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Abstract

Purpose
In order to start to explore the possibilities for makerspaces as a new learning space within Academic Library services in Higher Education (HE), this original research study ask two key questions:

1) How is learning achieved and supported in makerspaces?
2) What can Academic Library services bring to the effective organisation and support of makerspaces?

Design/ Methodology/ Approach
An extensive literature review is followed by a Template Analysis (King, 2012) of data from an online forum of three professionals operating makerspaces in Academic Library services in the US, and a discussion incorporating relevant educational theory and philosophy.

Findings
The three overarching learning themes found were: Experiential Learning (Dewey, 1909; Kolb, 1984), Communities of Practice (Lave and Wenger, 1991) and Self-efficacy through social learning (Bandura, 1997).

Research limitations/ implications
The one week forum of three professional library staff provided detailed and informative data. Substantial field work with students will also be required to see how far this professional lens has provided insight into how students are learning and supported in these and other makerspaces.

Social implications
The wider cultural implications are examined, including the potential social value of makerspaces as transformative creative spaces empowering communities and individuals.

Originality/ value
This is the first study to date on the potential educational value of makerspaces within HE, and the specific support Academic Library services can offer if they choose to host a makerspace (including teaching Information, Digital and Critical Literacies).

Makerspaces: A beneficial new service for Academic Libraries?

Introduction

This research has been carried out in order to start exploring how learning is achieved in makerspaces, and how these largely self-directed learning environments can be effectively supported by Academic Library services within a Higher Education (HE) context. In the UK makerspaces are an emerging phenomenon with some UK universities such as Cardiff, Falmouth, Strathclyde, Kent, and University College London (UCL) having developed these technology based community workspaces (but not within the library service). This initial exploratory research piece incorporates a literature review of contemporary research on makerspaces, an interpretation of data from the life-worlds of a small sample of professionals working in Academic Library services in the US which host and support makerspaces, and a hermeneutic discussion incorporating the thoughts and insights of relevant educationalists and philosophers to try to understand the potential of this emerging phenomenon better. The two key research questions used in the literature review and original research are pertinent to HE Academic Library services in the UK and elsewhere who may be considering getting involved in running a makerspace, and should also be of interest to educators of all kinds, and library services outside of HE:

1) How is learning achieved and supported in makerspaces?

2) What can Academic Library services bring to the effective organisation and support of makerspaces?

Literature review

1) How is learning achieved and supported in makerspaces?

Makerspaces, a relatively recent phenomenon popularised by Dale Dougherty and his company Maker Media, are a community workspace where people can come and experiment with technologies including computers, machining and digital art to create whatever they want. Makerspaces are a growing phenomenon with over 500 established world-wide (Schrock, 2014) including approximately 100 in the UK (Sleigh, Stewart and Stokes, 2015) that has developed in communities, and subsequently museums and libraries: “The Makerspace is the more DIY-oriented cousin of the hacker-space” (Willingham and De Boer, 2015, p.2). The maker movement (which has its own manifesto: “Making is fundamental to what it means to be human. We must make, create and express ourselves to feel whole” (Hatch, 2014, p.1) incorporates Maker Faires showcasing innovative products often developed in makerspaces using older technologies (e.g. typewriters, cassette tapes, old floppy disks) as well as newer platforms (such as Raspberry Pi, Arduino, Galileo, Linux, Android and 3d printing), and often utilising crowdfunding to further development. Although “success” is not essential to learning in makerspaces, there have been many examples of innovative new technologies that have been created (e.g. Kraft, 2014, Make magazine: “Newborn Incubator Helping Save Premature Babies in Rural Villages”). In America the Maker Movement has been supported at Government level (as evidenced by the White House Maker Faire June 18th, 2014).

Sheridan, K. et al. (2014) “Learning in the Making: A Comparative Case Study of Three Makerspaces” (US research on two community based makerspaces and one in a museum) use an ethnographic methodology to view makerspaces as “informal sites for creative production in art, science, and engineering” (Sheridan et al., 2014, p.505). Lave and Wenger’s (1991) concept of “Communities of Practice” is used productively by Sheridan et al. (2014) as a way of focusing on the process of learning in the informal environment of

makerspaces, emphasising how learning can occur through social interaction in communities of shared interests. Sheridan et al. use Communities of Practice as a concept to show aspects of makerspaces in a positive light with "*making*...the shared domain" (Sheridan et al., 2014, p.509). Statements from participants in the Mt. Elliot makerspace suggest the learners' self-identity can be positively strengthened through participation in the makerspace, with a degree of increased self-efficacy being shown (Sheridan et al., 2014, p.518). Despite the differences in learning activities in the different spaces, with a mixture of short and long term projects, solo and group work, they conclude that certain key themes emerge in their study: multidisciplinarity, the blending of formal learning and Communities of Practice and a "focus on learning as production rather than mastery of a composite set of skills." (Sheridan et al., 2014, p.526).

The mix between formal and informal learning by doing is part of the account of Educause Learning Initiative report: "7 things you should know about Makerspaces" (2013), as is the multidisciplinary aspect. In terms of learning styles this report highlights the self-directed learning opportunities for people that learn best by doing. This learning by doing aspect of makerspaces is also reflected in an interesting connection made by Schrock (2014) between the philosopher and educational reformer John Dewey's thoughts on the importance of social experiential learning through empirical observation, problem solving and enquiry in a playful interdisciplinary environment (Dewey, 1909), and the possibilities that makerspaces provide: "maximizing individualism while encouraging collaboration" (Schrock, 2013). Dewey emphasised the importance of practical experiential student oriented learning, uniting the division between knowledge and action: "the science and philosophy of education can and should work together in overcoming the split between knowledge and action, between theory and practice, which now affects both education and society so seriously and harmfully." (Dewey, 1964, p.19). The most well-known contemporary learning theory concerned with experiential learning is Kolb's Learning Styles and Experiential Learning Cycle (1984), which is in part influenced by Dewey's focus on learning through experience with no fixed limits: "Ideas are not fixed and immutable elements of thought but are formed and re-formed through experience..." (Kolb, 1984, p.26). Kolb's "Experiential Learning Cycle" (1984) identifies four stages in the learning process: Concrete Experience/ Reflective Observation/ Abstract Conceptualisation/ Active Experimentation. Makerspaces seem to offer a particularly strong opportunity for experiential learning for a hands-on "Accommodating Learning Style- doing and feeling" (Kolb, 1984). As a well-established learning theory Kolb's take on experiential learning has been extensively criticised (e.g. arguably the cycle could occur in a different order, or with stages occurring simultaneously), but more field research may benefit from this theory as a starting point for a closer look at how participants are learning in a particular makerspace.

A more idealistic take on makerspaces as a cultural phenomenon is presented in the Royal Society of Arts (RSA) Action and Research Centre's research report based on a mixed methodology of desk research, data mining, expert discussions, interviews and visits to 12 UK makerspaces (Dellot, 2015): "We argue that the act of making is one means of regaining mastery over technology- not just because it enables us to be more self-reliant but also because it can boost our sense of agency." (Dellot, 2015, p.5). Self-fulfilment, learning and enterprise are seen as potential positive outcomes for the engagement with technology that occurs in makerspaces. Makerspaces are seen as way of connecting in a more positive and human way with technology where we use our agency to learn and achieve mastery, potentially resisting the inevitability of more dystopian predictions such as a future where many more jobs become automated (e.g. Frey and Osborne's (2013) prediction that in the next thirty years 47 percent of occupations will be automated to the extent they no longer exist for humans is cited). Positive benefits of makerspaces are outlined including socialising, increased well-being through the creative process, learning through more formal scaffolding including introductory classes for technologies such as 3D printing and Arduino, and more targeted skills based projects such as the "Digital Skills for Women" highlighted

from the MadLab in Manchester (Dellot, 2015, p.27). In conclusion Dellot makes the strong claim that the “practical projects” and “tangible impact” of makerspaces, in contrast to expressive manifestations of discontent with the current capitalist model such as the Occupy movement, may be “a new institution through which to reimagine capitalism.” (Dellot, 2015, p.45).

Although much of the literature is positive about the educational and social possibilities of makerspaces, this literature review did highlight a number of cautionary points about how far reaching the benefits of this phenomenon might be. Despite the idealistic nature of the RSA report current issues are not ignored, including financial pressure, environmental issues and engaging “with particular demographic groups, notably women.” (Dellot, 2015, p.7). Some concern is raised about how ethical makerspaces will be unless strong ”collective leadership” addresses issues such as sustainability with the materials used, legal issues around the tension between creative commons and intellectual property rights, and ongoing health and safety concerns (Dellot, 2015, p.44). Holman (2015) looks at makerspaces’ ongoing potential as part of the “sharing economy”, questioning how inclusive this movement is: “according to Maker Media’s own surveys, the movement is overwhelming male, well-educated and affluent.” (Holman, 2015, p.4). Holman goes on to reference Chris Anderson (2012) who argues the future of manufacturing is in “distributed design and production” through a resurgent “workshop system, powered by digital fabrication and a decentralised workforce.” (Holman, 2015, p.18). Holman counters the assumed likelihood of this kind of prediction: “conventional manufacturing is still really good at making high-quality and mass-customised products.” (Holman, 2015, p.19).

2) What can Academic Library services bring to the effective organisation and support of makerspaces?

The wider social and cultural possibilities for libraries supporting the Maker Movement are recognised by Halverson and Sheridan (2014), with makerspaces possibly joining “FabLabs as Freirian opportunities for empowerment and consciousness raising.” (Halverson and Sheridan, 2014, p.500). As places where making activities and identities can be forged in a non-formal space open to all Halverson and Sheridan argue: “Libraries in particular hold promise for democratization, given their history as free, embedded community resources” (Halverson and Sheridan, 2014, p.500). There is no in depth research on makerspaces in Academic Library services as yet. Within the Library and Information Science (LIS) literature, questions are emerging more frequently around the future roles of libraries beyond providing access to resources and Information Literacy support. The myriad future possibilities for library services including Academic Libraries are examined in Noh’s (2015) extensive literature review article: “Imagining Library 4.0: Creating a Model for Future Libraries”. Much is made of the possibilities of digital interconnectivity: “The revolutionary service spirit of next-generation digital libraries is based around the ideals of space for free community networking, technological choices provided free of charge, connections to the local economy, a sense of belonging to community” (Noh, 2015, p.3). The Educause report also highlights some interesting possible future developments with makerspaces around digital interconnectivity including campus to campus joint project collaboration, assessed portfolios for employers or university credits, and the possibility of the remote operation of machinery (Educause, 2013). Many of these potentially positive service elements arguably need a physically embodied space less formalised and restrictive than a wholly traditional library environment. The potential of makerspaces as part of the emerging vision in the LIS literature is touched on by Noh later in the article: “librarians have reached for new identities within their core mission of information community helpers. Infinite creative space (or makerspace) is a natural extension of that identity.” (Noh, 2014, p.15).

Fourie and Meyer (2015) look at how a makerspace service is a step outside the “traditional role of libraries related to information resources and information literacy.” (Fourie and Meyer, 2015, p.521). However, they point a number of coherent ways a library service can contribute to supporting these informal experiential learning spaces (e.g. connecting physical to virtual spaces with libraries providing relevant information sources, linking the importance of self-efficacy with innovation and “subtle ways to link this to finding information” (Fourie and Meyer, 2015, p.522) including promoting key hardcopy material). A possible connection is also made to other library “movements”: “such as clubs, hubs, communities of practice and commons.” (Fourie and Meyer, 2015, p.522). The socio-political aspects of library makerspaces are also touched on: “Makerspaces can be associated with social capital, power play and power dynamics.” (Fourie and Meyer, 2015, p.523). Fourie and Meyer conclude with a warning for librarians not to be involved with makerspaces as providers of the space only: “The issue for libraries to consider is how makerspaces can be combined with extension initiatives such as learning commons, research commons and embedded librarianship.” (Fourie and Meyer, 2015, p.523). Although encouragement for starting a library makerspace is often found in the literature, pragmatic difficulties are also highlighted. For example Kurti, Kurti and Fleming (2014) highlight the difficulties of creating a makerspace from scratch that may have to be overcome: “some policies will stand in the way, space will be hard to obtain, and the budget for tools will be almost nonexistent” (Kurti, Kurti and Fleming, 2014, p.7).

Methodology

As no Academic Library service examples could be visited in the timescale available (as there are none in the UK as yet), Academic Library services in the US found to have makerspaces were contacted to ask for a library representative to take part in an online research forum. Time constraints also made it not possible to include student feedback in this initial research piece. Three participants (library staff involved in running makerspaces) agreed to take part on a one week online forum/ discussion; although not a large sample, the data collated was detailed and informative. Participant A (Assistant Professor/ Digital Resources Librarian) has two years of experience with the makerspace organising events, promoting activities and involvement in projects. Participant B is a Library Support Specialist who has overseen makerspaces for three years responsible for maintaining the equipment; troubleshooting issues/ problems; and providing instruction to students and faculty on demand. Participant C is the University Librarian and has been involved in running a makerspace since 2012, and has worked with American Studies, Art, Theatre and Classics faculties/ students in the makerspace “in addition to more traditional STEM disciplines”.

Data Collection

A Template Analysis (King, 2012) was used to help establish themes/ sub themes and overarching themes from categories/ codes drawn from the research data. This method was employed as it allows for themes to be established from the literature and used as *a priori* presuppositions (to be utilised as a lens and discounted if found to be not appropriate given the research data obtained). Questions were established during the email exchange with participants that addressed the two key research questions.

Makerspaces research - Template Analysis from asynchronous online forum

Overarching themes (Relevant to all themes) Communities of Practice Experiential Learning Self-efficacy	1. Self-directed learning	1.1 Academic, personal and entrepreneurial activities/ learning	1.1.1 Learning achieved through student choices/ agency 1.1.2 Student led classes, clubs, workshops and activities
	2. Mediated learning	2.1 Staff led classes 2.2 Staff support available	2.1.1 Mastery
	3. Cross disciplinary opportunities	3.1 Liberal arts - STEM/ STEAM	3.1.1 Craftsmanship 3.1.2 Art

Summary of data from participants

From this sample three significant interrelated themes provide an overarching initial heuristic framework of learning in these makerspaces: Experiential Learning (Dewey, 1909; Kolb, 1984), Communities of Practice (Lave and Wenger, 1991) and Self-efficacy through social learning (Bandura, 1997). All these makerspaces offer informal experiential learning opportunities through a combination of mediated activities in the form of staff led classes and workshops, student led groups using the makerspace, and the freedom for individuals to use the space as they wish in a self-directed manner, potentially developing self-efficacy and forming new Communities of Practice on an ongoing basis. Key examples from the data are organised below under overarching themes; although for each makerspace activity reported there is potential overlap and interplay between many of the themes identified, including the overarching themes.

Communities of Practice

Participant A described an interesting variety of clubs that use the makerspace: “Robotics club, fashion club, maker club” and projects (also relevant to theme 2 Mediated learning): “Engineering, Technology, Art, History, Anthropology, Ethnic studies, Dance.” Participant A went on to clarify: “some of our offerings are more cross disciplinary than others.. However, a lot of our students from different backgrounds and with different goals come together to use the 3D printer in particular. Lots of STEAM cross-over there.” (STEAM being the addition of Art to the traditional STEM subjects: Science, Technology, Engineering, Art and design, and Mathematics). Participant C gives an interesting example of potentially new professional Communities of Practice forming amongst academics and teachers within the description of “Science Education” in the makerspace, whereby a colleague as well as teaching within a makerspace, created other makerspaces on campus for use with colleagues on the teacher preparation programs. Courses run by the College of Education were created to support student teachers in learning how to “integrate making into their classes”. The colleague has also done “a great deal of work with area schools, and he has worked with them to develop makerspaces of their own.”

Experiential Learning

Participant C also described an impressive variety of organised activities (mediated by library or academic staff- theme 2): classes, clubs and projects including “American Studies”, “Physics”, “Freshman Seminar: Makerbots and Mashups” helping “first year students transition into college.. through highly interactive projects.. demonstrating mastery of a particular skill”, “DGST 201: Tinkering, Hacking, and Making in the Digital Age.. A project-based course.. with a greater emphasis (on) student feedback/ communication through blogging.” Participant C gave good examples of mediated learning opportunities created through the involvement from academic colleagues, including a collaboration between a professor on the Classics program and a colleague from the College of Education on Pompeii, using “3D design programs to recreate buildings, and.. artefacts .. using our 3D printer. They also scanned themselves in Roman costumes.” The 3D printer was also used for a “Theatre” project, “a staged production of Lady Windemere’s Fan..The class designed an elaborate chandelier for the set, and we printed various parts of it on the 3D printer.”

Self-efficacy

Opportunities for individuals to build confidence in independent learning, through self-directed learning (theme 1) opportunities, were prevalent in all the makerspaces discussed in this forum even in some challenging circumstances. Participant A described no permanent dedicated space but "open maker studios and specific workshops (3d printing, knitting etc.)" are scheduled where "students can come and work on whatever they want." Participant A also reported being "fortunate to have students involved in leading makerspace activities." Participants B and C reported they had permanent spaces allocated for their makerspaces with freedom for students to do what they want within them. Participant C mentioned challenges in terms of restrictions to access in terms of available staffing ("scheduled students.. or other staff to be in the space). Participant B described 5 different studio spaces available to students with a valid ID 24/7 (Rendering, Audio, Visual, Production and Editing). Within the mediated learning opportunities mentioned reflection on learning can be built in, but there is a certain amount of trust in handing over significant learning opportunities to a mainly self-directed approach, as participant A states: "We really try and collaborate with faculty in order to make sure we are helping to meet their learning outcomes. That said, as we've discussed before, a lot of the makerspace is student driven, and their own creativity and innovation can guide their progress."

Discussion

Research method

Template Analysis (King, 2012) was chosen as the filter for the interpretation of the research data for this study, and successfully helped to provide a flexible theoretical framework established from the literature that could be challenged and added to in accordance with the findings from the data. Although limited in scope due to the sample size, the rich data from the experienced research participants has provided valuable insights into the possibilities of makerspaces within HE library services, which could be explored further. This method of interpreting quite detailed intra subjective observations and discussions from a small group of professionals can be considered a reasonable place to start exploring the ontology of an emerging phenomenon in a realist framework: "a realist naturalism emphasises the stratification of reality as a general metaphysical principle...it also accepts the "hermeneutic" principle that the concepts and theories of the social sciences must make substantial reference to those of actors in the life-world." (Outhwaite, 1987, p.108).

1) How is learning achieved and supported in makerspaces?

The collaborative learning in makerspaces can be seen in terms of the influential psychologist Vygotsky's notion of the Zone of Proximal Development with its identification of the additional learning that can occur with help from "more capable peers" (Vygotsky, 1978, p.86). Students may choose to join in the activities in the makerspace through observing others working in the space first, what Lave and Wenger initially termed "legitimate peripheral participation" (Lave and Wenger, 1991). The importance of the agency of the student from the start of their experience within a makerspace can be seen as a positive element in potentially developing self-efficacy (Participant A: "their own creativity and innovation can guide their progress"); innovation and creativity both requiring a high level of self-efficacy: "above all innovativeness requires an unshakeable sense of efficacy to persist in creative endeavours with uncertain outcomes" (Bandura, 1997, p.239). The large variety of creative student organised clubs described in this research (e.g. Participant A: "robotics club.. fashion club.. maker club") show opportunities for developing confidence in personal capabilities through the informal, largely self-directed experiential learning available in the

makerspace. Lave and Wenger's theorising could also possibly be used to critique aspects of makerspaces, with arguably too much freedom sometimes apparent: "a neglect of explanations and formal structure, can easily result in an experience of meaninglessness." (Wenger, 1998, p.67). Bandura also highlights the importance of mastery through reflection on learning (which may need to be encouraged) in developing self-efficacy (Bandura, 1997). However, all participants in this study described a mix between spaces where students can come and use the space for "any purpose, academic, personal, entrepreneurial" (Participant B), and more structured workshops and activities students can attend "with someone leading students through a process" (Participant A), where establishing mastery and reflection on learning could be more formalised and the benefits of experiential learning fully realised.

The philosopher Martin Heidegger looked at our complex relationship with technology in "The Question Concerning Technology" (Heidegger, 1977), identifying the "danger of the surrender" (Heidegger, 1977, p.235) that can cause us to be chained to harmful technologies. The essence of technology that Heidegger portrays as key to us avoiding "merely gaping at the technological" (Heidegger, 1977, pp.235) is: "a realm that is, on the one hand, akin to the essence of technology and, on the other, fundamentally different from it. Such a realm is art" (Heidegger, 1977, pp.237-8). One of the more intriguing aspects of the emerging makerspace movement is the incorporation of art and design into the makerspace concept (e.g. participant A: "lots of STEAM cross-over" described in the use of the 3D printer in particular). The STEAM movement championed by the Rhode Island School of Design is an emerging influence in the US and potentially elsewhere, highlighting the importance of art and design in transforming technological innovation. Art and design courses hold a disciplinary interest in hands on experiential learning, and the advent of relatively easy to use open source platforms and technologies found in makerspaces presents an opportunity for individuals who may not have previously thought of themselves as able to engage with technology, to do so in a creative and positive manner.

It is also interesting that makerspaces often have older and newer technologies, as found in the literature review (also evidenced by the variety of activities found in this research piece from sowing to 3D printing). Such diverse activities show how a familiarity and re-visited engagement with older technologies in relation to emerging technology can allow for an interpretive hermeneutic circle of understanding generating new possibilities (accepting a broad, less logocentric sense of how technology can be "read" in terms of measuring its particular meaning, value and potential against our cultural and social presuppositions). The philosopher Hans-Georg Gadamer's thoughts on "historically-effected" consciousness and the fusion of historical "horizons" of understanding (Gadamer, 1975) are useful in trying to understand this aspect of the phenomenon of makerspaces. As learning fields change through time and are stimulated by new cultural perspectives, older technologies (e.g. typewriters, sewing machines) can, through the interplay with modernity, offer different insights and new creative possibilities: "far more of the old is preserved in the supposed transformation of everything than anyone knows, and it combines with the new to create a new value." (Gadamer,1975, p.293).

The enthusiasm for making and being involved in making projects can be seen from all the participants in my research piece (e.g. Participant's C's makerspace described as her "happy place": "I have always been something of a maker and am happiest when I am making something").The case made by the RSA report that makerspaces allow us to master technology to a more human end (Dellot, 2015) is worth considering in relation to this research piece, with all participants clearly enthused by the possibilities of the maker movement. The White House Maker Faire 2014 showcased many examples of new innovations that could be considered as a positive human relationship with technology (e.g. "Solving a 5,000 Year-Old Problem: Student Develops Comfortable Crutches", "Developing Smart, Eco-Friendly Urban Furniture for the Digital Age", "West Philly Teens Build Ground-

Breaking Biodiesel Car", White House Fact Sheet, 2014); philanthropy as well as fun seems to be integral to maker culture.

2) What can Academic Library services bring to the effective organisation and support of makerspaces?

A makerspace offers a creative space that allows the opportunity to learn through failure as well as success, and an immersion in a safe "third place" (Oldenberg, 2000) where identities can be formed and personalities expressed. As a service within a university used to providing support through non-formal interdisciplinary learning spaces, Academic Library services are in a position to incorporate new spaces, providing they can avoid a detrimental impact on existing "traditional" services including the ongoing value of quiet and silent spaces: "the makerspace is a safe space to try new things, and a safe place to fail. Failing in the classroom setting does not feel safe for students and sometimes they are afraid to try something new, or fear can prevent them from completing a task. The space of the library is neutral, and if something goes wrong, well that is okay." (Participant A). In terms of what Academic Library services can specifically bring to the effective organisation and support of makerspaces there is much to consider including the cost implications of new equipment and space (e.g. a reasonable quality 3D printer costs £1000, Maplin: The electronics specialist, 2016). Spaces that are already used for learning commons may lend themselves to be adjusted to include a makerspace.

Another key question for Academic Library services is whether the makerspace itself is somewhere learning support from librarians can be "embedded". Some librarians may not be comfortable supporting students in a space where questions around so many old and new technologies may arise. Although Learning Technologists may seem a more obvious fit, librarians and paraprofessional library staff may also have something positive to offer with Information and Digital Literacy skills key in finding and evaluating information sources quickly. The complex and unpredictable nature of students' working and learning in makerspaces may benefit as much from support and teaching/ training around Information and Digital Literacy as any detailed expertise on a particular technology; it is unlikely anyone will be able to stay proficient and always familiar with the many new creative technologies emerging. Although library e-resources will be useful in makerspaces so might hardcopy resources; as Fourie and Meyer (2015) highlight there are possibilities with connecting physical to virtual spaces, including promoting key hardcopy material. For those who hold arguably reactionary postmodern concerns about "hyper-reality" the prospect of a return to more corporeal based, embodied forms of learning using technology in makerspaces may be of interest. Although an embodied learning environment on the whole makerspaces can also incorporate the digital environment. For example participant's mobile devices can allow software and hardware to interact, and makerspace users often have the freedom to swap quickly between digital platforms and physical material/ tools/ hardware in interconnected processes (e.g. 3D printing from designs initially drawn on paper, then re-imagined using software to be physically printed and used and interpreted as an object).

There are opportunities for new forms of pedagogic engagement with students from library staff in makerspaces that can be considered. It is too early to see if makerspaces can genuinely upset current capitalist models in terms of moving the means of production from corporations to individuals, with some large companies seeming to be happily absorbing and supporting aspects of the maker movement (e.g. The Maker's Manual 2015 "powered" by Intel), and some makerspaces existing in more professional business models (e.g. the London "Makerversity", visited on 26/05/15, aimed specifically at entrepreneurs). However, aspects of Critical Literacy could be usefully taught by librarians in makerspaces in terms of highlighting the current privilege held by limited communities who have access to these creative/ experimental spaces, and the potential social good in helping to grow the maker movement as an opportunity for empowerment and innovation. There is an element of hope

and freedom in these informal learning spaces to step outside the neoliberal constraints of education as a purely technical training for future employment as identified by educationalists such as Paulo Freire: “a *neutral* education...dedicated to the transmission of content in all the emaciation of its technicity and scientism.” (Freire, 1992, p.126).

Conclusion

Although maker culture is inevitably open to criticism on the grounds of being an unrealistic ideological movement, it is perhaps impossible to achieve any kind of socially and culturally transformative change without an element of “hope” of positive outcomes: “hope is an ontological need” (Freire, 1992, p.2). The tenacity required by the participants in this study and others identified in the literature to create and maintain successful makerspaces is admirable and infectious, and itself part of the ontology of these makerspaces. Within universities this study has begun to explore how learning can be achieved in makerspaces (research Q1). Through participation in open access learning environments outside of restrictive normative curriculum structures, each makerspace potentially provides a cross disciplinary experiential learning space that fosters innovation and creativity and allows for self-efficacy to be developed through self-directed learning opportunities in a productive, mutually supportive community environment. Although specific skill sets learnt from particular makerspace activities may be hard to always quantify, it is perhaps the confidence in, and understanding of their own creativity and learning ability for the individuals participating in these spaces that educators will be most interested in; with much further research needed incorporating students. From this initial research piece makerspaces can also be seen as an emerging phenomenon that could help form positive new directions for Academic Librarianship (research Q2) as well as Learning Technologists, an opportunity to be involved in supporting a less distant, more embodied and human relationship with technology and of teaching Information, Digital and Critical Literacies in a new context. As a service within the university used to providing support in terms of informal cross-disciplinary learning spaces, Academic Library services are in a position to effectively incorporate these new spaces, providing they can avoid a detrimental impact on highly valued existing services due to space and cost implications.

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