Culture, technology and local networks: towards a sociology of 'making' in education

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Published version

PERROTTA, Carlo, BAILEY, Chris J and GARSIDE, Claire (2017). Culture, technology and local networks: towards a sociology of 'making' in education. Cambridge journal of education, 48 (5), 553-569.

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To cite this article: Carlo Perrotta, Chris Bailey & Claire Garside (2017): Culture, technology and local networks: towards a sociology of 'making' in education, Cambridge Journal of Education, DOI: 10.1080/0305764X.2017.1375459

To link to this article: http://dx.doi.org/10.1080/0305764X.2017.1375459

Author Accepted Manuscript

Culture, technology and local networks: towards a sociology of 'making' in education

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ABSTRACT

This article is about 'making' in education. Often associated with software programming (as in 'digital making'), making can also involve creating or modifying physical technological artefacts. In this paper, making is examined as a phenomenon that occurs at the intersection of culture, the economy, technology and education. The focus is not on the effects on cognitive gains or motivations, but on locating making in a social, historical and economic context. Making is also described as a form of 'material connotation', where connotation refers to the process through which the technical structure of artefacts is altered by culture and society. In the second part of the paper, the theoretical discussion is complemented by a case study in which making is described as a networked phenomenon where technology companies, consultants, volunteers, schools, and students were all implicated in turning a nebulous set of practices and discourses into an educational reality

KEYWORDS Making; fabrication; digital technology; materiality

1. Introduction: making as a cultural and educational phenomenon

Activities that involve making and tinkering with technology have a long history, but they undoubtedly received a significant boost in recent years, thanks to the increased availability of affordable, child-focused computers such as the popular Raspberry Pi, and 'fabrication tools' such as 3D printers, laser scanners, computer-controlled sewing machines, and so forth (see Vossoughi & Bevan, 2014 for a review). This was accompanied by the exponential growth of freely available technical expertise, in the form of networked communities of enthusiasts and hobbyists, who create and share development tools, standards and tutorials. Making is now being vigorously framed as an educational practice (Blikstein, 2013), underpinned by the sort of student-centred pedagogies that trace their origins to the work of seminal progressive educators and thinkers (Dewey, 1902; Freire, 1974; Montessori, 1965), as well as research on technology-based constructivism since the 1980s (Papert, 1980; diSessa, 2000). These ideas have had an influence on the more progressive sections of formal education, especially in the US and the UK, but only now are beginning to come to wider fruition thanks to what has been called the 'democratisation of invention' afforded by fabrication tools and accessible design knowledge (Blikstein, 2013; Halverson & Sheridan, 2014).

Beyond education, more expressly 'political' readings of making are also available (e.g. Ratto & Boler, 2014). The focus here is on so called 'DIY citizenship' and the ways in which creative and grassroots engagement with technology may open up new opportunities for political participation and democracy. According to Ratto and Boler (ibid.), the roots of this view can be traced back to the American counterculture of the late 1960s, which was in turn informed by the individualist and anti-establishment values that shaped certain aspects of the American psyche. The term 'DIY citizenship' was introduced by John Hartley (1999) to extend the traditional forms of citizenship first theorised by Thomas Marshall (Marshall & Bottomore, 1950). Famously, Marshall described three types of citizenship that developed in different historical moments but converged in modern times: civil, which is about rights and freedoms; political, which is about democratic representation; and social, which is about welfare. To these types, Hartley added a 'Do-It-Yourself' citizenship, which was later reframed as a manifestation of identity politics (Jacka, 2003): a form of individualised engagement with the liberating affordances of technology and media in order to build a distinctive identity. DIY citizenship is thus based on 'the practice of putting together an identity from the available choices, patterns and opportunities on offer in the semiosphere and the mediasphere' (Jacka, 2003, p. 185).

The framing of the making movement as political and progressivist – a technologically mediated process through which individuals can freely and democratically define their place in society – is also shaped by the notion of participatory technological design at the heart of the open-source movement, itself a product of American counterculture. Open-source means that software is shared with its source code for no more than the cost of distribution, open to everyone to modify and redistribute without royalties or licensing fees. Since the first pioneering initiatives in the early 1980s, such as Richard Stallman's GNU project[1] and the establishment of the Free Software Foundation,[2] the open-source movement progressed during the 1990s and 2000s with communities of programmers and hackers forming around a broad range of collaborative projects.

The reading of making and open-source practices as forms of technologically mediated citizenship is important from an educational perspective, because it helps us understand the broader socio-cultural context in which they are situated. Indeed, these practices should always be interrogated as historical and political phenomena, to avoid reducing them to a collection of discrete 'educational opportunities' that present themselves fully formed and ready to be applied by keen teachers and entrepreneurial young people. Therefore, it is important to be aware that two forms of ideologies tend to converge (often becoming confused) in the discourse of hacking and making (Blikstein & Worsley, 2014; Selwyn, 2013). A distinctly progressivist narrative emphasises democratisation and equity. At the same time, a neo-liberal reading is also present, one that emphasises utilitarian notions of job-readiness, entrepreneurship and economic benefits. The political nature of making and hacking is not only reflected in broad ideologies, but also in the power imbalances in the actual participatory development processes. Far from being 'flat' or distributed, communities of makers, hackers and grassroots designers are organised around 'rigid hierarchies of privileged and authorised elites of charismatic leaders and core users who oversee and moderate the creative process' (Selwyn, 2013, p. 77). The implications of such imbalances in education are significant; we cannot ignore that open, unstructured making processes require considerable levels of skill, professional confidence and motivation, and that the most technically gifted individuals are better positioned to engage in meaningful participation. Similarly, Blikstein and Worsley (2014) highlight the pitfalls of a hacker culture of auto- didacticism and a 'sink or swim' approach to technological design, which, when applied to educational contexts without an appreciation for inclusive pedagogy, alienates most students except a small elite of high-end performers. In an effort to address these problems, Blikstein and Worsley (ibid.) make a convincing call for a more research-based approach, under- pinned by an ethical drive to increase the inclusiveness and accessibility of making beyond the traditionally privileged contexts where it mostly occurs. In addition, some valuable work has been done on the gendered nature of making, often associated with a male-dominated culture of electronics, gadgetry and garden-shed tinkering, with some authors highlight- ing the inclusive opportunities offered by alternative traditions of grassroots technological design, such as e-textiles (Buchholz, Shively, Peppler, & Wohlwend, 2014; Peppler, 2015).

The present article seeks to contribute to this more informed, emerging discourse by expanding the theoretical scope of 'making research' beyond learning, that is, beyond a narrow concern for impacts on knowledge or skills. We therefore invite researchers to also consider the cultural, historical and sociological dimensions, which cannot be ignored if we are to develop a comprehensive, critical understanding of these practices (see also Nemorin & Selwyn, 2016; Potter & McDougall, 2017). In the first part of the paper, making is considered as a broad cultural trend that can be analysed sociologically, historically and semiotically. Making, viewed as an educational, child-oriented phenomenon, is considered as 'underdetermined' (i.e. not determined by a single force over the others) by the plurality of economic, cultural and technological changes that, together, altered the ways in which childhood is viewed in industrial and post-industrial societies. In addition, making is described as a form of 'material connotation', where connotation refers to the process through which the technical structure of artefacts is altered by culture and society. Drawing on the notion of semiotic connotation (Barthes, 1967), where language mutates through the post hoc attribution of meanings, material connotation is described as a process in which technological design and culturally mediated modification are indistinguishable. In the second part of the paper, the theoretical discussion is complemented by an empirical section which reports findings from a study that analysed making in a specific context: a large city in the North of England. In this second section, 'making' is described as a networked phenomenon where

technology companies, consultants, volunteers, schools and students were all implicated in turning a nebulous set of practices and discourses into an educational reality.

1.1. Changing notions of childhood, labour and technology

An important, pivotal debate regarding the nature and purpose of childhood took place in nineteenth-century England, during the industrial revolution (Feenberg, 2010). During this period, influential and vocal sections of the Victorian establishment brandished economic and technological imperatives to justify the continued employment of children (and women) to operate industrial machines. A common argument was that the very nature of those machines was such that many tasks were better accomplished by workers with short limbs and small hands. Any interference with this 'objective' state of affairs was bound to have dire economic consequences, such as productivity slumps, bankruptcy, unemployment and ensuing social tragedies. Critically examining these claims, the philosopher of technology Andrew Feenberg (ibid.) notes that there was nothing inevitable about the relationship between Victorian industrial machinery and child labour. Rather, those machines had often been designed from the ground up to be operated by small people; in other words, the nature of industrial machinery did not determine the condition of child labour, which was instead sustained by a cultural and economic discourse that had several tangible technological manifestations.

The trajectory of child labour, with its related technological infrastructure, illustrates the limits of the deterministic argument in technological debates, that is, the idea that technologies are always the result of rational design and unavoidable imperatives. Although technologies are without doubt rational, i.e. they reflect an attempt to make sense of the world using laws, principles, mechanisms, algorithms and so forth, technological progress is never a straightforward matter of finding the most rational solution to a problem. Rather, it is based on finding or designing what seems to fit best with the values, expectations and assumptions which are dominant in a particular field at a particular moment in history. Technologies are therefore 'underdetermined'. The thesis of 'underdetermination' (Feenberg, 1991) holds that there is never a single rational solution to technical problems, thus opening the technical sphere to various socio-cultural influences. Child labour was eventually abolished in most western economies as new machines emerged that did not need children to be operated, and a social and ideological consensus coalesced around notions of childhood as a period of innocence, leisure and unproductive learning that requires a mix of moral safeguarding and compulsory instruction – a consensus which has endured for the large part of a century and has become interwoven with economic and educational considerations (see also Buckingham, 2013). According to Feenberg:

> A vast historical process unfolded, partly stimulated by the ideological debate over how children should be raised and partly economic. It led eventually to the current situation in which nobody dreams of returning to cheap labour in order to cut costs, at least not in the developed countries … today we see children as consumers, not as producers. Their function is to learn, insofar as they have any function at all, and not earn a living. This change in the definition of childhood is the essential advance brought about by the regulation of labour. (Feenberg, 2010, pp. 13–39)

Notions of childhood in modernity have always been contested and shaped by ideological, economic and cultural factors, and the relationship between children and the world of productive work has evolved historically. The contemporary emphasis on making as an educational activity can be examined, to an extent, as the latest manifestation of this historical process. For instance, precursors of making, as it is understood nowadays, can also be observed in the cross-age trajectory of hobbyist cultures in industrial and post-industrial economies and, in particular, in the interface between leisure time and work/study time. In his study of hobbies in American culture from the mid-nineteenth century, Gelber (2013)

notes that the boom in leisure activities went hand in hand with the diffusion across all swathes of society of a capitalist, self-driven work ethic:

> For a leisure activity to be a hobby it must, above all, be productive. Like work itself, hobbies generate a product and therefore hobbyists have something to show for their time, it has not been wasted. Even if they never even think of selling the products of their leisure, hobbyists know they have economic value, and that knowledge ties their free time to the ideals of the market economy. (Gelber, 2013, p. 295)

The expansion of capitalism and its various crises after the Second World War once more called into question the idea of childhood as an idle period of learning: a protected (and protracted) state of 'moratorium' (Erikson, 1956) during which children and young people could learn without being productive, while exploring different identities before choosing a suitable path. On the one hand, this was accompanied by a growing dissatisfaction with traditional educational institutions and their ability to provide children with economically viable skills; on the other, it was underpinned by the 'economisation' of leisure time for adults and children alike, and by the rise of a hobbyist culture ideologically and materially tied to the world of technological innovation and entrepreneurship. Gradually, childhood became a condition entirely contained within an economic worldview: the antechamber to work and productivity and a site of material and cultural consumption. Today's notion of the child as productive, self-motivated, digitally literate 'maker' is not comparable with that of the uneducated, impoverished and ill-treated Victorian child labourer, but the relationship between culture, economics and making can still be explained in terms of underdetermination. Not only is making the result of economic and cultural trends that challenged notions of childhood, education and productivity, but the very technologies that enable making among young people can be examined along these lines: as the result of design languages conceived from the ground up to be 'child friendly', and as artefacts that can be operated, hacked into and modded effectively by inexperienced young users. Examples include simplified and visual programming languages like Scratch[3] and credit-card sized, single-board computers like the Raspberry Pi[4] and the CodeBug[5], which was used in this study.

1.2. Making as material connotation

In his reflections on the 'system of objects', Jean Baudrillard (1996) talks about two planes of technological artefacts which mirror the classic semiotic distinction between denotation and connotation, that is, between the literal meaning of objects and the socially mediated alterations of that meaning. This logic works well when applied to artefacts: there exists, for Baudrillard, a structural plane in which the material properties of an artefact are 'denoted'. Baudrillard argues that this plane is real but, in actuality, it can only be studied in abstract, because the 'integrity' of objects' materiality is continuously disturbed and, indeed, modified by the sociological and psychological realities – the direct experiences of meaning-making, which he equates with the linguistic process of connotation. Connotation is the meaning that is developed and negotiated as a social and cultural process. Talking about technological artefacts, Baudrillard suggests that they are in a 'perpetual flight from their technical structure (denotation) towards their secondary meanings, from the technological system towards a cultural system (connotation)' (Baudrillard, 1996, p. 6).

There is, however, a key difference between denotation vs. connotation in linguistics and denotation vs. connotation in technology studies. Linguistic connotation never actually alters the literal meaning of a word, so for instance the expression 'red rose' may be used in a sentence to symbolise passionate love, but the literal, denoted meaning of 'rose' as a flower remains unchanged. Conversely, material connotation has a profound effect on the underlying structural properties of a technological artefact. This happens because techno-

logical artefacts convey meaning through their functional operations as mechanisms, as well as through culturally mediated usage in the context of human interactions. Ideally, the cultural connotation of technologies will lead to some sort of equilibrium with the structural, denoted properties, but this is not always the case in reality, where connotation often leads to the proliferation of semiotic features, at the expense of their denoted aspects. The car, for example, has a number of structural properties and a very specific use value (transport). This is what Baudrillard calls its denotation. When the car became entangled with the 'system of signs' of modern capitalist society, it turned into a symbol of style, prestige, luxury, power, and so on. According to Baudrillard, these connotative features kept piling up, encroaching on the structural properties which gradually become inaccessible and invisible, buried under layer upon layer of cultural meanings. Eventually, excessively connotated objects undergo a process of 'functional aberration' (p. 121), in which the structural properties become irrelevant, and objects become degraded versions of themselves: disposable gadgets and gizmos whose only value is as signs.

This form of 'aberrant connotation' is, possibly, the main hurdle to making as a meaningful socio-material practice – something that was already present at the very dawn of the movement. For instance, aimless connotation was, for Baudrillard, a distinctive trait of the eager inventors and tinkerers who came together at the turn of the twentieth century, in the wake of the industrial revolution – the forerunners of modern makers, hackspacers and moonlighting programmers. These like-minded science and technology enthusiasts, with their own gatherings and a lively subculture were, according to Baudrillard, complicit in encouraging the functional aberration of objects, obsessing over secondary functions and celebrating technological ornamentation and automation for their own sake, by creating artefacts that did not accomplish anything and yet 'worked'. The French Concours Lepine, one of the longest running competitions of small-time inventors, held annually since 1901, is described thus:

> The tinkering tradition of the Concours Lepine, where no true innovation can be seen, but by juggling stereotyped techniques objects are created that are once incredibly specific in their function and absolutely useless…. The object answers no need other than the need to function. (Baudrillard, 1996, p. 122).

Although Baudrillard's name is never mentioned in current accounts of fabrication as an educational practice, echoes of his ideas can be heard distinctly. For example, Blikstein (2013) argues the tools of digital fabrication can easily lead to a situation where the fabrication process is no longer valued amongst students as meaningful technological design, but as a shallow exercise, appealing because manufactured objects and digital outputs look like 'the real thing' with a 'near-professional finish'. Blikstein calls this the 'keychain syndrome', a scenario in which young makers focus on the frictionless creation of simple artefacts (e.g. keychains), by iterating basic aesthetic features and not much else. As Blikstein puts it, this is the result of:

> … two of the crucial elements of learning environments based on digital fabrication. First, the equipment is capable of easily generating aesthetically attractive objects and products. Second, this generates an incentive system in which there is a disproportionate payoff in staying a 'local minimum' where the projects are very simple but at the same time very admired by external observers. (Blikstein, 2013, p. 10)

The above statement shows that, while Baudrillard's critique was rooted in a fairly traditional view of capitalist production, it still helps us make sense of similar problems in the contemporary, post-industrial world of affordable fabrication devices and amateur software coding. The crucial point is that the notion of material connotation provides a helpful framing to examine making as a socio-cultural phenomenon. For instance, the concept of connotation can also help us make sense of alternative forms of making shaped by competing economic

interests, like those championed by Apple and Google (see Ratto & Boler, 2014). Famously, Apple adopts a 'walled garden' approach where devices, content and users are bound to each other through a stringent framework of non-negotiable technical specifications, Application Programming Interfaces (APIs) and licence agreements. This framework exists to ensure that every facet of the Apple universe, from the creation of new content by independent develop- ers to the end-user experience, is consistent with Apple's branding as a producer of exclusive, stylish and seamlessly functional devices. Google's approach, on the other hand, appears to be completely at odds in its championing of openness – not because of a genuine ethical stance against Apple's closed ecosystem, but because of a different business model where profits are generated through a parallel ecosystem, heavily reliant on advertising and data analytics and fundamentally 'device-agnostic'. These two approaches translate in different visions of making. Apple seems more inclined to constrain independent developers, while offering in exchange a streamlined environment and emphasising the curation of newly created content to support quality and innovation. On the other hand, Google advocates a form of grassroots development that emphasises the indeterminacy and 'moddability' of open-source technologies. As already mentioned, such a position ought not to be mistaken for a principled stance, as both openness and closure are in fact contained within the same socio-technical dynamic. Their opposition must instead be problematised as a surface-level connotation of similar forms of production: the rhetorical claims may appear different, but the core assumptions remain shared and uncontested. This is also noted by Ratto and Boler (2014), who rightly point out that making in the global, networked ecosystems of Google and Apple.

> … will always incorporate not only 'do it yourself' but 'do it for them', especially for the vast majority of keen technology enthusiasts unwilling to explore new opportunities present within new media and new technologies for novel and non-normative forms of cultural and political engagement. (ibid., p. 256)

In this sense, the more 'corporate' forms of making, which tend to dominate in the public imaginary, can be conceptualised as labour-intensive material connotations, symbolically and materially interwoven with the world and language of technology companies, and subsumed in a narrow and normative neo-liberal rationality (Appleby, 2011; Fuchs, 2014).

Until now, the paper has argued that the study of the making movement in education demands an appreciation for its historical and cultural origins and implications, and for its nature as a process where semiosis and materiality become enmeshed. The second part of the paper will introduce the third component of this analytical framework: a descriptive, empirically grounded focus on the networks that allow this collection of practices, values and forms of technical knowledge to become an educational reality.

2. Observing and describing making in schools as a networked phenomenon

Like other educational technology trends, such as learning analytics (Perrotta & Williamson, 2016), making can be described as a thoroughly networked and culturally mediated phe- nomenon. In this respect, some research has already been done on how actor relations in the British education policy space shaped a discourse that emphasises the importance of coding and computing skills in formal education (Williamson, 2016). Along similar lines, but adopting a more granular approach, a sociologically oriented observer could look at how schools, individual teachers, consultants, commentators, technology providers and volunteers are all implicated in turning making into an educational reality. This happens through a range of activities that include regional brokerage, the securing of sponsorship and donations, and the fostering of market-like relations between suppliers, distributors

and purchasers (mainly schools). These ideas are indebted to Actor-Network Theory and related concepts, such as that of 'ontological politics' (Law, 2007; Law & Singleton, 2005) – a process through which 'socio-technical assemblages' are realised through technologies, negotiations and alliances. This approach favours descriptive accounts of how events involving technologies, people and institutions take shape and develop – never in a complete way, but producing 'gaps, holes and tears' (Fenwick & Edwards, 2010, p. 4).

With this section the paper begins a transition from a theoretical discussion to a more empirical, descriptive analysis of making in situ. In the study, the fieldwork data were considered holistically alongside contextual information about the maker scene in the city of Leeds, in accordance with the principles of the case-study method (Yin, 2009). The fieldwork took place from September 2015 to February 2016 in three data-collection sites. The first site was the Leeds Hackspace, a community-run setting where technology enthusiasts share equipment and expertise to collaborate on hacking, making and coding projects. The remaining two sites were two secondary schools in Leeds, both serving urban communities and with a higher than average proportion of students from disadvantaged backgrounds. In each school we worked with a mixed gender/mixed ability group of 15 students aged 12–13 (Year 8). The gender split was 60% girls, 40% boys. The data include verbal interactions and supporting photographic material collected during 'making' sessions with students. The same template was adopted in both schools: students were encouraged to produce ideas and develop them through an iterative design process, starting from drawings and sketches and progressing to actual physical or digital prototypes. The activities were developed on the basis of the previous experience of one of the members of the research team. They involved a combination of programming using CodeBugs (low-cost microcontrollers), a visual programming editor (Blockly[6]) and wearable technologies. We carried out four design sessions in both schools. Interviews were recorded using voice recorders. A total of 292 min of verbal interactions were transcribed and analysed for recurring themes using a qualitative and interpretative approach (Denzin & Lincoln, 2011). The software for qualitative analysis NVivo® (QSR International Pty, Daresbury, UK) was used to assist with the interpretation of the data. The study was carried out in accordance with mandatory ethical guidelines established by the author's institution. Signed consent forms were obtained and all names have been changed to pseudonyms.

2.1. Localities and tensions in the British maker networks

The material dimension of making entails a certain degree of complexity and administration, as different types of equipment – not only computers – need to be procured, various forms of technical expertise are required, donations are solicited, sponsorships are actively sought, and so forth. In the British context, this has led to the emergence of a cottage industry of educational making and hacking, with start-ups, consultancies, after-school gatherings and camps, events and actual products that target the educational market. Often, these networks have a regional dimension, for instance gravitating around influential 'nodes'. One such node is the Raspberry Foundation, i.e. the designers and producers of the popular micro-computer Raspberry Pi who built on existing networks of expertise and the reputational capital of Cambridge University, as well as a vibrant regional ecosystem of Hackspaces. According to a recent survey (Sleigh, Stewart, & Stokes, 2015), there are currently 97 Hackspaces in

the UK, and they can be found in every region, although key cultural and economic hubs tend to dominate the landscape in terms of size, quality of equipment and range of activities allowed. Manchester and London, for instance, are the only cities where hackspaces are equipped with 'biolabs' to experiment with molecular biology and microbiology. Men tend to be prevalent by a large margin in these settings, with membership predominantly male in 80% of the spaces.

The networked and mediated nature of making can also be observed in other local contexts, although arguably at a smaller scale than in the more affluent South of England. One of these contexts is Leeds, the case study considered here. Leeds is a large, growing city in the North of England where the service sector has almost completely replaced the traditional manufacturing activities that played a significant part in the historical development of the region, such as the textile industries. Leeds is now one of the main financial centres in England outside London. Like in all major cities in the UK and around the world, a hackspace is present in Leeds. One of the most prominent sponsors of the Leeds Hackspace is Farnell Element14, a global distributor of technology products and services, whose headquarters are also located in Leeds. Not only is Farnell a key distributor of the Raspberry Pi, selling half of all devices in the UK and worldwide, it also sponsors Raspberry Pi Jams, hackatons and similar events, and is actively involved in supporting commercial initiatives around applied STEM education in the North of England. For instance, it established a formal partnership as exclusive distributor with a small start-up called CodeBug, which launched through a successful Kickstarter campaign[7] in 2015. CodeBug produces a 'microcontroller' not too dissimilar to the Raspberry Pi. The company was founded by a team with strong links to the North of England making scene, in particular the one gravitating around Manchester and, to a lesser extent, Leeds.

By engaging with the Leeds hackspace, the research team came into contact with a network of local consultants and innovative teachers who positioned themselves as 'early adopters' of the CodeBug microcontroller, which eventually became the key device around which the fieldwork in schools revolved. In other words, the Leeds hackspace provided us with an entry point into an emerging regional network involving commercial entities, schools, consultants and a specific device. Our observations and interviews in the Leeds hackspace also shed light on the tensions within this network. The data collection took place during an 'open evening', when the workshop can be accessed by non-members who are free to ask questions and experiment with the equipment, under the supervision of more experienced makers. During the course of the evening, we focused our questions on the relationship between the national and international network of hackspaces and educational institutions (schools and universities) in the region. The main two themes to emerge from the interviews were one of 'distinction' in relation to larger hackspaces and other commercial realities, and one of incompatibility between the 'true' maker movement and the world of formal education. The more senior members of the Hackspace were indeed keen to emphasise the charitable and community-based nature of the activities– something that, they claimed, set them apart from the more recent developments in the maker movement, branded as 'commercial' in nature. Here is a representative extract:

> Mark: Yeah I think the worry is that you end up with sort of commercial maker spaces, which do exist, and there are sort of varying levels in between as well. We're about as uncommercial as you can get really. Occasionally members will take on projects for other people, but that's about as far as it goes. But you get some places where they're

> deliberately set up as say a co-working space and they happen to have a workshop as well, and you get others (which are) purely commercial. But, I don't know, there's probably room for all of those models.

Some of the younger members were more open to such commercial models, and a few were actively exploring the possibility of setting up parallel spaces or 'offshoot' initiatives as business ventures, even though they were conscious of the challenges and, in particular, the fact that Leeds could not achieve the same level of sponsorship and 'critical mass' that seemed to be commonplace in larger and more affluent contexts:

> James: So literally the company I'm trying to get running, the only reason I'm going down that route is literally because this model can't support the very thing I do want to do with it, like, having a bio-hacking lab where you really can do the proper things rather than just going, 'Oh yes, I've got to play around with the microscopes a bit', that's fun, but it's not actually modifying stuff. If you want to do that you need proper controlled conditions. You need to be responsible for it. And you can't do that without sufficient lab space which is not going to happen here because, as lovely as all these guys are, not everyone is interested in doing this sort of things, and we certainly don't all have a few thousand grand lying around to just go and chuck in for the random offshoot that may or may not work out for people.… London is the classic example, they are licensed.… They're actually licensed for bio-hacking, and basically because I want to do that sort of thing but as far as I can tell, we don't have anything nearing that amount, because London is that critical mass … literally a case of anything could go on there … I mean London is a whole other organism in itself, I don't think you can ever compare that to everything else in the country.

This interest in the commercialisation of the Maker movement stopped, in a manner of speaking, at the school gate. While the Leeds Hackspace is actively involved in the local cultural life, with a presence during events, festivals and other community-based activities, involvement with schools is largely indirect and mediated by educational consultants and entrepreneurial teachers who act as brokers between the more commercial manifestations of the movement and schools. During the interviews it became clear that this situation was underpinned by a rather ambivalent position towards initiatives that specifically target education. The educational side of making was viewed by hackspacers as unequivocally commercial and business-oriented, rather than a natural extension of the charitable, communitarian approach that otherwise inspired, according to them, the broader movement. Most importantly, it was viewed as a compromised and watered-down version of making:

> Mike: They (schools) will turn the whole thing into an educational activity, completely denying the social and creative aspects – simply put, it won't work like that and it will fail.

> John: I worry about bringing schools into it – with their regulations, safety and control – as opposed do what you want … schools bring their own set of instructions and protocols that make the idea unfeasible.

While our engagement with the Leeds hackspace left us disheartened as to the possibility of involving experienced makers in the research project, it granted us access to an extensive mailing list that included various individuals and groups interested in making. We came therefore into contact with the local network of educational consultants experimenting with CodeBug in Leeds and North Yorkshire. One of them joined the research team, acting as a mediator between the study and the two schools where the fieldwork continued.

2.2. Making in schools: small-scale material connotations

The making sessions in schools were organised to replicate a simplified design process from idea to final prototype. Students were first introduced to the process through generative activities, such as drawing a basic circuit using conductive ink and the opportunity to manipulate the equipment playfully. Following the introduction, they were encouraged to work collaboratively, sketching out ideas for an artefact that could be 'digitally enhanced' using the CodeBugs, whose most distinctive feature is that they can be sewn on most garments or soft fabric items (e.g. a toy) using metal eyelets located around the device (see Figure 1).

What became clear from the outset was the support required to produce feasible designs, coupled with the effort to manage the mildly disruptive behaviours, while keeping imagination and creativity constantly stimulated. As the design activities progressed from one session to the next, a few students became more involved than others in negotiating designs. On a couple of occasions, these discussions developed into heated debates about the direction of the design process, with students trying to convince each other (and the researchers) that their idea was the one to be taken forward into production. In one case, two students spent a considerable amount of time debating the same idea about wearable technology, involving a 'smart' cat-flap and cat-collar combination (see Figure 2):

Ikana: Basically, you know how like there's sometimes you see other people, they're wearing something and you wanna know where they got it from but you don't want to ask, you don't want to sound like an idiot, so obviously, you've got like clothing recognition, where you take the picture of the actual item, it analyses it and then it tells you where it's from and you can go buy it from the shop without asking where it's from…. What about … you know you said about the cat one …

Sam: So, my idea, I'm working in group but Ikana came up with the actual idea, and it's this cat flap that's connected to your phone and you can change whether the cat flap lets your own cat in, out or both ways or no way, like, locked. It's also … the cat's also wearing a collar that it tells the cat flap whether it's in … the cat is in or out or not. You can … and you can … it also stops any cat that's not your cat getting in, so like a cat, even with the same brand, it's got a different serial number or high, like, frequency so that it doesn't let anyone else's cat in, even if it's with the same brand. I just came up with this idea.

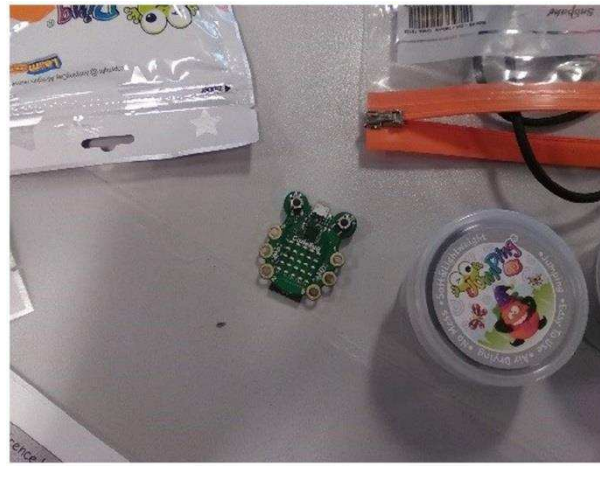

Figure 1. a Code bug – one of the micro-controllers used in the project.

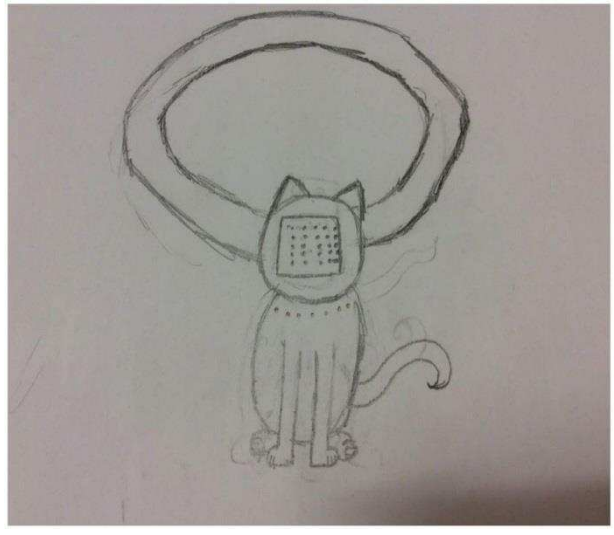

Figure 2. the 'smart cat collar'.

Ikana: What if you saw a cat, and thought, 'Oh, I wonder if that's the same cat that's on this poster?', and maybe you could have something so that you take a picture of the cat and it registers…

Sam: That's what I said…

When the smart cat-flap + collar design sketch (with the CodeBug at the centre) was taken forward into 'production', it soon became clear that it would have been too demanding and complex to develop, given the many constraints in which the project was operating in terms of time and resources. The same applied to other ideas, which were playfully considered and then discarded: an automatic clothing recognition system to simplify shopping, a surveillance system involving a doorbell, a camera, some glue and obviously a CodeBug. Therefore, the process continued by exploring individual technological functions associated with the original designs, eventually focusing on implementations which, although basic, were realistic and achievable given the available equipment and the level of technical expertise in both groups of students. This involved the creation of personalised messages and loops using the LED lights integrated into the CodeBugs (Figures 3 and 4).[8]

Material connotation, that is, semiosis becoming entangled with technological design, was involved at various stages of this process. It was there when we asked students to draw on their interests, passions and concerns to propose ideas: pets, fashion and shopping, and so forth. It was also visible in several discussions that took place at the margins of the design process, which revolved around self-expression. During these discussions students playfully explored roles and identities that they believed were associated with the activities they were engaging in. For example, the stereotypical 'geek' identity, which was explored as part of a positive, socially acceptable mode of engagement with technology, and positioned in contrast to the less appealing but equally stereotypical 'nerd' identity:

Sam: Being a geek is good because people are kind of calling you smart then … or it could mean, like, you have no life

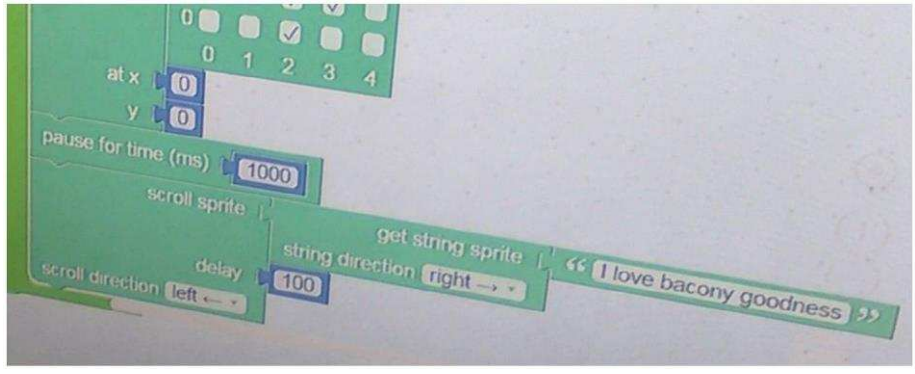

Figure 3. lines of code in blockly.

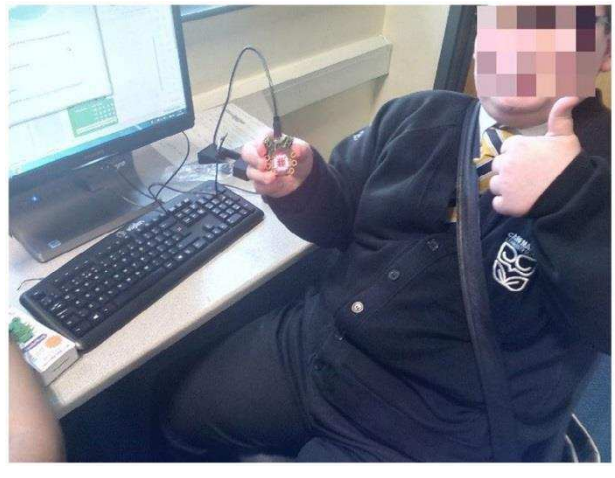

Figure 4. ‘eureka’ moment as the device worked as intended.

Jasmine: I think the word ‘geek’ is like … a geek is someone … they’ve got a social life yeah, and they can like go out and like be with friends, but they’ve got skills and, like, science-y type stuff and, like, computer and all that sort of stuff and loads of people, like, get geeks and nerds mixed up. Because stereotypically geeks are the ones who like to go out and they can do stuff with their friends, but they can also come in and do techy stuff, and nerds are just lonely, and just sit at a computer all day, just like this far away from the screens like (she puts her hand in front of her face).

Sam: I think that it just depends on who, like, no matter who you are, whether you’re a geek or a nerd, as long as you have that one person that likes you (laughs), no honestly, you’ll be able to go out, you know. As in though, as in they both have friends there, so they will lead a mainly concentrated life, whatever they’re doing, but then there will be times when they just go out and people don’t realise it but it’s all just … I mean they … that they are a geek or a nerd.

The educational value of these discussions is open to debate. A critical observer could point out their mundanity and the departure from the design process – something to take into consideration when schools or policy-makers may reasonably expect these activities

to foster learning outcomes, or increased technical proficiency. A supporter of classroom dialogue, on the other hand, would gladly reposition the entire situation as an instance of meaningful discourse about careers, interests in STEM subjects and identity development.

In this sense, media and cultural studies can provide additional theoretical resources to make sense of these phenomena, highlighting factors that may evade the gaze of more conventional educational lenses. For instance, poststructuralist ideas that draw on the work of Deleuze and Guattari (1987) could be usefully employed to gain a perspective that foregrounds the afore-mentioned complexities and acknowledges the messiness and mobilities inherent in the practice of making. 'Deleuzian' perspectives have indeed been used to offer insights into experiences involving different media, such as video games (Cremin, 2015**]**), film (Rizzo, 2012) and music radio (Akindes, 1999), and to research diverse phenomena and practices, such as creativity (Jeanes, 2006), collaborative writing (Wyatt, Gale, Gannon, & Davies, 2010) and classroom literacy (Leander & Rowe, 2006). In line with these studies, making can therefore be understood as a process, a 'becoming' (Deleuze & Guattari, 1987, p. 10), rather than a fixed or stable idea. In this way, an exploration of making is not bounded or restricted by established definitions but influenced by historical conceptions intersecting with in-the-moment adjustments and responses, drawing in ideas and inspirations from a range of cultural sources and contexts. Such a gaze, therefore, takes account of both finished product and ongoing process. This helps us to focus on making as an emergent practice, not necessarily understanding 'design' as predetermined or prolonged engagement, but as an ongoing process that is, at times, spontaneous and creative, with its origins in multiple influences from the lives and experience of those involved.

Whatever theoretical view may be taken on the cultural-educational tension that seems to underpin making, it is important to acknowledge the gradual departure, the 'semiotic flight' to return to Baudrillard's terminology, from an interest in the structural properties of technological artefacts, to the cultural worlds inhabited by young people.

An awareness of this dynamic can have pedagogic implications, potentially helping a facilitator or teacher understand – and manage – the inevitable semiotic flight in a productive fashion, stopping it from becoming 'semiotic drift', where cultural connotation completely takes over the process and the interest in the structural properties of artefacts falls by the wayside.

3. Conclusion: making and democratic education

The main contribution of this paper is to a theoretically informed research agenda on educational making. The maker movement, and its influence on formal education, can be productively examined as a topic of sociological and cultural interest, in order to better understand the pedagogic implications. Making, in other words, is not a brand new educational innovation, nor does it signal the emergence of radically different educational approaches. It should instead be viewed as part of historical and cultural trends that include changes in the nature of industrial production, the increase in, and sophistication of, 'productive' leisure time among the middle classes, changes in notions of childhood and shifts in the perceptions regarding the economic and social purpose of education. Similarly, the empirical study of making in education can take place along sociological lines, analysing the actual local networks, alliances and actors that turn making into an educational reality, before moving on to the ethnographic analysis of implementations in actual settings, in

order to observe how young people draw on their cultural worlds to 'connotate' the design process.

This study has implications for the democratisation of making, beyond narrow utilitarian agendas of job readiness and skill gaps in the economy, and the elitist, exclusionary approach of the hacker culture. Increasing equity and inclusiveness can be done at the level of classroom interactions and group composition, as suggested by Blikstein and Worsley (2014). This is important from a pedagogic perspective, but it will not succeed at a systemic level without taking into consideration the broader actor–network relations through which making becomes an 'educational thing'. The interweaving of interests, roles and technologies that revolve around design approaches, child-friendly programming languages, and actual devices such as CodeBugs, Raspberry Pis, 3D printers, and so forth. Research and interventions should therefore focus more on the linkages between centres of expertise and authority, such as universities, suppliers, corporate sponsors and funders; and on the brokers (teachers, consultants and indeed researchers) who mediate between distributors, start-ups, schools and communities. A form of political work is required in different 'regions' of these networks, literally lobbying for inclusion, equity and democratic participation; encouraging diverse groups from civil society to insert themselves as stakeholders; creating platforms and forums for democratic participation which are not monopolised in the name of excluding criteria underpinned by socio-economic and cultural privilege.

Whether this political work is possible in the current education policy landscape is open to debate, as the emphasis on making, coding and technological proficiency more broadly may not be driven by democratic zeal after all, but by a subtle governance strategy to reconfigure young people as makers and coders – docile techno-labourers expected to solve social problems on behalf of an increasingly reluctant and disengaged small state (Williamson, 2016; Sims, 2017). There is no denying that the values of technical problem-solving and 'fixing' that often transpire through the making movement are underpinned by an ideology – one that often shows impatience or outright disdain for the slow-paced, negotiated nature of democratic processes, and is more inclined to frame the world as a design challenge or a sequence of debugging issues (Morozov, 2014). Nonetheless, the reading of educational making as a particularly cynical form of social engineering is one we do not entirely subscribe to. An appreciation for the diverse localities of making and a willingness to listen to the voices of young people can in fact open up alternative perspectives, and more nuanced narratives of becoming and appropriation involving technology become visible – some of these can indeed be resistive and idiosyncratic, rather than aligned and uncritical. It is in these localities that democratic education is best served by pursuing inclusion and dialogue, without renouncing critical analysis.

Notes

1. https://en.wikipedia.org/wiki/GNU_Project
2. https://www.fsf.org/
3. https://scratch.mit.edu/
4. https://www.raspberrypi.org/
5. https://www.codebug.org.uk/
6. https://developers.google.com/blockly/
7. Kickstarter is a crowdfunding website where people can financially back projects, and are offered tangible rewards and/or experiences in exchange for their pledges.
8. https://www.codebug.org.uk/

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by the Society for Educational Studies [grant ID 2015MayPerrotta].

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References

Akindes, F. (1999). Methodology as lived experience: Rhizomatic ethnography in Hawaii. Diegesis, 5, 17–26.
Appleby, J. (2011). The relentless revolution: A history of capitalism. New York, NY: WW Norton & Company.
Barthes, R. (1967). Elements of Semiology. New York, NY: Hill & Wang.
Baudrillard, J. (1996) The system of objects. (J. Benedict, Trans.). London and New York: Verso.
Blikstein, P. (2013). Digital fabrication and 'making' in education: The democratization of invention. In J. Walter-Herrman & C. Buching (Eds.), FabLabs: Of machines, makers and inventors (pp. 203–222). Bielefeld: Transcript Verlag.
Blikstein, P., & Worsley, M. (2014). Children are not hackers. In K. Peppler, E. Halverson, & Y. B. Kafai (Eds.), Makeology: Makerspaces as learning environments (Vol. 1, pp. 64–78). New York, NY: Routledge.
Buchholz, B., Shively, K., Peppler, K., & Wohlwend, K. (2014). Hands on, hands off: Gendered access in crafting and electronics practices. Mind, Culture, and Activity, 21(4), 278–297.
Buckingham, D. (2013). Beyond technology: Children's learning in the age of digital culture. London: John Wiley & Sons.
Cremin, C. (2015). Exploring videogames with Deleuze and Guattari: Towards an affective theory of form. London: Routledge.
Deleuze, G., & Guattari, F. (1987). A thousand plateaus. Minneapolis, MN: University of Minnesota Press.
Denzin, N. K., & Lincoln, Y. S. (2011). The SAGE handbook of qualitative research. London: Sage.
Dewey, J. (1902). The child and curriculum. Chicago, IL: University of Chicago Press.
diSessa, A. A. (2000). Changing minds: Computers, learning, and literacy. Cambridge, MA: MIT Press.
Erikson, E. H. (1956). The problem of ego identity. Journal of the American Psychoanalytic Association, 4(1), 56–121.
Feenberg, A. (1991). Critical theory of technology (Vol. 5). New York, NY: Oxford University Press.
Feenberg, A. (2010). Between reason and experience: Essays in technology and modernity. Cambridge, MA: MIT Press.
Fenwick, T., & Edwards, R. (2010). Actor-network theory in education. London: Routledge.
Freire, P. (1974). Pedagogy of the oppressed. New York, NY: Seabury Press.
Fuchs, C. (2014). Digital labour and Karl Marx. London: Routledge.
Gelber, S. M. (2013). Hobbies: Leisure and the culture of work in America. New York, NY: Columbia University Press.
Halverson, E.R., & Sheridan, K. (2014). The maker movement in education. Harvard Educational Review, 84(4), 495–504.
Hartley, J. (1999). Uses of Television. London: Routledge.
Jacka, E. (2003). 'Democracy as defeat', the impotence of arguments for public service broadcasting. Television & New Media, 4(2), 177–191.

Jeanes, E. L. (2006). 'Resisting creativity, creating the new'. A Deleuzian perspective on creativity. Creativity and Innovation Management, 15(2), 127–134.
Law, J. (2007). Pinboards and books: Juxtaposing, learning and materiality. In D. W. Kritt & L. T. Winegar (Eds.), Education and technology: Critical perspectives, possible futures (pp. 125–149). Lanham, MD: Lexington Books.
Law, J., & Singleton, V. (2005). Object lessons. Organization, 12(3), 331–355.
Leander, K. M., & Rowe, D. W. (2006). Mapping literacy spaces in motion: A rhizomatic analysis of a classroom literacy performance. Reading Research Quarterly, 41(4), 428–460.
Marshall, T. H., & Bottomore, T. (1950). Citizenship and social class. London: Pluto Classic.
Montessori, M. (1965). Spontaneous activity in education. New York, NY: Schocken Books.
Morozov, E. (2014). To save everything, click here: The folly of technological solutionism. New York, NY: PublicAffairs.
Nemorin, S., & Selwyn, N. (2016). Making the best of it? Exploring the realities of 3D printing in school. Research Papers in Education, 32(5), 578–595.
Papert, S. (1980). Mindstorms: Children, computers, and powerful ideas. New York, NY: Basic Books.
Peppler, K. (2015). Chapter 5, A review of e-textiles in education and society. In M. Lesley & B. Guzzetti (Eds.), Handbook of research on the societal impact of digital media (pp. 268–289). Hershey, PA: IGI Global.
Perrotta, C., & Williamson, B. (2016). The social life of learning analytics: Cluster analysis and the 'performance' of algorithmic education. Learning, Media and Technology. doi:10.1080/17439884.2016.1182927
Potter, J., & McDougall, J. (2017). Third spaces and digital making. In Digital media, culture and education (pp. 37–59). London: Palgrave Macmillan.
Ratto, M., & Boler, M. (2014). DIY citizenship: Critical making and social media. Cambridge, MA: MIT Press.
Rizzo, T. (2012). Deleuze and film: A feminist introduction. New York, NY: Continuum International.
Selwyn, N. (2013). Distrusting educational technology: Critical questions for changing times. London: Routledge.
Sims, C. (2017). Disruptive fixation: School reform and the pitfalls of techno-idealism. Princeton, NJ: Princeton University Press.
Sleigh, A., Stewart, H., & Stokes, K. (2015). Open datasets for UK makerspaces: A user guide. London: Nesta. Retrieved from https://www.nesta.org.uk/sites/default/files/open_dataset_of_uk_makerspaces_users_guide.pdf
Vossoughi, S., & Bevan, B. (2014). Making and tinkering: A review of the literature. National Research Council Committee on Out of School Time STEM. Report commissioned by the Committee on Successful out-of-school STEM learning, part of the National Academies of Sciences, Engineering and Medicine. Retrieved from https://www.researchgate.net/profile/Shirin_Vossoughi/publication/305725173_Making_and_Tinkering_A_Review_of_the_Literature/links/579d19e008ae80bf6ea48669.pdf
Williamson, B. (2016). Political computational thinking: Policy networks, digital governance and 'learning to code'. Critical Policy Studies, 10(1), 39–58.
Wyatt, J., Gale, K., Gannon, S., & Davies, B. (2010). Deleuzian thought and collaborative writing: A play in four acts. Qualitative Inquiry, 16(9), 730–741.
Yin, R. K. (2009). Case study research: Design and methods (4th ed.). London: Sage.