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Citation for published version:

Eaves, S & Harwood, S 2018, The emergence of makerspaces, hackerspaces and fab labs: Dewey's democratic communities of the 21st Century? in R Heilbronn & R Higham (eds), *Dewey and Education in the 21st Century: Fighting Back.*, 2, Emerald Group Publishing Ltd.

Link:

[Link to publication record in Edinburgh Research Explorer](#)

Document Version:

Peer reviewed version

Published In:

Dewey and Education in the 21st Century

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The emergence of makerspaces, hackerspaces and fab labs: Dewey's democratic communities of the 21st Century?

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Running head (up to 65 characters in length): The emergence of makerspaces, hackerspaces and fab labs

Abstract – 250 words:

A new form of learning space has emerged across the world, marking a shift from Do-It-Yourself (DIY) to Do-it-Together (DIT). This space, generically known as a makerspace, is located in accessible and affordable venues, both within communities and serving communities. It offers a resource that allows people to discover their latent capabilities through exploration, experimentation and iteration, alongside the knowledge openly shared by those around them. The underlying rationale is found in the work of John Dewey, notably *Democracy and Education* (D&E, 1916).

This chapter examines this newer form of space to gain insight into what it implies for learning and education. It commences with a reflection of salient aspects of Dewey's D&E (1916) and how this informs understanding on what is desirable in a learning space. This is followed by a reflection upon research on makerspaces to establish how they can be conceptualised. A case study provides rich insights into characteristics, ethos and practices, whilst acknowledging that each space is unique and not representative of them all. Nevertheless, it foregrounds the essence of what defines a makerspace. The chapter closes with discussion of the implications and what may be concluded.

Whatever has transpired between the publication of Dewey's D&E (1916) and the present, his vision of the empowered individual clearly manifests in the makerspace. It allows an individual to break free from the limitations of the formal educational system and as part of a social learning community, discover their potential in new, natural, non-linear and often unexpected ways. Further, and perhaps only just beginning to be understood, is its wider potential to ignite alternative approaches on how to contribute to society and catalysing new directions for the future of work. With increasing research insights alongside broadened awareness of the possibilities, individuals can gain the capability to design and build for their future - that is only limited by their capacity to imagine it.

Keywords – up to 6 which encapsulate the principal topics of the paper: makerspace, hackerspace, Dewey, experiential learning, creativity, informal education

INTRODUCTION

Traditional forms of domestic space that enable 'doing' (garages, garden outbuildings) have re-emerged as new forms of active space in communities. Hobbies and DIY (Atkinson 2005) have been transformed from something undertaken in isolation; perhaps accompanied by membership of a local or national club, to something done in a shared space – a makerspace. This represents a move towards a DIT or 'Do IT Together' ethos and approach that is self-organising, creative, entrepreneurial and interconnected.

The term 'makerspace' is an encompassing designation to denote those locales whereby members of the community are empowered to be creative and can do/make something. What was once limited in terms of resources and knowledge afforded at an individual level, has been expanded to what the community can afford. Underpinning these spaces is the nature of the learning that they foster. Learning is iterative and experimental – the endeavour to make something work, failing and learning from mistakes, all supported by peers who openly share skills and expertise.

The rationale for this community grounded and social learning experience can be found in the work of John Dewey, most particularly, in the seminal work of *Democracy and Education (D&E, 1916)*. Dewey argued against the contemporary forms of learning that required a prescriptive consumption of facts, demanded compliance and stifled curiosity and creativity. By contrast, he proposed an experiential and organic form of learning which is grounded in the everyday of the community. This resonates strongly with today's makerspaces and how participants in these settings enrich their lives, individually and collectively, through learning and sharing practices.

The chapter examines this newer form of DIY or DIT space with a view to understanding what it implies for learning and education. It commences with a reflection of relevant aspects of Dewey's *D&E (1916)* and how this informs understanding on what is desirable in a learning space. This is followed by an evaluation of research on makerspaces to establish how they can be conceptualised. A case study is then presented which provides insight into the realities of such spaces, acknowledging that each is unique and not representative of them all. Nevertheless, the case draws attention to the essence of what defines a makerspace.

The chapter closes with discussion of the implications of the insights presented and what can be concluded.

FORMALLY OR NATURALLY OCCURING EDUCATION

John Dewey's *D&E* (1916) offers a critique of the then contemporary formal educational system, which is contrasted with the informal education that arises from social engagement (Figure 1). This provides a basis for an argument which can view education in terms of something externally imposed with development in compliance to the rules of society (traditional) or something that specifically meets the needs of the learner, personal growth and preparation for membership of society (experiential).

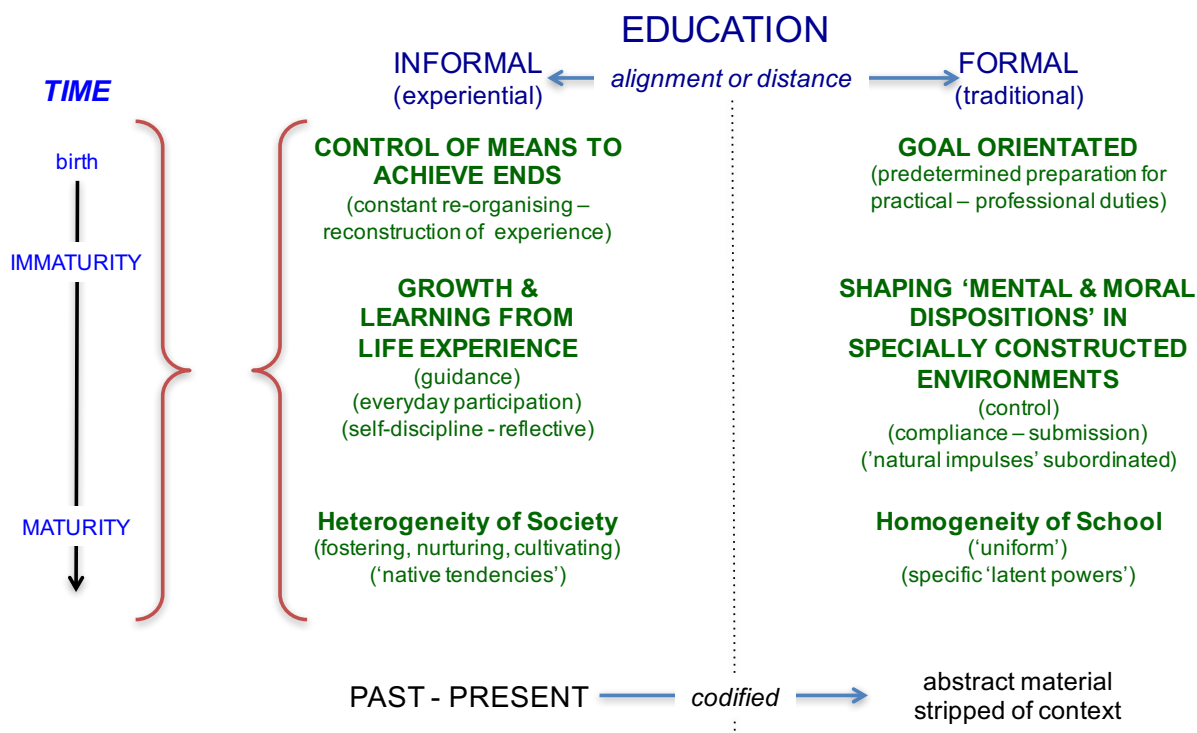


Figure 1 Education as experienced naturally in contrast to the traditional view

The traditional view of education invokes a formal process, which takes place within the specially constructed environment of the school *'with the express reference to influencing the mental and moral disposition of their members'* (Dewey, 1916: 22). The role of education is to guide, to control or to direct on a particular course. Whilst guidance supports the compliant, control is exercised upon the non-compliant, who are made to submit. This disregards natural instincts, suppresses 'obnoxious traits' and brings all into conformity and uniformity, with an aversion for novelty, progress and uncertainty. There is a 'common subject matter', codified into an abstract form and distant from the reality of 'life-experience'. Knowledge concerns the acquisition of

information, i.e. the *'body of facts and truths ascertained by others'* (ibid: 220), independent from the process of inquiry that brought it into being as material for further inquiry. The use of knowledge is therefore mechanical. Within this view, the aim of education is to prepare children for society through the development of specific latent powers (e.g. perceiving, retaining, recalling) to accomplish 'practical and professional duties'. Through repetition in practice the mind can be trained. It serves the goals of a higher body, that of the state?

In contrast, Dewey presents an experiential orientated view of education. Learning as part of the experience of being a member of a community. Education is a social function: *'the education which everyone gets from living with others'* (ibid: 7). In this sense, education is informal and supports personal growth, which commences at birth. 'Immaturity' is the 'ability to grow' and learn from experience. Education enables people to develop both an intellectual disposition and the ability to handle novel situations, adapt to changes and continually grow. It is surmised that, if life is development, then growth (development) is life. Thus, the educational process is its own end; it is one of *'continual reorganizing, reconstructing, transforming'* (ibid: 59). Thus, it can be argued that education does not end upon leaving school, but should be ongoing, learning from life itself with the 'finest product of schooling' being the making of *'conditions of life such that all will learn in the process of living'* (ibid: 60). Education is not about *'telling' and being told, but an active and constructive process'* (ibid: 46). It involves 'fostering', 'nurturing', and 'cultivating', but, this draws attention to the conditions in which this growth takes place, i.e. those conditions *'that promote or hinder, stimulate or inhibit'* (ibid: 13). These conditions involve others so constitutes the social environment, which is educative by virtue of how it shapes behaviour.

Experience and reflection are important features of education. Experience is 'trying' (ibid:163) where, through experiment, meaning is made explicit, i.e. is active. Alternatively, experience is 'undergoing', something is done which does something in return, by which we undergo the consequences of our action, i.e. is passive *'when the change made by action is reflected back into a change made in us, the mere flux is loaded with significance. We learn something'* (ibid 163). Meaning emerges as a consequence of our actions. Both imply learning. However, *'mere activity does not constitute experience'* (ibid: 163). This reveals the importance of 'reflection', which relates to how we discern the relationship between *'what we try to do and what happens in consequence'* (ibid: 169). In experiences characterised by experimentation

(‘trial and error’), different things are done until it works, which then becomes the ‘rule of thumb’ method for subsequent actions. Through our reflection (intentional thought) about our experimentation, we make explicit the ‘specific connections’ between what we do and the resultant consequences.

This results in Dewey’s proposal about how these insights into an informal experientially orientated education can inform a formal educational experience (Figure 2).

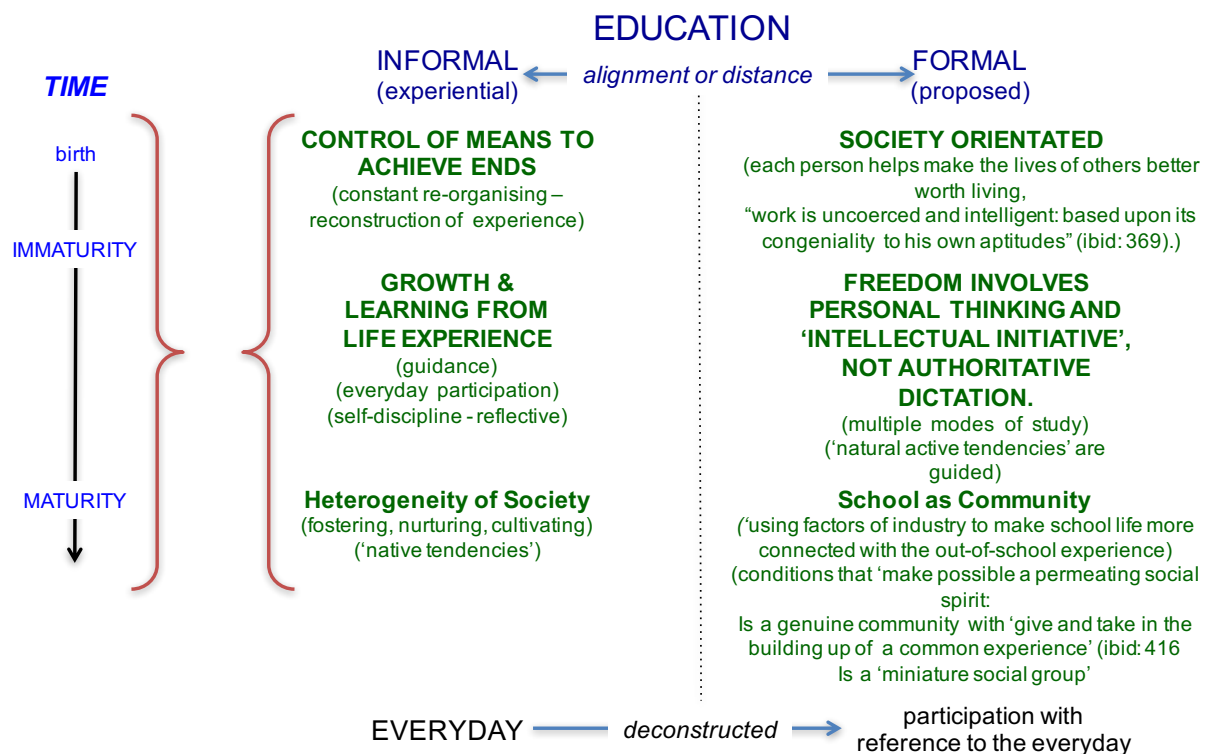


Figure 2 Education as experienced naturally and its feed into a formal setting

Dewey concludes that the key to the ‘present educational situation’ is to reconstruct the ‘materials and methods’, ‘relegating’ literary approaches (e.g. textbooks) to ‘necessary auxiliary tools’. This implies embedding what goes on outside school into the curricula, and not viewing school as a vehicle to technically prepare students for work:

The problem is not that of making the schools an adjunct to manufacture and commerce, but of utilizing the factors of industry to make school life more active, more full of immediate meaning, more connected with out-of-school experience (ibid: 369)

The aim is to allow people to develop into valued members of the community:

It signifies a society in which every person shall be occupied in something which makes the lives of others better worth living, and which accordingly makes the ties which bind persons together more perceptible -- which breaks down the barriers of distance between them. It denotes a state of affairs in which the interest of each in his work is uncoerced and intelligent: based upon its congeniality to his own aptitudes (ibid: 369-370).

The emphasis is upon the ability to use knowledge in doubtful situations and thereby deal effectively with problem situations. Thus, the instructor should be less concerned with the subject matter and instead be more focused on how the learner is engaging with the material. Further, it is important to learn from the past, but a past not disconnected from the present: ‘...knowledge of the past is the key to understanding the present... [with the] true starting point of history is always some present situation with its problems’ (ibid 251). This draws attention to the ‘permeating social spirit’ underpinning how the school is administered, the curriculum and its methods of instruction. This requires the school to be a genuine community, a ‘miniature social group’. There is ongoing entanglement between school and out-of-school with a common social life as opposed to ‘*The proverbial separation of town and gown, the cultivation of academic seclusion, operate in this direction*’ (ibid: 416).

At the heart of this enterprise is the concept of democracy. Dewey’s view of the role of democracy in education is captured in the statement whereby democracy is:

a mode of associated living, of conjoint communicated experience. The extension in space of the number of individuals who participate in an interest so that each has to refer his own action to that of others, and to consider the action of others to give point and direction to his own, is equivalent to the breaking down of those barriers of class, race, and national territory which kept men from perceiving the full import of their activity (ibid: 101).

Activity is considerate and respectful to others; it is accessible, inclusive and participatory, orientated towards shared social goals. This social element pervades education. Education is about the ‘*freeing of individual capacity in a progressive growth directed to social aims*’ (ibid: 115). It is orientated to enabling ‘*an individual to make his own special contribution to a group interest, and to partake of its activities in*

such ways that social guidance shall be a matter of his own mental attitude, and not a mere authoritative dictation of his acts' (ibid: 352). In this sense, education is not about authoritative dictation, rather that the individual has freedom to engage in personal thinking and 'intellectual initiative', but within a social context.

NEWER FORMS OF SPACE – THE MAKERSPACE

There is no definitive definition of a 'makerspace' reflecting its heterogeneous dimensions and newness of spatial form. It is not a word found in the Oxford English Dictionary. Moreover, definitions in scholarly materials are rare. Sleigh, Stewart & Stokes (2015) define a makerspace as:

an open access space (free or paid), with facilities for different practices, where anyone can come and make something (ibid: 2)

However, this is a very generic statement which reveals little about those who are 'anyone' and why they have an ongoing engagement. Instead, it is to the practising makerspace community that one needs to turn. An online search reveals the website www.makerspace.com. This explains that a makerspace is:

... a collaborative work space inside a school, library or separate public/private facility for making, learning, exploring and sharing that uses high tech to no tech tools. These spaces are open to kids, adults, and entrepreneurs and have a variety of maker equipment including 3D printers, laser cutters, cnc machines, soldering irons and even sewing machines... It's more of the maker mindset of creating something out of nothing and exploring your own interests that's at the core of a makerspace... Makerspaces are also fostering entrepreneurship and are being utilized as incubators and accelerators for business startups. www.makerspaces.com/what-is-a-makerspace/ [accessed 19th March, 2017]

It also presents over fifteen other definitions, drawing attention to activities such as build, create, 'make meaning', risk-take, craft, tinker, wonder, experiment, collaborate, explore and socialise. A further online search reinforces this diversity of interpretation with additional operative concepts including: dream, fail, problem solve, innovate, share and play. The message is that, since such spaces are so diverse, then it is perhaps unproductive to attempt a precise definition of makerspace. Instead, it is

considered more important to think of makerspaces in terms of a physical space, operated collectively, in which people do things in accord to the spirit created for the space, irrespective of what this is called (e.g., hackerspace, hackspace, fablab, techshop, repair café, refab space).

This is a space with an ethos that is liberating not conformist, as well as social and non-judgemental. Individuals can be true to themselves in what they are doing, working with people they can trust. Venue is important in the sense of how it shapes the learning of those engaged in the space. Whilst a hackspace in a rented property may support informal learning, exploration and the making of mistakes, an institutional setting may impose a more structured approach (Halverson & Sheridan, 2014; Hsu, Baldwin & Ching, 2017). Lande & Jordan (2014) categorise the different types of makerspaces as: shared co-working, collaborative clubhouse, library community centre, school innovation space, science museum for informal education and for-profit shops (e.g. TechShop)

Further, the interplay of the physical space with the affordances of Web 2.0 should not be overlooked and moreover, can be considered a key contributor to their growing global reach and development. The majority of makerspaces operate with a parallel online virtual environment (Eaves 2014a, 2014b, Davies, 2017) which may include websites, social media pages, image sites (e.g. Flickr) and wikis. These typically provide advice to would-be makers on starting new spaces, and make public key information on current projects, events, membership options and opening hours for those already operating. They also provide key conduits for makers within a space, or across spaces, to communicate, make decisions and share design schemas. The core communication devices are email listings, often split into multiple lists grouped by the nature of the discussion (finance, event planning etc) and which enable a continuation of in person conversations and use of the IRC – internet relay chat.

The transformational nature of makerspaces has led to the proposition that they characterise a ‘new industrial revolution’ (Gershenfeld, 2012) which connects to broader developments in society. Naboni & Paoletti (2015) claim that this is the ‘third industrial revolution’; the first industrial revolution characterised by mechanisation, the second by mass production, whilst the third is ‘*characterized by affordable manufacturing tools connected to the internet*’ (ibid: 16). Whilst the 20th century saw the democratization of information, Bull et al (2010) propose that the 21st century

symbolises the '*democratization of production through personal fabrication*' (Bull, Maddox, Marks, McAnear, Schmidt, Schrum, Smaldino, Spector, Sprague, & Thompson, 2010: 331).

A comparable view is presented by Fox (2014), which views the makerspace and previous developments in terms of their Do-It-Yourself (DIY) aspects. The first wave (subsistence DIY) reflects what is grown and made, without recourse to markets. The second wave (industrial DIY) is characterised by bought kits for self-assembly (e.g. furniture). The third wave (new DIY or DIT) exploits the functionality of online digital domains with their interactional capability and the mobility of newer digital forms of production technologies (e.g. 3D printing) . This is a field of rapid emergence - 4D printing adds the additional dimension of time, enabling users to build from multiple materials with parts able to transform from one shape to another on their own. The capacity to self-assemble, self-fold and shift shape offers an array of new opportunities for DIY and DIT personalised manufacturing alongside new conduits for their distribution (Mao at al. 2015).

Whilst first wave DIY emphasised production for self-consumption, the second wave is characterised by pre-designed goods, lack of access to production capability and limited technical knowledge. The third wave is characterised by sophistication in knowledge, accessible production technologies and entrepreneurial opportunity, though its financing can present a challenge. Within the educational community (e.g. schools, museums, libraries) makerspaces may encourage interest in STEAM (science, technology, engineering, arts and mathematics) (Halverson & Sheridan, 2014; Vossoughi & Bevan, 2014; Bevan, Gutwill, Petrich, & Wilkinson, 2015; Hsu, Baldwin & Ching, 2017). Further, their discursive nature and the capacity to advance thinking is emphasised in Brooke's description of such spaces as the '*digital-age equivalent of the English Enlightenment coffee houses*' (Brooke, 2012: 22).

Makerspaces have emerged in a variety of established venues: public libraries (Slatter & Howard, 2012; Boyle, Collins, Kinsey, Noonan & Pocock, 2016), schools (Blikstein, 2013; Vossoughi & Bevan, 2014; Halverson & Sheridan, 2014), universities (Barrett, Pizzico, Levy, Nagel, Linsey, Talley, Forest, & Newstetter, 2015; Burke, 2015; Wong & Partridge, 2016; Shapiro, 2016) and museums (Bevan, Gutwill, Petrich, & Wilkinson, 2015). This reflects the growing awareness of the potential for public spaces to attract members of the local community. They provide opportunities for co-

creation and knowledge sharing ('open design') (Neves & Mazzilli, 2013) as well as for professional development (Paganelli, Cribbs, Silvie'Huang, Pereira, Huss, Chandler & Paganelli, 2016) and entrepreneurship (Mortara & Parisot, 2016, 2017). However, these spaces have been questioned with regard to barriers to women giving rise to gender bias (Lewis, 2015; Richards, 2016) as well as having limited accessibility for the disabled (Brady, Salas, Nuriddin, Rodgers & Subramaniam, 2014). To add are debates on whether makerspaces contribute to sustainability and, if so, how they do so (Maldini, 2015; Nascimento, Pólvora, Paio, Oliveira, Rato, Oliveira, Varela & Sousa, 2016). Particular type of events associated with makerspaces are hackathons and Maker Faires (Dougherty, 2012; Johnson & Robinson, 2014; Komssi, Pichlis, Raatikainen, Kindström & Järvinen, 2015; Irani, 2015; Criado & Otárola, 2016). Whilst the latter offer opportunities for people from different makerspaces to share, the former are intensive experiences where, over a few days, groups of people can creatively address specific challenges. This introductory overview of makerspaces highlights some of the core discussions about their inclusivity and how the concept of a makerspace has shifted from an exclusive domain for like-minded persons into a more inclusive community through public venues. More importantly, it hints at the diversity that characterises the makerspace community.

This diversity is revealed further in a detailed empirical study of the 97 UK makerspaces identified at the time, conducted by Sleight, Stewart & Stokes (2015), which led to a publically available rich dataset (NESTA, 2015). Our analysis of this dataset suggests that there is a generic conceptual model which characterises these spaces (Figure 3). Central is the notion of a space which is occupied with the facilities, tools, materials and people that combine to support the activity of the maker, typically complemented by the affordances of virtual space.

Second is the manner in which the space is controlled or regulated (i.e. governance) drawing attention to such issues as funding (e.g. sponsorship or membership fees), management (e.g. legal structure) and ownership (i.e. influence upon activity or ability to withdraw space) - each of which play a role in the survival of the space and its development over time. Third is the relationship between the local community and the space and whether there are explicit or veiled issues about who can and cannot become a maker. Finally, is the nature of the experience itself (e.g. empowering, learning, making, socialising) and the norms that govern what is and what is not acceptable. Collectively this creates the culture – the defining spirit in

which learning and creativity is encouraged to foster and what this might lead to. Identity and ideology is central in this determination of what a space is and what it may evolve to, establishing its uniqueness.

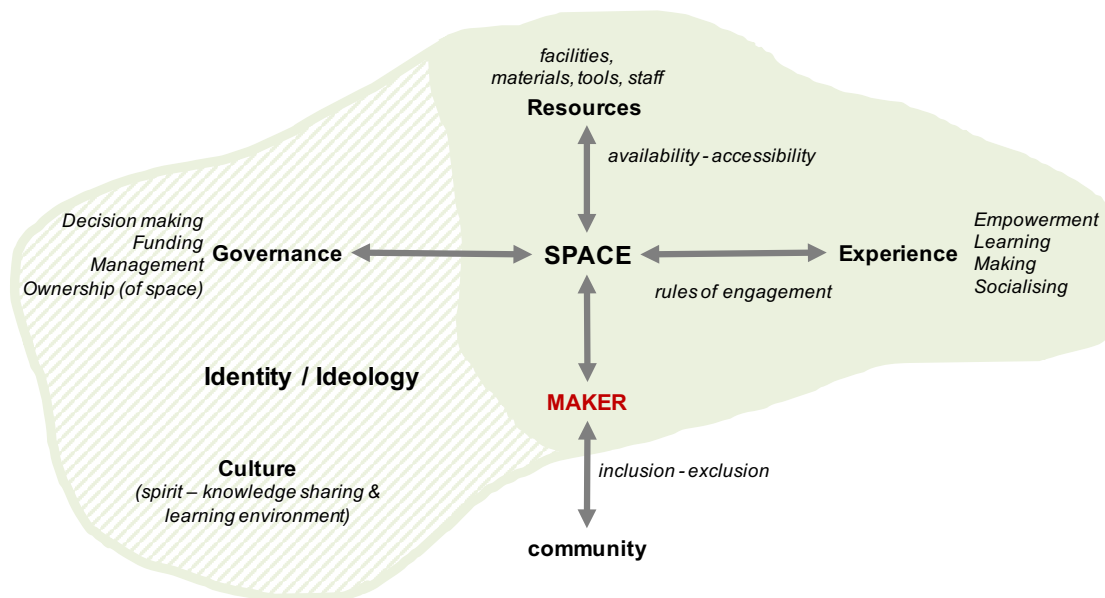


Figure 3 Conceptualising makerspaces (based upon analysis of NESTA, 2015). (the solid area denotes the space of an individual within the collective space of the makerspace – semi shaded area – characterised by its identity, culture and governance mechanisms)

CASE STUDY

The object of this longitudinal study is urban and well established makerspaces across the UK, with more recent expansion into developing nations. The aim is to provide insight into the characteristics, ethos and practices of these spaces, notably in respect to the nature of the individual and social learning experiences that can be fostered, and their implications for more formal learning environments. It offers an accumulative and reflective account of the empirical mixed methods research undertaken, alongside active participation as a mentor in several settings. The approach is considered highly illustrative of the heterogeneity of the community, with experience gained in independent spaces located in the creative quarter of a city, to spaces embedded or affiliated to a university or council regeneration program.

Thematic vignettes are drawn from this depth and breadth of research and experience as gained over more than 5 years, endeavouring to enable the voices of the participants to be foregrounded and elucidating the core realities of such spaces, whilst acknowledging that each is unique. Drawing on “*experience-near*” methods

(Estrella & Forinash, 2007: 382) and in the spirit of Dewey, this approach also responds to increasing calls to '*relocate academic inquiry within the realm of local, personal, everyday places and events*' (Finley. 2008: 72).

Particular focus is afforded to Access Space (2017) in Sheffield, given its pivotal role and pioneering position within the UK, first opening in 2000 and remaining the longest running and open access media lab in the country. There are no cost or entry requirements for interested participants – it is available so that *anyone can take part*, perhaps making this one of the purist forms of makerspace observed to date. Indeed, operating under registered charity status by volunteers and with a keen interest in local social action outcomes, 50% of participants at activities run at the space have been in '*danger of exclusion and are on the margins of society*'. Access Space provides resources and skill development across a spectrum that includes open source software, web development, photography, art, audio/visual digital skills and fabrication, notably 3D printing and laser cutting.

The second space drawn on in depth is Bristol Hackspace (2017) which was founded in 2009 as a limited company before becoming a social enterprise in 2011. Its stated aim is to "*open up technology to anybody who takes an interest in it*". In common with Access Space, this lab is committed to an ethos of encouraging making and unmaking to understand how things work and to the open sharing of the knowledge gained in doing so. In contrast to Access Space, aside from a weekly public open evening, a monthly subscription (typically £10-20) is required to become a member with 24hr access to the hackspace. Activities are primarily individual and project based and cover areas such as electronics, robotics, metalwork, woodwork, bike maintenance and crafts, particularly knitting and jewellery making. Strong links are maintained with local technology groups and the wider hackspace community.

The Nature of Learning and a Space to 'Be'

After the triangulation of a depth and breadth of data sources, it is the nature of learning, unlearning and open knowledge sharing that emerges as the central characteristic and enduring ethos of all makerspace forms. Indeed, the nature of the space itself can provide a conduit to becoming for its participants. Knowledge is shared primarily peer to peer, within a highly active, engaged and constructive local community. This can create a virtuous circle of learning as elucidated by one Access Space member 'it is incredible to observe the 'newbie' participant evolve to be a

mentor themselves – a richly empowering experience’. Knowledge does not develop via a mechanical, linear or formal process towards very specific end goals, but by contrast, is typically a cumulative experience, acquired in a natural, informal and explorative way through iterative practices of making, taking apart and trying again:

I try something and fail, I tinker a while, change some aspects of the set-up and try again the result may not be what I expected but I will notice something else instead and run with that..... it's so often a surprising new direction with expanded possibilities. Yes, that's the best way I can describe what it's like learning here... It's all about being free to experiment, to tweak, its fine to fail!!!! Just be curious, ask questions but always seek to find out the why yourself and keep on moving forward - sharing what you find along the way (Bristol maker)

This reflects how an individual's development can be embedded within the active and facilitative social learning that is taking place as part of the everyday experience of being a community member. The processes of inquiry and of creation are as critical, if not more so, than the actual physical artefact/outcome that may be produced. As one contributor stated *'My ideas just seem to flow better, things come together when I am working and reusing materials, reshaping and reconstructing them'*. In essence, this describes an opening up of opportunity to explore, to experiment, to make and unmake, to build connections and ultimately, to make meaning of the very experience of doing itself. This ethos is exemplified in the 3D printed signage found at Access Space below (Figure 4).

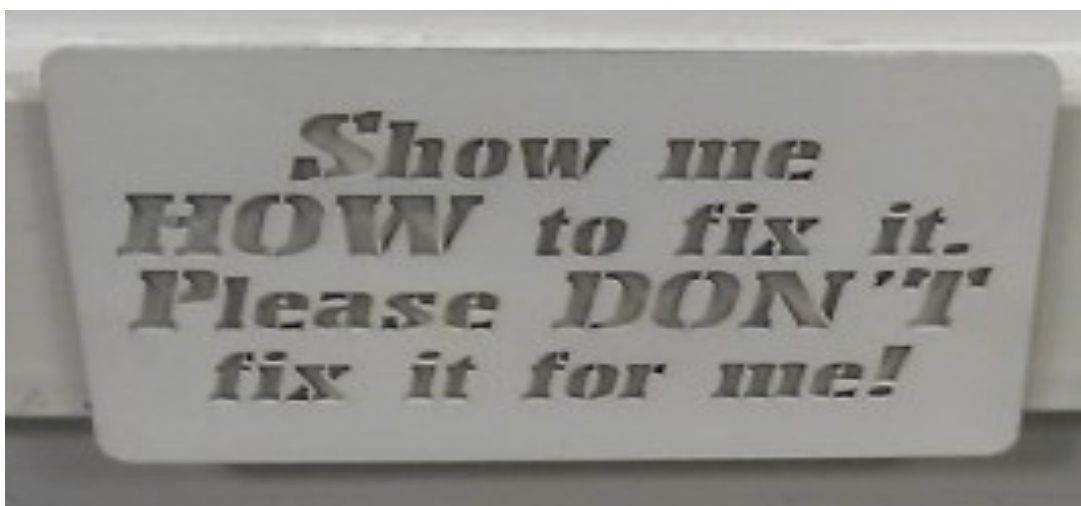


Figure 4 Signage from Access Space Main Lab

This acquisition of knowledge and expertise alongside personal growth acquires further legitimisation from the prominent and everyday display of participant artefacts in many spaces. At Access Space, this is taken a stage further with dedicated exhibition evenings. These are occasions where contributors have literally taken an identical blank canvas and transformed it in any way that *'mattered to them'* as illustrated in Figure 5. Both forms of showcasing make a difference - this is not a case of *'art for art's sake'* (Abrams & Harpham 2009: 4). The artefacts highlight the individuality of participant works: *'their interests, their creativity and their priorities, congruent with a do-ocracy ethos'* (Chen 2009: 55). Further, meaning can be elaborated collectively within a social context, the intersubjective process of which can also support empowering participant transitions often associated with their sense of identity. As one participant stated, *'I never saw myself as an artist at all, nobody else would give me this opportunity. I can now say I have exhibited!'*

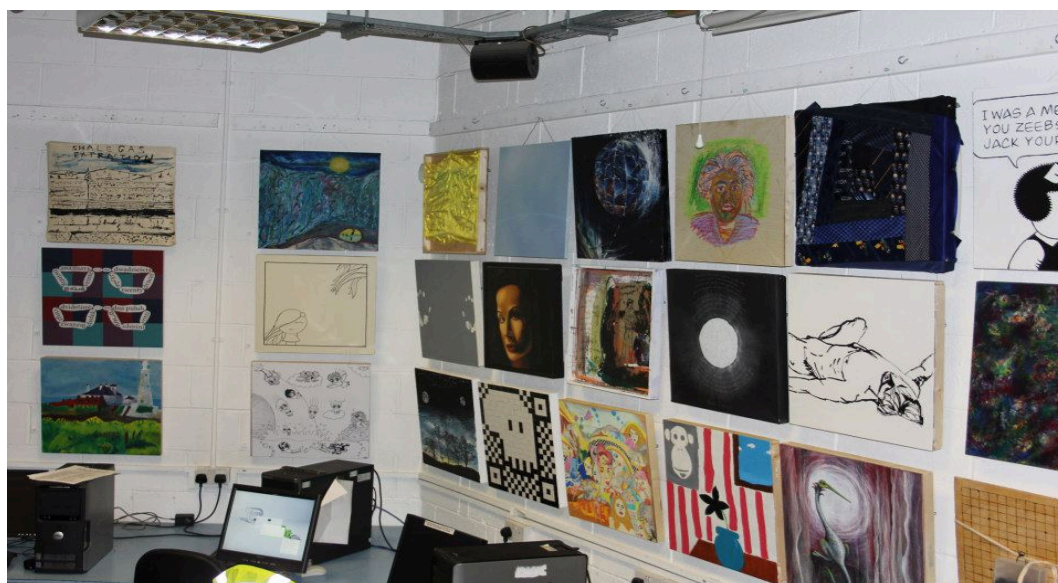


Figure 5 A 20x20 Canvas Exhibition at Access Space

Finally, the very nature of space is brought into sharp focus. With regards to physical design, features such as clearly identifiable activity zones, connective walkways to enable easy flow between areas and provision of informal seating can facilitate a balance between individual quiet working and opportunities for socialisation and creative discovery which can *'bring the unexpected together'*.



Figure 6 A Quiet Zone at Bristol Hackspace

These spaces are much more than a specific local setting and its practical affordances however, or even the virtual space that typically provides ongoing global support. It is the people within the makerspace and their shared sense of purpose which defines what a particular setting is all about, how it operates and the ways in which it can evolve over time. This can also prove an area of tension where a founder member(s) retain strongly held views regards the ideology of a space and who can or cannot participate – yet a burgeoning community and the impact of new members may evolve the character, focus, aspirations and overarching trajectory.

This tension is evidenced on and offline, most explicitly via open discussion threads that provide a rich window into the development of these issues, and different approaches to mitigate them over time. Access Space for example was open to work alongside researchers to help surface the key themes and build towards a consensus regards its underlying superordinate goal, whilst debating areas such as governance, structure and roles (Eaves & Walton 2013). Today Access Space foregrounds inclusivity, bringing people from different backgrounds together to share and develop skills, working on creative, enterprising and technical projects. The founder left to establish a new making centre in the same city combining craft shop, facilities such as laser cutting and evening skills workshops, run by the crafters themselves.

Space therefore has highly emotive, cognitive, reflective, identity linked and ideological dimensions which change with time and experience. It is associated with shared ownership and self-permission, with the cumulative voices of participants

suggesting that it scaffolds the process of “letting-go”. Indeed, it is clear that makerspaces are highly liminal (Küpers 2011) – offering a place to transition, to become and to simply just be.

Nothing about our space is fixed or final – our future is driven by our members, by us. We are what we are because of the people here and we will grow as our people do (Long term Bristol participant).

DISCUSSION & CONCLUSION

The case study reveals a particular form of space (makerspace) that breaks with the formal educational spaces that comprise today’s schools, colleges and universities. Implicit is a form of learning that contrasts with the more traditional forms of education found in these formal settings. These newer forms of space are characterised by access to both resources and pools of knowledge, but of a form and use different from existing formal locales. Resources are not those typically found in formal spaces (e.g. texts) that are geared to the requirements of institutional educational demands, but instead, offer facilities to make things which cater to more personal motivations (e.g. 3D printer, laser cutter). The pools of knowledge are not those in authority whose role is to educate, but rather, comprise the members of the community that constitute the space, where knowledge is openly shared as required.

Conditions have been created in these spaces to foster inclusivity, accessibility, sharing, opportunity and discovery of self. Importantly, these spaces are embedded in their local community. Like the formal spaces, these newer settings highlight the importance of learning, but in an informal and organic manner. Learning is by trying, tweaking, experimenting, fusing and failing, with no judgement nor recrimination. Opportunities to explore one’s (unconventional – impossible) ideas can lead to a transformation of self – the creation of something not thought possible and the realisation of achievements. Exhibition of these achievements enables this discovered self to be better understood and expressed. These issues are revealed in figure 3, where the space is the point of confluence whereby members of the community can engage with each other in shared experiences, and individuals can realise their self. However, no two spaces are the same. Each has a unique identity shaped by the way in which the space is owned, funded and managed (Governance) and the underlying Ideology that guides how things are done (Culture).

This insight into the nature of makerspaces appears to strongly resonate with Dewey's distinction between the formal traditional schooling system and how it may be informed by the more natural experience grounded approach that typifies informal out-of-school learning. A makerspace is an experientially orientated learning environment, which should comprise a genuine maker community entwined within the larger community. It should be a safe trusting space, with a social spirit, where, though the sharing of expertise, people can make possible their imagination. It should allow personal development, so can foster education, but of a highly applied and engaged nature, with the maker active and constructive in trying to make things work – continually experimenting, reflecting, and learning from mistakes. It is a mode of inquiry or a form of research, where trial and error are the norms in the search for a solution to whatever it is that is being attempted. Most importantly, it should be a democratic space that is accessible, inclusive and participatory, with its participants being considerate, open and respectful to others. It allows for the breakdown 'of those barriers of class, race, and national territory' (Dewey, 1916: 101).

The implications of the insight provided by Dewey's *D&E* (1916), the literatures relating to makerspaces and the case study itself are three-fold. First, the implications for formal educational institutions. The growing recognition of the value of makerspaces has resulted in their emergence in schools (Blikstein, 2013; Vossoughi & Bevan, 2014; Halverson & Sheridan, 2014), colleges and universities (Barrett, Pizzico, Levy, Nagel, Linsey, Talley, Forest, & Newstetter, 2015; Burke, 2015; Wong & Partridge, 2016; Shapiro, 2016). However, do these offer a complement to the more traditional curriculum or should they be embedded as part of the curriculum? For example, makerspaces can provide facilities to do things that can be related to project and coursework and naturally support inter-disciplinary learning.

Second, Dewey makes the distinction between the development of a person's latent powers to accomplish 'practical and professional duties' and the development of the independently thinking individual, as a member of a community. The makerspace offers the individual the opportunity to engage in learning to make something using the latest of technologies, which has the possibility of providing self-employment. Whilst makerspaces can satisfy personal interest, they also offer entrepreneurial avenues to sell and scale what is built (Mortara & Parisot, 2016, 2017). Are makerspaces the incubators of the 'third industrial revolution' (Naboni & Paoletti, 2015) which can thereby play a pivotal role in the much debated, future of work itself?

The third issue relates to inclusivity. A perennial concern relating to science and technology fields is the perceived exclusivity of these domains to women – they remain male dominated environments (UNESCO 2017). This can extend to makerspaces with their hands-on orientations utilising newer forms of technology as discussed by Lewis (2015) and Richards (2016). As community embedded ventures, such as in public libraries (Slatter & Howard, 2012; Boyle, Collins, Kinsey, Noonan & Pocock, 2016), museums and schools, by virtue of these being inclusive community spaces, they offer the opportunity to break down this perceived exclusivity and encourage, not only women and girls, but others from disadvantaged social groups, to engage in science, technology, engineering, arts and mathematics (STEAM) activities (Halverson & Sheridan, 2014; Vossoughi & Bevan, 2014; Bevan, Gutwill, Petrich, & Wilkinson, 2015; Hsu, Baldwin & Ching, 2017).

To conclude, whatever has transpired between the publication of Dewey's *D&E* (1916) and the present, his vision of the empowered individual clearly manifests in a space perhaps not envisaged by Dewey. This space, the makerspace, allows an individual to break free from the limitations of the formal educational system and as part of a social learning community, discover their potential in new, natural and perhaps unexpected ways. This raises an important point to reflect upon – are these new learning spaces becoming the catalysing incubators of a new renaissance for prosumers and for a democracy of production? If this is the case and with increased awareness of these spaces, individuals have a capability to design and build for their future that is only limited by their capacity to imagine it.

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