Geographies of digital skill

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Abstract

In an era of rapid technological change, especially considering the rise of robotics and AI, there is widespread anxiety about the impacts of digital technologies across a vast range of industries. Policy responses to this changing employment landscape champion the necessity for growing 'digital skills'. However, we argue that these dominant macropolitical interpretations draw on a restricted understanding of spatiality where digital skills are discretely located in particular bodies and in particular geographical locations. The paper develops a novel geographical response through an exploration of the micropolitics of digital skills. This focuses on the material and practical dimensions of work with digital technologies that produces a more dynamic spatiality and thus a more complex politics of labour. We argue that the dynamic spatiality of digital skills can be evaluated according to: 1) site-specific dimensions, as digital skills are co-minglings of humans and technologies; 2) extensive dimensions, as digital skills are networked across geographically dispersed sites; and 3) intensive dimensions, as digital skills emerge across bodies and environments through repetitive practices. This analysis suggests that policy declarations of digital skills 'shortages' are problematic, since they overlook the contested and shifting forms of enablement and constraint that labour practices involving digital technologies give rise to. Unpacking this labour politics therefore requires geographical approaches that are adept at grasping these complex spatialities of labour.

Key words: digital labour, economy, geography, micropolitics; posthuman, skill

1 Introduction

1.1 The question of digital skills

The urgent question of how digital technologies are affecting work is prompting widespread debate across academia, industry and government. The impetus for much of this debate is the looming spectre of robotics and AI. Foresight studies claim that this technological 'revolution' has the capacity to cause mass unemployment through the substitution of human workers for robotic counterparts (Frey and Osborne, 2013). Brynjolfsson and McAfee (2014) warn that this new technology will radically change the nature of skills required by workers of the future. Accordingly, to avert the mass unemployment that such studies warn of, recent

policy attention has grappled with the precise nature of the new skills required, so that workers of the future can be trained accordingly. These are often referred to as 'digital skills'. However, this is a concept that invites a diversity of responses, definitions and implications. Responding to the prevalence of policy and emerging academic discussion on the nature of digital skills, we examine what a geographical dimension to these debates might involve. We do this to show that the concept of digital skills, often heralded as the solution to the labour challenges that are predicted to be brought about by technological change, is by no means self-evident, introducing a series of new conditions and political concerns.

At first glance, new technologies can have opposing impacts on skill requirements. As Marxist labour process theorists have argued, new technologies can result in de-skilling by reducing the diversity of work tasks through automation and divisions of labour that proliferate 'low-skill' jobs (Braverman 1974). However, new technologies can also be used to facilitate 're-skilling' or 'up-skilling' through the provision of greater time and resources for workers to undertake 'skilled' work (Adler 1990). This contradiction is intensified through the ongoing evolution of labour practices that are increasingly digital. Think here, for example, how this very tension of deskilling and reskilling can be found in contemporary accounts of working with digital technologies in which menial 'on-demand' jobs and the 'threat of unemployment' increase (Ford 2015), concurrent with opportunities for entrepreneurial innovation and even 'postwork' futures (Srnicek and Williams 2015). Part of why there seems to be a simultaneous deskilling *and* reskilling at play in the evolution of labour with digital technologies is because of the diversity of activities that the term 'digital skill' gathers together. On the one hand, through everyday (human) entanglements with software and hardware, new digital technologies have given rise to a plethora of digital skills (Ash, 2013; Boyer and England 2008; Kinsley, 2012; Wilson 2014; Valentine, 2006). Yet on the other, despite these new configurations, reports indicate that government and business are increasingly concerned that there is a shortage of digital skills (STC 2016; BIS/DCMS 2016). Herein lies an intriguing contradiction: currently there is both a proliferation *and* a shortage of digital skills. It is this contradiction that interests us here, because it indicates the pressing need for an exploration of what, precisely, constitutes digital skills.

1.2 The spatial politics of labour
Broadening out from digital skills, questioning the nature of skill more generally is important because it focuses attention on the relationship between the politics of labour and

technological change. As geographers have demonstrated, the politics of labour has distinctive spatial articulations. However, we suggest that the concept of skill directs us towards two different but related spatial articulations of labour politics, one perhaps familiar to geographers, the other, less so. The first more familiar articulation is a *macropolitical* framing, where skill operates as a classificatory schema that divides and locates labour in discrete space. The distinction between high skilled and low skilled human labour has long provided the justification for different points of remuneration, and thus fed into the broader inequitable distributions of income that geographers have noted occur at different spatial scales (Massey and Meegan 1982; Massey 1984; Dicken 2003; Coe 2013). In this macropolitical understanding of skill, labour politics is similarly contained in discrete institutional spaces, such as trade unions, in order to agree more equitable remuneration and working conditions. Accordingly, in this human-centred understanding, individual workers are enabled or constrained depending on where they are located within these classifications.

The second, less familiar articulation is a *micropolitical* understanding of skill, that occurs through a dynamic space of *ongoing transitions in enablement and constraint* that produce workers through the contingencies of their working environment. Here politics is understood through a more processual lens that focuses on how the bodily motions and dispositions that constitute working environments give rise to in-situ forms of enablement and constraint that wax and wane. This dynamic space thus evokes an understanding of skill that extends 'outside' the human, such that agency might seem sometimes to concentrate 'in' the worker, and seem sometimes to be distributed beyond them. We argue that the prevailing notion of digital skills currently championed in policy arenas is the first, macropolitical articulation, which provides only a partial rendering of the spaces of labour, and thus of labour politics with digital technologies. Therefore, to pluralise the spatial politics of labour, we develop the second, micropolitical articulation of enablements and constraints through the dynamic space of digital skill.

To make this argument we turn next to a context-setting empirical section that introduces the partial geographical understanding implicit in current policy on digital skills in the UK, in which skill functions to classify labour, often at national and regional scales. Contrasting with this macropolitical articulation of more or less skilled workers apparently contained in discrete space, section three puts forward a micropolitical approach premised on the contested and shifting nature of skill as the doing of labour, rather than skill as a labour

classification. Through this focus on how labour takes place, we develop three dimensions of a more dynamic understanding of space and skill that illustrate the contingent agency of the human as a figure in labour processes. These differently 'posthuman' geographies open out alternative spatial configurations of enablement and constraint, and thus alternative understandings of the spaces of labour politics.[1]

Firstly, we establish a dynamic sense of space through which skill is performed as a co-mingling between humans and technologies as labour takes place. Taking an historical focus, we show how the contested nature of skilled labour comes into view at times of technological change in the workplace, complicating neat ideas of a skills shortage, and thus of a fixed site for enablement or constraint. Secondly, we show how the networked constitution of digital labour necessarily means a shifting understanding of digital skill that distributes the enablement and constraint of labour performance beyond a contained workplace. Whilst certainly involving the more or less individualised 'close doing' of labouring activity, digital skills must also be understood through an extensive space of connections with dispersed people and places that are often obscured in policy debates. Thirdly, we show how the constitution of digital skills also shifts intensively via their emergence through ongoing repetition of bodily practices in specific environments. Through this intensive space, digital skills become less an attribute of specific bodies that can be known in advance, but rather might be understood as 'incorporeal' units of analysis that form between bodies and environments.

By outlining this dynamic space of the micropolitics of digital skill, we show the necessity for an approach to digital labour that reconfigures and extends beyond a humanist framework – in this case one where digital skills are 'individualised' in certain bodies – if we are to appreciate the complex sites of enablement and constraint through which such laboring takes place. To be clear, this posthuman style of analysis does not negate important question of workers' rights in the face of what some see as intensified capitalist oppression through new technologies (Stiegler, 2010; Guattari, 2015). Rather, by showing that the spaces of digital

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[1] We are terming such approaches ʹposthumanʹ for the purposes of brevity to serve our wider argument. Nonetheless we recognize both the variations in such scholarship that is obscured by any umbrella term, and the plural interpretations of the term ʹposthumanʹ itself. For some recent critical discussion of the term in human geography see Anderson (2014) and Joronen and Ha Kli (2016).

skill are dynamic, we seek to show that the units of analysis for a labour politics with digital technologies are neither singular nor necessarily predictable. This nuanced geography of digital skills is therefore intended as a fruitful extension of the subdiscipline of labour geographies that has yet to extensively engage with the question of digital technologies (Bissell and Del Casino Jr, 2017).

2 The macropolitics of digital skill

Our starting point is our observation that governments in many countries have become interested in digital skills. In this section, we show how this interest is produced through a macropolitical definition of digital skills that prevails in policy literature. To illustrate this, the empirical focus is on the definition of 'digital skills' in national policy debates unfolding in the UK, which allows us to drill down into one example. This appearance of digital skills conjures a particular understanding of space and the location of digital skills within that space. We describe this understanding of digital skill as *macropolitical* in so far as it is a government-propagated definition which is concerned with making programmatic policy 'from above' that is generalizable and can be rolled out across large populations (Massumi, 2015).

Uniting many policy reports emerging from governments around the world is the claim that there is a digital skills shortage, and further, that this shortage is an urgent problem that needs to be addressed. In the context of the UK, a report to the government by the House of Commons Science and Technology Committee (STC) (June 2016) is indicative of this understanding of digital skills as a national problem. The committee identified what it termed a 'digital skills crisis' in the UK. For them, the main driver of this crisis is the difficulty in recruiting suitably trained staff. The report highlights the needs of the so-called 'datavore' (NESTA 2012), businesses that make heavy use of data analytics for strategy and productivity, two-thirds of which have struggled to fill at least one vacancy when trying to recruit analysts over a 12-month period (STC 2016: 9). This reiterates some of the findings of the earlier joint report from the Department of Business, Innovation and Skills (BIS) and the Department of Culture, Media and Sport (DCMS) entitled 'Digital Skills for the UK Economy' which noted that the number of 'big data' vacancies has risen by 212% every year since 2013 (BIS/DCMS 2016: 42). This demand for data analytics illustrates how requirements for 'digital skills' are not simply limited to what might be understood as 'scientific and technical' sectors, but rather can extend into other areas of business. For

example, the report notes that in the creative sector, albeit with a limited definition of 'digital and social media marketing', the 'opportunities provided from an increased reliance on data analytics seem limitless' (p. 40).

On the face of it, this policy definition of digital skill seems rather narrow, restricted to data analysis. However, importantly, this 'gap' in digital skills is not confined to an absence of data analysts. The BIS report suggests that there is a more systemic problem in that 'many employers and organisations are failing to maximize productivity on the basis of limited existing digital skills in their workforce' (BIS/DCMS 2016: 35). This 'latent skills gap' (*ibid*.) has raised questions over provision of education and training. BIS has commissioned two reviews looking at training for 'digital skills'; one to examine the accreditation and graduate outcomes of computer science degrees, and the other looking at the skills taught more broadly on 'STEM' (Science, Technology, Engineering and Mathematics) degree courses and how these relate to labour market demands. These reviews respond most directly to the disconnect in ICT fields between formal qualifications and subsequent successful employment, where for example in the UK 13% of computer science students are still unemployed six months after graduating (STC 2016: 9). There are also though a catalogue of more informal training initiatives in place led by the private sector because 'business not only needs a digitally skilled workforce but also a digitally literate customer base' (p. 16).

Whilst the UK government may be inadequately leading on specific training for 'digital skills', it has taken a more strategic role in the provision of infrastructure to enable such digitally-skilled labour to take place. The UK government's 2015 'Digital communications infrastructure strategy' put forward the case for 'better connectivity'. Such connectivity is a measure of the quality of digital infrastructure, such as fibre-optic broadband and 4G mobile coverage, as that which provides the capacity to be always more connected, whether or not this connection is realized. The strategy argues that this connectivity increases opportunities for individuals to be (both) 'workers' and 'consumers', thereby enhancing economic growth.

We raise this point here because there are clear spatial implications arising from the promotion of ubiquitous digital connectivity, elevating the role of digital technologies in what Massey (1984) termed the 'spatial division of labour' at the national scale in the UK. On the one hand, increased digital connectivity can potentially reverse the tendency that Massey noted for 'skilled' work to concentrate in London and the wider southeast region, whilst 'low

skill manual' work became relegated to the 'regions', notably areas of Wales and the north-east of England. Contemporary investments in communications infrastructure mean that 'digital businesses' can nominally 'start-up' anywhere, as is emphasized by TechCity (2015) and BIS (2015). This differs from forms of skilled work at a distance from a (controlling) central office through electronic cottages, satellite offices and practices of telecommuting (Forester 1988; Mokhtarian et al 2004). The potential to build the products, the administrative operations and a customer base of a business through digital technologies opens possibilities for independent digitally 'skilled' individuals and businesses to be established with minimal ties to fixed location.

On the other hand, in spite of such ubiquitous connectivity, 'the classic theory of agglomeration' (Morrill and Sommers 2005: 350) still holds, as is indicated by recent figures documenting a 'brain drain' of graduates from the north, particularly to London (Homes for the North 2016). Aside from its significant 'cultural' draws, London offers greater access to expertise and support for nascent digital businesses through its 'start-up scene', together with the availability of finance or 'venture capital'. The concentration of opportunities and rewards for those working in 'tech' in London is by no means an accident. As Massey (2007: 128) noted, London is given a problematic priority as an 'escalator-region', an argument that not only assumes an inequality to begin with but 'does not ask what happens to those who do not wish to migrate, and ignores the vicious and virtuous circles the process engenders.' One aspect of this circularity is the perpetuation of London's 'advantage' through the capital's ability to recruit overseas. The STC report notes the significance of attempts to fill the domestic 'gap' in digital skills through 'recruitment globally', with larger tech companies in the UK 'sourcing 16% of talent outside the EU' (STC 2016: 14). Our observations here accord with geographical research that has critically interrogated how 'cyberspace' is not an unmoored, free-floating domain, but is entangled within and (re)produces local social and cultural particularities (Graham, 1998, 2005; Dodge et al 2009; Elwood and Leszczynski 2011; Leszczynski and Elwood 2015).

Taken together, we argue that this macropolitical government-propagated conception of digital skills developed through policy literatures in the UK produces a partial geography, and therefore a narrow understanding, of digital skills. This policy literature evokes a discrete understanding of space - both in terms of individual bodies, and at the level of the nation state - that must be filled with digital skills. Individual bodies must acquire more digital skills

through the development of expertise; and nation states are required to ensure that they have a digitally skilled population through provisioning to redistribute this expertise. Therefore, by identifying gaps in digital skills through quantities of individual workers – such as suitably qualified data analysts – this macropolitical definition uses skill as a classificatory schema for the existing capacities of human labour, rather than as an activity through which the capacities of human labour, and thus the human, are altered. Such a macropolitical articulation of digital skills is understandable, given the remit of national government. The concern for increasing digital skills arises from the requirement for growth that will count in measures of the (UK) national economy. However, whilst this macropolitical definition of digital skills might be useful in composing an aggregate picture of employment patterns, it tells us little about changes to the *doing* of labour. Examining this substance of digitally skilled work is important because it both illustrates the contested and shifting constitution of activities that count (e.g. at a particular level of remuneration) in the employment relation, and indicates the contingent navigation and negotiation of 'the workplace' by the worker. Such a focus on how labour takes place necessarily occurs through a more dynamic understanding of space, one that in the next section we term 'micropolitical'.

3 The micropolitics of digital skill

The macropolitical conception of digital skills proffered through government policy can usefully be supplemented with a micropolitical conception that is differently attentive to the spatial complexities of digital skills. We use the term *micropolitics* here to refer to more diffuse and decentralised forms of enablement and constraint that the concept of digital skills can potentially elucidate. Developed most comprehensively in the work of post-structuralist thinkers, the concept of micropolitics has risen to prominence in geography as a way of appreciating the complexities of power (Jellis and Gerlach, 2017). Where macropolitics concerns centralized top-down forms of power, and is based on categorical variables (e.g. high-skilled, low-skilled) of human bodies, the concept of micropolitics developed by Foucault (1991, 1998) in particular helps us to appreciate the knottier forms of enablement and constraint that emerge from moment-to-moment in specific sites. For our purposes, there are two key characteristics of Foucault's micropolitics that we find particularly useful. The first is a recognition that power operates through material site-specific arrangements. The second is that power is exercised and shaped through bodily practices. For our argument, what a micropolitical focus therefore provides through its dual attention to materiality and practice is a more dynamic and fluid understanding of space. So, rather than seeing space as a

discrete container that digital skills can fill, either at the level of bodies or distributed across nation states, appreciating the site-specific ways that digital skills combine materiality and practice provides us with a more dynamic and fluid understanding of the geographies of digital skills.

In what follows, we outline how this dynamic space of digital skills is co-produced, extensive and intensive. Through these three dimensions we develop a micropolital reading that foregrounds the practical and material constitution of digital skills and thus point to alternative sites of enablement and constraint. First, we backward-trace our object of analysis by situating digital skills within broader historical debates on the co-mingling of humans and machines. Second, we extensively-trace our object of analysis by exploring how digital skills rely on extensive sites of labour and production. Third, we intensively-trace our object of analysis by speculating on how digital skills give rise to tendencies and dispositions between bodies and technologies. Our claim is that all three dimension serve to unsettle a macropolitical and singularly humanist conception of digital skills by potentially opening up new sites and spaces for progressive intervention.

3.1 Backward-tracing: digital skills as co-mingling
Macropolitical debates advocating for the advance of digital skills in part respond to a growing unease about the employment implications of robotics and automation. Frey and Osborne's (2013) oft-cited report estimates that one third of UK jobs are at risk of automation in the next 10 to 20 years. Likewise, market research firm Forrester (Solon, 2016) report that by 2021, robots will have eliminated 6% of all jobs in the USA. So, in this 'ruthless economy' of labour in the 'digital age' (Head 2005), automation is perceived as a risk because it results in job losses. Such debates that connect digitally-induced automation to job losses strongly indicate that machines are separating workers from work. Many popular accounts of automation argue that, quite simply, machines are increasingly doing jobs that humans once did. This is not a new argument, as can be seen in powerful accounts of deskilling in response to technological change during the latter part of the twentieth century. Deskilling is a process which has been defined in corollary to technologies substituting or replacing humans (Braverman 1974), where self-acting machines displace the worker (Rosenbloom 1964: 489). These arguments are important, and certainly at the macropolitical level, they highlight some significant trends in the changing nature of production, and explore the implications of these changes in terms of their class politics. However, the suggestion that

workers are becoming separated from work, and thus deskilled, potentially overlooks the micropolitical interdependencies of humans and technology that have always been a characteristic of labour practices, both digital and non-digital.

This micropolitics of digital skill is articulated through the dynamic space of labour taking place as a co-mingling between humans and technologies. This challenges understandings of deskilling that begin by locating skill as a possession of the human worker that is subsequently removed or made redundant by technology. This sub-section establishes this micropolitical spatial articulation through an historical argument that shows how skills - both digital and non-digital - are competencies that are co-produced across body and technology, blurring the distinctions between the two. Rather than straightforward 'deskilling', technological change throws into question the nature of skilled labour, complicating neat ideas of a skills shortage and thus of a fixed site of enablement and constraint.

To begin in the now, contrary to arguments that digital technologies are deskilling workers, recent debates on skilled production invite us to consider how technologies might be better understood in terms of prostheses that intensify human capacities. As Adler suggests, in the transition away from 'natural conditions of production' that involve land and soil towards artisanal manufacture, the worker uses an instrument for work as an activity that is 'half-artistic, half end in-itself' (*ibid*. p. 796). In reworking the nature of production in this way, the tool becomes a way of extending or intensifying 'natural' worker capacities so that 'skilled work' becomes a shared activity across (and reconfiguring the boundaries between) the 'human' and 'nonhuman', rather than a capacity that is 'internal' to a human (see also Warren and Gibson, 2014; Carr and Gibson 2016). Recognising such co-production challenges any straightforward teleology of technological development as worker separation from work, and instead encourages us to attend to how skilled activity changes through human-technology interactions.

If this analysis moves the human closer to technology through the possibilities such tools offer for productive activity, their synthesis might also be considered through the somewhat ambiguous concept of automation itself. Attempting to isolate automation as a quality of the

machine[2] that threatens the viability of human workers, as is often presented in analysis, tends rather to illustrate the entanglements of automatic operations with understandings of the human action. As Hayles (2005: 132) points out, the idea that work can be automated makes it difficult to imagine a description of the worker that does not take machines as a reference point. This line of thought implies that rather than being a removal of human labour, as is often implied in popular accounts, automation is integrally tied to processes of *animation* and thus is reducible to neither distinctly 'human' nor 'machinic' capacities (Stacey and Suchman 2012).

Such debates on the interdependencies of human and machine can be traced historically. For instance, this complexity is found in Marx's attempts to make sense of the changes to production that he witnessed in the nineteenth century. Here we find a distinction between the 'lively' activity of manufacturing and the 'lifeless' system of the factory. From one perspective, there is a vitality to the possibilities of working in manufacture as a process undertaken by a 'living mechanism whose parts are human beings' (Marx in Rosenbloom 1964, 500). The emphasis here is on the manual – 'by hand' – performance of detailed operations of work tasks in concert with other workers. From another perspective, Marx casts the factory itself as 'lifeless', a 'vast automaton composed of various mechanical and intellectual organs' (*ibid*. p.496). In this case, the animated labour of individual workers in manufacture fades from view as perspective shifts to evaluate automation at the scale of the productive system of the factory overall. This view is certainly concurrent with historical accounts that trace an evolution of the worker as a human-machine, an idea that arguably reached its apotheosis in the latter part of the nineteenth century (Rabinbach, 1992).

However, viewing the factory as an 'automaton' of sorts, and therefore 'lifeless', is countered by other perpsectives that argue that the factory is constituted by a 'self-regulated moving force' (Ure in Rosenbloom 1964: 496) that operates 'independent of the workmen' (p. 501). Such readings seem to suggest that there is an *élan vital* to the collective work of the factory, drawing on Bergson's idea, that decouples the association of animation with the human worker. Further still, the 'life' of the factory—its 'self-regulated' functioning as an automaton—has an ambiguous agency that, whilst apparently productive in 'uninterrupted

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[2] Noting the many possible distinctions between conceptions of the 'machine' and of 'technology', for an overview discussion see Ingold's (2000) essay 'Tools, minds and machines: an excursion in the philosophy of technology.'

concert' (p. 496), is constantly at risk of failure 'to reproduce in the way for which it is designed' (Butler 2015, 23). Therefore, humans necessarily have to step in to repair and troubleshoot, with varying degrees of success. This means that the performance of automation, of the operation of the factory as a self-regulated and tireless system of production, is only achieved through 'moments of rupture, breakdown, and modifications and extensions of the system' (Hayles 2006: 157). We want to suggest, then, that rather than separation, a backward-tracing historical account of the relation between bodies and machines reminds us that through these complex feedbacks between worker and (factory) mechanism, there is a 'ubiquity and invisibility' (Haraway 1991: 153) to the coming together of human and technology.

These minglings or the 'progressive tendency towards technical interdependence' (Adler 1990: 798) of humans and machines indicates how automation technologies are involved in *transforming* both skills themselves, and conventional ideas of a bounded, discrete 'job'. The invention, operation and maintenance of machines produces new forms of ('skilled') working activity that may or may not go on to be specified tasks within the confines of formalized paid employment. In Adler's (1990) reading of Marx, these shifts in skill *with* machines occur across two axes. One is *historical* so that 'manifestations of de-skilling in the short term' are 'eddies in the broader current of a long-term skill upgrading trend' (p. 782). The argument here is that 'de-skilling' is a dynamic by which 'capitalism muddles through along this long term upgrading path' (p. 791). The other axis is *compositional* whereby mechanization might 'plausibly require a broader and deeper knowledge base' (p. 809). Here, Adler suggests that the 'intrinsic technical difficulty of machine design might help explain the upgrading bias of mechanization.' In short, the intricacies of technology design and operation require development of new skills; and it is these new skills that can be overlooked in arguments that point to deskilling tendencies.

This historicisation of the concept of worker skill encourages a suspicion of headline proclamations of mass unemployment resulting from automation; a situation that is best remedied by developing digital skills. Rather than the removal or development of skills within individual bodies, as macropolitical conceptions suggest, a focus on the micropolitics of how labour takes place through technological change illustrates that skill is necessarily a co-mingling of human and technology. One implication of this is that effects of contemporary automation technologies might not be so different from the past. That is, as Wacjman (2017)

argues, there are significant continuities between "digital" and "non-digital" work, not least in the labour involved in the development and operation of automated technologies. This means that rather than mass unemployment, changing definitions of job roles and the creation of new occupations are more likely.

However, this also means that new 'digital skills' are not in any simple sense a solution to absent or unsatisfactory employment. Attention to the co-produced workplace between humans and technology leaves 'considerable doubt about the overall direction of skill' through 'technological development' (Adler 1990: 795-6). Adler (ibid.) notes how visions of 'qualitative enhancement' (p. 801) compete with a vision of 'quantitative reduction'. In other words, possibilities for work of a better quality (i.e. 'high-skilled') are often challenged through processes in which technologies produce a greater number of ('low-skilled') servicing tasks that can fall beyond formal employment (e.g. the 'gig' as the genre of the work in the on-demand economy). In short, it is unclear whether changing skills will necessarily result in better – more fulfilling, higher paid – employment. Taken together, these complex co-minglings of workplace skill through human-machine interactions indicate that far from automation as a straightforward trajectory along which workers are separated from work and therefore de-skilled, different forms of skilled activity arise through technological changes and contest the 'nature' of a 'job'. This challenges attempts to find a fixed location for labour enablement and constraint, and instead points to the ways worker skills and capacities might be dispersed through space, explored next.

3.2 Extensive-tracing: digital skills as dispersed
The macropolitical focus on quantities of 'digitally skilled' workers can tether work to fixed places that are contained in space. This section argues that such a 'pointillist' analysis (c.f. Doel, 1999) overlooks the more extensive networks and flows that different forms of work, and thus 'skills', involving digital technologies are wholly contingent on. As well as a space that occurs through complex co-minglings of workplace activity between humans and technology, the networked constitution of digital labour means that this dynamic spatiality of digital skills is more extensive than is often appreciated. We evoke the global and the urban to show how the material and practical dimensions of digital skills can be understood as distributed between sites and beyond individual bodies, producing a dispersed space of enablement and constraint.

We start at the level of global production chains. Investigations of the global production chains that constitute the digital economy have revealed how the demand for digital skills made in some parts of the world is wholly contingent on the production (and destruction) of digital hardware. Tracing these production chains reveals extensive networks of more traditional manufacturing and service industries required by the digital economy. Urry (2014) describes the processes by which much of this labour is becoming increasingly 'offshored'. Enabled through the establishment of free trade zones, and importantly, the efficient transportation that containerised mobilities afford, cheaper labour in low-cost manufacturing centres has given rise to long supply chains. As Urry argues, one of the key problems of offshoring work is the concealment and the lack of scrutiny that allows human rights violations to take place. Fuchs (2014) deepens Urry's claims empirically by providing a more detailed, sobering analyses of some of these 'networked' sites of digital labour by describing, for example, the gruelling conditions experienced by manual labourers in Chinese factories that manufacture the digital devices at the heart of the digital economy and the deplorable working conditions of ICT-related mineral extraction. Others have examined how these global circulations then extend back to majority-world nations through the disposal of e-waste that is created by the digital economy (Grant and Oteng-Ababio, 2012), providing another instance of the offshoring of unwanted matter.

Focusing on the mobilities of circulation reveals how multiple sites of production and disposal are essential in facilitating the digital economy. Further to our argument, the forms of circulation and connection between these different sites are produced through a diverse range of skills. Therefore, an appreciation of the extensive spatiality of digital skills requires attention to the micropolitical specificity of each of these networked sites. For example, one of the most renowned sites involved in sustaining the digital economy are support services, such as call centre service work. The extensive networked qualities of this site are in part produced through the close(d) control of the call centre space itself - its protocols, surveillance systems, and service targets. These reveal a site where the individual worker's capacities are stultified, reduced by the 'protological' requirement for verbal exchanges (G. Urry, 2014). Such observations of the curtailment of creativity and improvisation in labouring activity have also been echoed in research on other sites that compose digitally networked spaces. Kanngieser's (2013) analysis of the logistics industries, for instance, spotlights the changing skills of labourers in light of increasingly sophisticated forms of surveillance and control. Bodily micromanagement of movement is revealed in the

digitalisation of duties through labour management systems, where workers' bodies are not just disciplined in terms of a top-down mode of power, but are 'modulated' through constant and ongoing incentives and checks, such that the boundary between 'external' domination and 'internal' complicity become difficult to discern. Further still, because these global logistics systems interlock in complex 'patchworked' ways across different sites of distribution, far from subject to a totalising 'panoptic' gaze, their many frictions and blind spots give rise to a multitude of partial, situated 'oligoptic' knowledges that workers must negotiate (Gregson et al., 2016).

The networked urban space of the 'on-demand' economy that is often the 'last-mile' of these global logistics systems produces a further rendering of the extensive nature of digital skill. Urban space becomes workplace, coordinated by 'digital platforms' that connect consumers to a service or commodity through a mobile application or website (Cockayne, 2016b, 73). Although empirical research on workers and consumers remains underdeveloped (Ash et al., 2016), nascent studies indicate that this work involves a host of complex skills that go beyond the competencies of operating digital interfaces (Rosenblat and Stark, 2016). In particular, Cockayne emphasizes how a key dimension of the on-demand economy is the 'social, trusting, and reciprocal encounter between strangers' (2016b, 77), indicating the significance of forms of emotive and connective activity. These social, soft, and often less-than-tangible aspects of work resonate with the sorts of skills required to produce the cognitive and affective commodities of 'immaterial labour' (Lazzarato 1996). However, Lazzarato (1996: 136) provides us with a complex picture of skill as he grapples with changing definitions of work and workforce through technologies of production 'Post-Ford'. Immaterial labour, for him, combines

"*intellectual skills, as regards the cultural-informational context; manual skills for the ability to combine creativity, imagination, and technical and manual labour; and entrepreneurial skills in the management of social relations and the structuring of that social cooperation of which they are part.*" (*ibid.*)

Thus, immaterial labour is not in any simple sense opposed to 'material labour', nor is it a restating of the 'mental and manual labour' dichotomy. In fact, Lazzarato (p. 133) argues that such 'old' dichotomies risk 'failing to grasp the new nature of productive activity.'

Instead, Lazzarato sees a reconfiguration of the split between 'conception and execution, between labour and creativity, between author and audience' through new communications technologies. This is exemplified in the space-times of on-demand work where, through continuous connectivity, the worker becomes 'an interface between different functions, between different work teams' (Lazzarato 1996, 133), thereby involving a variety of skills through which the 'informational' is embodied in the 'manual'. For example, the urban logistics platforms (such as Uber and Deliveroo) that provide one of the largest growth areas of on-demand work (Deloitte 2015; New Economics Foundation 2016), require a host of often overlooked practical and safety-related mobility skills for navigating the complexity of road systems, including negotiation of other road users, whilst in interaction with or direction by digital media (Bissell, 2015b). Further to this, such intricacies of 'interfacing' constitute workers as 'active subjects', requiring skills to coordinate working opportunities, rather than simply being subjected to them. This is illustrated in the flexible nature of on-demand work that is performed by a 'polymorphous self-employed autonomous' worker who is 'inserted within a market that is constantly shifting and within networks that are changeable in time and space' (Lazzarato 1996, 139). Working through such platforms then involves a certain 'opportunism of labour' (Virno 1996, 18): combinations of skills that seek out and negotiate potential connections, resonating with the problem-solving capacities of the 'entrepreneur' that some reports suggest will be key to a thriving digital economy (Deloitte, 2015). In this shift from workers as the 'subjects of production' towards work as 'the production of subjects' (Du Gay 1996), job insecurity, poor employment rights, and 'on-the-job' surveillance each require financial and time-management skills to get by.

These extensions of paid labouring that seem to combine elements of 'creative' and 'menial' activity through mobile devices have also been charged with inducing new forms of unpaid labour through managing online presence. These 'reputational economies' involve similar aspects of creative self-promotion and menial box-checking, whereby both client and service provider through digital platforms work to ensure that they have an up-to-date and clean profile, reflected in both the 'quantity and quality of received reviews' (Stabrowski 2017, 332). Where some have argued that the promise of the digital is to free people from the burden of labour, Berardi suggests that our enslavement by digital devices, such as smartphones, has induced a new set of individualised labouring demands. When he suggests that 'the time apparently freed by technology is in fact transformed into cyber time, a time of mental processing,' (2009, 24) we might surmise that this is not just about our entanglement

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in virtual networks, but a whole world of time-consuming digital maintenance and repair (cf. Graham and Thrift, 2007; Carr, 2017). Updating, managing and servicing our digital selves can become an all-consuming activity, illustrating the complex spatiality of digital skills in their 'unmooring' from specific times and locations.

So, where the previous section illustrated the interdependencies of humans and technologies that is obscured in macropolitical debates on digital skills, this section has deepened this analysis to show how such co-minglings occur through an extensive space that disperses skill. Rather than situated within the individual working body, global and urban spatial imaginaries illustrate how skills extend beyond a contained human-machine workplace. Such an extensive space of skill illustrates the distributed material and practical dimensions of different forms of labouring, and thus of enablement and constraint, to highlight again how the distinction between digital and non-digital skills is difficult to maintain. This is necessary to account for the ways 'technology keeps alive myriad distinct modes of production, and even resuscitates those that are obsolete and anachronistic' (Virno 1996, 17). Such micropolitical extensions of digital skill can be supplemented by focusing on the intensive space through which digital skills emerge between and beyond individual bodies in specific environments. It is this dimension to which we turn next.

3.3 Intensive-tracing: digital skills as emergent

Together with their extensive dispersal beyond contained workplaces, digital skills must also be understood as processes that happen across bodies, objects and environments. This is to emphasise the emergence of digital skills as they take place, meaning that they occur through and thus alter material arrangements through practice. This sub-section develops the important implication of this line of thought: the ways that skills become less an attribute that is possessed by individual bodies that can be known in advance, and instead have a shifting constitution through their 'intensive' emergence via the ongoing repetition of bodily practices in specific environments.

Poststructuralist process theories provide an important conceptual bedrock here. These theories have been instrumental in sensitising geographers to the relational constitution of bodies. Rather than bounded, stable and complete, process theories see bodies as continually re-formed through the ongoing practical encounters that they have with other bodies, human and non-human in specific environments (Anderson and Harrison, 2009). This relational

understanding of bodies is also more transitional since it understands bodies in terms of their changing capacities, rather than a more immobile and potentially idealised sense of their subject-based identities. A transitional account of bodies is helpful for approaching the changing geographies of the workplace through digital technologies. Instead of taking 'worker identity' as a starting point, we can begin by focusing on the capacities of the body that might (or might not) *become work*, despite not being in a formal workplace. Process theories of habit provide one sense of how such a rethinking of the body can push our understanding of digital skills. Bodies develop skilful competencies through repeated movements. Over time and through repetition, repeated movements become easier, more intuitive and the sensations associated with effort decrease (Ravaisson, 2008). Therefore, over time, and through repetition, a specific digital skill such as touch-typing or navigating a specific digital interface becomes 'second nature', because a repeated practice gives rise to forward-leaning bodily tendencies that operate below the threshold of our conscious attention, (potentially) freeing this up for other creative labours.

What marks this understanding of skill out from earlier geographical work on 'embodied knowledges' (Crang, 1997) is that these subconscious tendencies emerge through distributed body-brain-environment circuits (Thompson, 2007). It is the formative relationship with the specific material environment itself that is crucial to the competency of the skill taking place. This is because this environment cues a particular set of tendencies below the threshold of consciousness. A useful illustrative example here would be how even for an experienced typist, typing on an unfamiliar keyboard might be difficult and take some time to regain proficiency. Struggling with a practice which, in a different milieu, might previously have been 'second nature', demonstrates just how important the 'agency' of the material environment is for the successful execution of a skill (Bissell, 2013).

This idea of a digital skill being intensively distributed within an active 'body-brain-environment circuit' is well captured by Ash's (2015) concept of the 'interface envelope'. In the context of the specific digital skills that emerge through computer gaming, Ash outlines how, through repeated engagement, the material affordances of interfaces themselves sculpt the temporal and spatial perceptions of players. Emphasising the agencies of the interface, through this understanding, digital skills are wholly contingent on the particularities of the materialities of the interface environment, including the screen, resolution, and the controls. This conceptualisation invites an understanding of digital skills as emergent in ways that are

conditional on the specificity of particular environments (in this case, 'interfaces'), rather than something that discrete bodies are in possession of and can deploy in any situation. Ash also provides a sensitivity to the temporal complexities that can be overlooked in macropolitical conceptions of digital skill. Rather than digital skills being known proficiencies that, once learned, are unchanging, this understanding indicates how bodily capacities continue to be shaped by these material environments over time in slow-creep ways. As Ash's work indicates, the material digital interfaces with which an individual engages, over time and through repetition, change human capacities to act, to perceive and to sense.

This contingent milieu for skill raises questions of difference and translation: the extent to which skills, when understood as 'body-brain-environment circuits', are transposable through space and time. Whilst a specific digital skill could be isolated and subjected to examination, process theories remind us that in the course of the 'onflow' of everyday life (Thrift, 2008), bodies are in the thrall of countless practices, or 'practice bundles', as Shove et al. (2011) describe. Where digital skills might form through repeated practices within one 'interface envelope', such as the gaming space that Ash describes[3], or other interfaces such as the smartphones so central to the 'on-demand economy' touched on earlier, the intuitive bodily tendencies that develop through this specific envelope might find expression in other similar interfaces that are encountered (Ash et al 2017). Particularly significant here are the ways multiple digital interface architectures are becoming standardised in terms of the nature of interaction invited. Haptic gestures, visual grammars, and notifications, for instance, are repeated across multiple milieus. The standardisation of platforms as socio-technical arrangement and business model (Langley and Leyshon 2016), are a clear example of how a diverse range of services (e.g. transport, hospitality) have been designed around relatively similar interfaces. The purpose of this standardisation can be read precisely to cue latent pre-conscious habits so that the experience of using the interface for both worker and consumer is intuitive, not requiring cognitive labour and the associated sensations of effort. Digital skills here are therefore perhaps best understood as the pre-conscious intuitions that are developed through routine inhabitation within a range of different, but increasingly standardised, interface environments.

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[3] Noting the convergence of gaming and labouring environments that some argue is characteristic of forms of labour in the digital economy (e.g. Rogl 2016; Scholz 2013)

This intensive dimension of the dynamic space of digital skills shares a similarity with the focus on the co-minglings of bodies and technologies in section 3.1 in that it serves to 'distribute' agency across multiple materialities (Bennett, 2010). Capacities to act are not the sole preserve of the worker, the supervisor, or the owners of the means of production. Other objects such as screens and data do important agentive work, unsettling the seductions of locating skill in specific human forms. However, there are also important differences that are special to this intensive understanding of the micropolitics of digital skill. Where, in the historical co-production of skill, changes in the *form* of the human in workplace were evaluated (e.g. how the human might be extended or diminished; and how the human might be separated from or combine with technological devices), here inhuman *forces* have been evaluated, such as habit, that give rise to different qualities of digital working and which produce different bodily experiences. Thus, whilst co-mingling illustrates the contested nature of skilled labour with (digital) technology through challenging and changing definitions of human animation, process theories begin to indicate how digital skills open alternative sites of enablement and constraint. They do so by appreciating how digital skills could be understood as specific configurations of forces that emerge through ongoing routine practices across bodies, objects and environments, changing what are usually seen as 'human' capacities in the process.

4 Conclusion

Returning to our initial problematic, in an era of rapid technological change there is widespread anxiety concerning the potential impacts of digital technologies across a vast range of industries. Policy responses to this changing employment landscape have tended to champion the necessity for growing 'digital skills'. However, the prevailing macropolitical definition of digital skills which characterise policy responses tend to be narrow. Such policy responses draw on a restrictive 'discrete' understanding of space that sees digital skills as being individualised in discrete human bodies, and collectivised in discrete geographical locations. Whilst appreciating that this is necessarily so, given the remit of government, we have argued that such a discrete definition provides only a partial picture of the spatial politics of labour emerging through the diversity and complexity of digital skills.

To balance this, a dynamic space of digital skill elucidates a spatial politics that these dominant policy accounts tend to neglect. Where a macropolitical perspective imagines

power in a top-down way, that delimits and contains digital skills in individual human bodies, our micropolitical perspective draws out a more complex spatial politics by attending to the in-situ forms of enablement and constraint that take place in evolving forms of work. Rather than narrowly focusing on job loss or creation in numerical terms, as the more macropolitical perspectives do, we argue that the question of digital skill from a geographical perspective invites us to consider what the doing of work involves with digital technologies. This involves fine-grained attention to the materialities and practices that make up digital labour (c.f. Carr and Gibson 2017).

Through three dimensions of a micropolitics of digital skill, we set out a politics of enablement and constraint that occurs through dynamic spatial formations. First, our historical analysis highlighted how the co-mingling of humans and technologies in workplaces enacts a dynamic space where skills are distributed through multiple material forms in workplaces themselves. Second, our extensive analysis highlighted how the networked constitution of contemporary production enacts a dynamic space where skills are distributed across different often dispersed sites. Third, our intensive analysis highlighted how the inhuman forces to which bodily practices give rise enacts a dynamic space where skills have a virtual dimension, distributed between bodies and machines.

Our analysis indicates that government responses to evolving labour demands—which typically call for training more workers to become digitally-skilled—overlooks a more dynamic spatial politics of labour that a micropolitical focus provides. This micropolitical focus highlights the insufficiencies of singular accounts of the trajectory of both the quantity and the quality of 'digital skills'. Where accounts that prioritise *quantity* tend to evaluate digital skills according to proliferation or shortage, accounts that prioritise *quality* tend to evaluate digital skills according to the level of skill involved in the work (eg. low-skilled click-work vs. high-skilled data analysis). We have illustrated that in both cases, there are possibilities for positive and negative changes along these axes. Furthermore, where macropolitical understandings of digital skills imply a discrete phenomenon, a micropolitical attention to the materialities and practices of labouring involving new technologies indicates that the distinction between digital and non-digital skills is not clear cut. Whilst new forms of labouring with digital technologies are certainly emerging, our micropolitical account has demonstrated the importance of adequately historicising labour involving new technology, as well as attending to the continuities with previous ways of working.

The geographies of digital skill outlined in this paper raise several further areas of interest regarding the intersections of labour, life and digital technologies (Richardson 2016, 2017). One aspect involves expanding the 'objects' of research in economic geography, and with this, the spatial formations that are mobilised. Where more traditional approaches have often channelled their analysis through nested hierarchies of cities, regions, nations and global economies, our focus on the dynamic space of digital skills has indicated the complex geographical units that are forming and dissipating, both in practice and through the discursive circulation of spatial scales as targets of economic governance. Enhancing understanding of the variegated spatialities created by digital labour seems all the more relevant given the apparent return to economic protectionism that is currently being witnessed. As well as advocating for re-interrogation of these terms, we have also pointed towards alternative approaches to what an economic geography might be, grappling with questions of ontology which are concerned with rethinking these objects of research and their relationships. Such ontological questions open up new ways of appreciating what constitutes labour in changing regimes of production and consumption as a result of technological development.

Another trajectory might follow our emphasis on destabilising long-held views of the human labourer in two ways. First by historicising this figure; and second, by appreciating the non-human or posthuman dimensions of work. When the category of the worker no longer holds, as Braidotti argues (2013, 43), processes of 'political subjectivity' in relation to 'advanced capitalism', must necessarily engage with scientific and technological complexity. In this 'political economy that connects bodies to machines more intimately' (p. 89), accounts of materiality, and particularly the notion of 'immaterial' labour require further investigation. If the 'matter' of work is 'affective and auto-poetic or self-organising' (p. 158) then it is not surprising that more traditional labour politics no longer seem to achieve their aims. As we have suggested, through digital technologies there is a sense of labour taking on a life of its own, occurring beyond traditional institutions and conventions of employment. This raises questions concerning the purpose and method of a labour politics within the context of a complex changing system that is inadequately engaged by the 'organising workers' against 'employers'.

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