across every community. So, in Brighton, it's largely maker focused and people are coming in and making physical things to sell, in some cases for commercially viable propositions, and prototyping. Here, it's more of an education space. We have lots and lots of schools coming through here" (Shepherd, 2016).

Shepherd sees a role in standardizing and promoting best practice, for example in developing teaching modules to help in getting the best out of the BBC micro:bit. He explains: "So my job, and we do this really quickly, is to take what's really the best out of all the Labs and then nationalize that…across the distribution network" (Shepherd, 2016).

Shepherd focusses on staff becoming better able to help customers, for example to stay safe online, he adds that this is "something we have become quite evangelical about" and sees the widespread presence of Barclays in communities, and the broad customer demographic, as an opportunity to spread digital knowledge and facilities like wi-fi. He says, "Because what we've found in the bank is that our demographic across the bank in branches would mirror the demographic of society, the youngest to the oldest. And then, in the last year and a half, we've moved from digital inclusion to this idea of digital empowerment" (Shepherd, 2016).

Business incubation is clearly where there is potential for Barclays expertise and business skills to promote entrepreneurship. Shepherd says Eagle Labs intend to provide masterclasses, for example in accountancy or app development, and that businesses will benefit from "having Relationship Managers on tap, there to incubate and advise, guide, and direct entrepreneurs" (Shepherd, 2016). The interest in new business growth opportunities is reflected in the launch of 'Flight' (https://labs.uk.barclays/flight) late in 2016. This is a business accelerator programme for creative industry start-ups, including the offer of investment funding, and a 3-month residency in the Brighton Eagle Lab (Barclays Flight, 2016).

9.14 Torsten Sherwood

Torsten Sherwood, Co-founder, Noook.

Torsten Sherwood (http://www.torstensherwood.com) is a London-based designer and inventor of Noook (http://www.noook.co.uk), a construction system made out of discs that slot together to form

structures that can become almost any kind of irregular shape, allowing children, for example, to build play dens. Sherwood explains "it's designed specifically for creative play, so it's a way of building that's designed to be as open-ended as possible but very easy to use … an object to kindle curiosity, you can put it together in lots of different ways" (Sherwood, 2016).

Noook began life as a way to engage the public in making, during an exhibition staged while Sherwood was one of the Designers in Residence at the Design Museum in London in 2014. Part of Sherwood's inspiration came from his love of LEGO, Sherwood explains he thought; "wouldn't it be great to have LEGO that worked at an architectural scale" (Sherwood, 2016). Encouraged by the positive responses to the exhibition including "people asking to buy it and people saying, 'this is great'" (Sherwood, 2016), Sherwood decided to invest more time in the project and explore the idea of launching Noook as a consumer product – a toy – aimed at the 5-12 age range.

The project was accepted into the first wave of incubatees at business Hardware Accelerator Programme at Central Research Labs (http://www.centralresearchlaboratory.com) (CRL) in 2016. CRL is based in The Old Vinyl Factory in Hayes, West London, the former home of EMI, the world's largest producer and exporter of vinyl records. The Hardware Accelerator includes a programme of mentoring, technical advice, exhibitions and events, as well as access to prototyping labs and workspace (CRL, 2017).

> Sherwood explains: "The selection process was online, with essentially an outline of the business plan, you needed a physical product and a proof of concept and a business plan". He lists some of the main benefits he has experienced from joining the programme: "There is office space to work, access to workshops, a series of workshops and lectures on the fundamentals of setting-up a business, and business accounting, law, IP, investment and then you get a mentor, and you have access to experts if you have a question, you can say 'Can you please help me out with this?'" (Sherwood, 2016).

He feels he has also benefited from mixing with other incubatees. He explains: "All of us are generally from product engineering background, and a lot of people have come out of the kind of hacker or maker community. So [there is] a real interest in how things are made and getting things made is shared with a lot of people here … [helpful if] I need to get this packaging done … or I needed to figure out a way of making a quick prototype" (Sherwood, 2016).

Sherwood trained as an architect but became frustrated by the lack of hands-on making during his training and developed an interest in construction, materials and making, through furniture design. To enable him to start making he joined a makerspace "I joined a new co-work space called Create Space London" (Sherwood, 2016) where he was able to start making DIY furniture.

> Although he had CADCAM and digital skills from his architecture training Sherwood felt these needed to be balanced by physical material experience. He explains: "I could have gone out and started 3D printing stuff and I did if there was something that I could only do through the 3D printing, but I think one of the things I was doing with the DIY was that I wanted to actually experience the making myself" (Sherwood, 2016).

Sherwood has spent much of the time at CRL grappling with how to design Noook for manufacture, settling on corrugated cardboard as a material has enabled him to look at UK manufacturers, and kept costs down. Sherwood feels that designing for manufacture is one of the biggest barriers to starting a new hardware business, describing how he feels there is a need to "from the earliest stage, figure out how it's going to be made in reality and that's not something you figure out in the workshop, you've got to have knowledge of factories and manufacturing and also it's not just knowledge of manufacturing, it's that partnership and network" (Sherwood, 2016).

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