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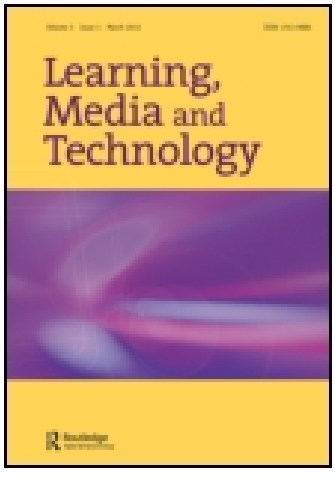

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Governing software: networks, databases and algorithmic power in the digital governance of public education

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Governing software: networks, databases and algorithmic power in the digital governance of public education

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This article examines the emergence of 'digital governance' in public education in England. Drawing on and combining concepts from software studies, policy and political studies, it identifies some specific approaches to digital governance facilitated by network-based communications and database-driven information processing software that are being discursively promoted in education by cross-sectoral intermediary organizations. Such intermediaries, including National Endowment for Science, Technology and the Arts, Demos, the Innovation Unit, the Education Foundation and the Nominet Trust, are increasingly seeking to participate in new digitally mediated forms of educational governance. Through their promotion of network-based pedagogies and database-driven analytics software, these organizations are seeking to delegate educational decision-making to socio-algorithmic forms of power that have the capacity to predict, govern and activate learners' capacities and subjectivities.

Keywords: algorithms; big data; databases; digital governance; learning analytics; networks; software

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Computer software has become thoroughly interwoven with contemporary forms of governance. More and more everyday practices, social interactions, cultural experiences, economic transactions and political decision-making are now mediated and governed through software systems. As a result, the software theorist Manovich (2013) has urged researchers from across all disciplines to examine how software changes what they study and how they study it. This article examines recent technology developments and related discourses in public education in England from a 'software studies' perspective, providing an analysis of some emerging software-mediated pedagogies and the organizations discursively sponsoring their application in schools. It situates these developments as part of what

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political scientists are beginning to describe as 'digital governance' in England, whereby public services are becoming the target for a host of governmental interventions and reforms augmented by software (Margetts and Dunleavy 2013). Education is an important site to examine the emergence of new methods and technologies of digital governance, yet to date there has been little research exploring the organizations participating in this shift or critically considering the digital technologies they seek to mobilize in such governing practices. The article seeks to address the near silence in the educational technology field to how digital technologies have become interwoven with the new governance of educational institutions (Selwyn and Facer 2013), most notably through the mobilization of educational data technologies to fabricate 'governing knowledge' (Fenwick, Mangez, and Ozga 2014). As Lawn (2013) has argued, 'data' has become a lively field of analysis in education, but there has been little acknowledgement of the role that software developments, technical capacities of data servers and the technical expertise of data analysts play in facilitating the collection, analysis, visualization and communication of educational data. Education is increasingly governed through data that is itself managed by actors and manipulated using software technologies that remain hidden and little understood. Likewise, in a previous issue of *Learning, Media and Technology*, Eynon (2013) identified 'big data' as an important but, to date, largely neglected subject of analysis in the study of education and technology.

Specifically, the article focuses on network-based communications and database-driven analytics software as emerging techniques that are increasingly augmenting, mediating and governing educational practices, and on the 'intermediary' organizations promoting these activities and discourses. It is concerned with how these organizations are increasingly delegating educational decision-making to 'algorithmic power' (Beer 2009), and with exploring how the contemporary governmentalization of software in education might act to shape and govern learner subjectivities. The article asks: What kinds of software are being promoted in the digital governance of education? Which organizations are sponsoring its use? And what kinds of effects might be exerted on the governing of learners' capacities and subjectivities? This analysis draws attention to some under-researched issues in educational technology: the role of intermediary policy actors such as think tanks in education policy and their mobilization of network-based and database-driven software in the digital governance of education.

Software studies

What is software, and why is it considered as a 'vital source of social power' that increasingly augments and governs contemporary societies (Kitchin and Dodge 2011, 246)? Whenever we speak of software, we are talking of something that is constituted by code, written in specific programming languages, and structured and operationalized through algorithms – sets of steps or

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processes which specify how to transform a given set of data inputs into an output – that can be automatically read and translated by a machine in order to *do* something. As the software researcher Mackenzie (2006, 2) has phrased it, 'what software does and how it performs, circulates, changes and solidifies cannot be understood apart from its constitution through and through as code.' As the substrate to software, code is significant as a kind of governing power because it can 'make things happen' by virtue of its 'execute-ability', its ability to perform tasks according to encoded instructions (Mackenzie and Vurdubakis 2011, 6). Software code is not inert. It is fundamentally performative. The performativity of code to make things happen and to produce outcomes autonomously lies at the heart of many recent accounts of the role of software in modern life.

Seeking to understand the mutual imbrication of software and society, a small but growing number of researchers in the social sciences and humanities – particularly in the interdisciplinary area sometimes known as 'software studies' (Fuller 2008) – have begun to examine it from a sociotechnical perspective as something that is both inseparable from its social, cultural, political and economic processes of *production* and its socially, culturally, politically and economically *productive* effects. Understood in software studies sociotechnically as a social product that is instructed by code and the socio-algorithmic procedures scripted by programmers to 'perform' tasks, rather than in a technologically determinant way, software therefore materializes particular ways of perceiving the world, as modeled and represented in the code that instructs it, which in turn can influence and shape how people act in and on that world. As Kitchin and Dodge (2011, 26) argue, computer code is

> the manifestation of a system of thought – an expression of how the world can be captured, represented, processed, and modelled computationally with the outcome subsequently doing work in the world. Programming then fundamentally seeks to capture and enact knowledge about the world . . . in order to augment, mediate, and regulate people's lives.

As a system of thought, software realizes and materializes particular ways of perceiving the world that can shape how people do things and interact with that world. It redistributes particular forms of thought and action, ways of perceiving and knowing the world, into people's lives, activities and practices of knowing and doing. Moreover, software studies suggest, people have been persuaded to view and understand software through the deployment of powerful and consistent discourses that promote, justify and naturalize it across a whole array of domains (Kitchin and Dodge 2011).

Both as a sociotechnical product that can model ways of thinking, seeing and doing, and as a set of powerful and persuasive discourses, software has now become a significant social actor that can govern and shape people's lives. The power of software is not just in its technical instructions but in how

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it sinks into collective discourse, thought, action and subjectivity. To say that we are increasingly subjects of 'governing software' means recognizing that code and data processing algorithms are immanent and everywhere in daily life, running as a substratum of experience with the power to variously instruct, seduce, educate, liberate, discipline and govern us, 'pervading more and more regions of beings' (Lash 2007, 70). As Mackenzie and Vurdubakis (2011, 4) express this, 'code is understood here not only in terms of software but also in terms of cultural, moral, ethical and legal codes of conduct' that are 'enacted in the contemporary world'. It is in this sense that, following Beer (2009), it might be argued that forms of 'algorithmic power' are increasingly playing a part in the coding and governing of contemporary societies.

Little research in education has adopted a critical social science perspective on software and code (though see Edwards and Carmichael 2012). Taking the sociotechnical perspective of software studies that acknowledges how software is embedded in the work of organizations and specific actors, and in the codes of conduct, ways of thinking and acting they promote, the article focuses on the participation of a cluster of cross-sectoral intermediary organizations in endorsing new forms of software in the digital governance of public education in England. These consist of a tight network of the Innovation Unit, the Nominet Trust, the Education Foundation, Demos and the National Endowment for Science, Technology and the Arts (NESTA). The focus is specifically on how these organizations mobilize software in discourses intended to reimagine public education, and on tracing the software effects that might result. Their current preoccupation, as the article shows, is with social media software as a platform for new forms of socially networked learning, and with database software through which learners are to be analyzed by data processing algorithms. Ultimately these intermediary organizations are seeking to reimagine educational governance as digital governance whereby cross-sectoral actors have more power and influence, and in which their governing power is extended into the shaping of learners' subjectivities through linking them in networks and 'knowing' them through database software.

Intermediaries

The article is part of ongoing research to document and analyze the participation of intermediary organizations, such as think tanks, social enterprises, policy labs and third sector institutions, in public sector governance in the UK (Williamson 2014). It focuses particularly on a tight network of organizations that promote software technologies in the governance of public services such as education. Throughout, the analysis assembles conceptual resources from three overlapping fields: from political and education policy studies of shifting governance, particularly the shift to what has been termed 'digital governance' (Margetts and Dunleavy 2013) and the emergence of cross-sectoral 'policy networks' in education governance (Ball 2012; Lawn and Grek 2012); from

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sociological analyses of styles and techniques of governing (Rose 1999); and from software studies related to governing (Kitchin and Dodge 2011; Ruppert 2013). In this article, then, I mobilize these resources to examine how cross-sector intermediaries are contributing to new ideas about the digital governance of the education system; and how they aspire to activate software as a means of governing individual learners. This is a form of governing through software-mediated pedagogies, with the aim of managing, administering, sculpting and enabling the capacities of the learner.

Adopting methods of 'policy network analysis' (Ball 2012), the emphasis is on identifying actors and organizations, and on tracing the connections, relationships and discourses that constitute their networks. Through this process I have identified a tightly connected interorganizational network consisting of NESTA, Demos, the Innovation Unit, the Nominet Trust and the Education Foundation. The next stage of policy network analysis involves policy text and discourse analysis. I focus on the reports, pamphlets, websites and other documents which articulate the ideas and aspirations of cross-sectoral intermediary actors in education. The analysis concentrates explicitly on their mobilization of discourses related to software and data systems, and considers what systems of thought and what subjectivities, ways of seeing, knowing and doing, are promoted through the kinds of software-mediated practices they aim to embed in education. From a Foucauldian discourse analysis perspective, Selwyn (2013) reminds us that discourse is the historical and cultural production of systems of knowledge and beliefs that both shape and are shaped by our behavior. All aspects of technology use in education are thus ultimately constructed in political, professional, academic and commercial discursive arenas. Discourses delimit what and how education can be thought, spoken and done, though they do not determine it. In this sense, software has been justified and naturalized discursively as a seemingly common sense solution to a whole range of educational problems. My approach is to trace the organizations that have produced particular discourses around software use in education, and then to explore how the network and database software they promote might exert material and subjectifying effects. Before getting into the detail of these discourses, it is first necessary to introduce the main network of intermediary actors and their interorganizational and discursive connections.

Demos was founded in 1993 as a cross-party think tank of the 'radical center' and over a 20-year span has been responsible for mobilizing a number of 'big ideas' in British political thinking, including many associated with emerging software forms, as detailed in its anniversary publication *Twenty Years of Ideas* (Scott and Goodhart 2013). In 2013 it established a Centre for the Analysis of Social Media (CASM) to use 'big data techniques' and algorithm-based processes of data mining, visualization and prediction, or 'social media science', in the analysis of public policy problems (Miller 2014).

NESTA was established by the New Labour government in 1998 and, though it is now fully independent, it participates in many debates about

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public sector reform (see NESTA 2012 for an organizational biography). In 2011 the former Demos co-founder Geoff Mulgan became NESTA chief executive. NESTA has established a 'Public Innovations Lab' dedicated to 'solving social challenges' and many of the documents, projects and web pages produced by the lab specifically apply technological discourses to reimagine and redesign future public services (Mulgan 2014). 'Digital education' is one of the lab's main themes and it has produced reports and web materials extensively in this area.

The Innovation Unit is a social enterprise first formed within the Department for Education and Skills in 2002 and spun-out as an independent not-for-profit organization in 2006 to innovate in public services (for organizational details see Innovation Unit 2014). A key Innovation Unit publication focuses on the role of 'innovation intermediaries' that deploy technological solutions and techniques of digital R&D to solve educational problems (Horne 2008), and one of its key areas of work is 'twenty-first century education'. The Innovation Unit has worked extensively in partnerships with Demos and NESTA.

The Nominet Trust was established in 2008 by Nominet, the internet registry which maintains the .uk register of domain names. The Nominet Trust (2014) invests in projects and programs 'using the internet to address big social challenges'. The trust describes itself through the discourse of social investment, social innovation and social technology entrepreneurship. Its chair is Charles Leadbeater, who has published reports for Demos, NESTA and the Innovation Unit, and it is closely linked and partnered with NESTA, particularly around initiatives promoting 'digital making' and computer coding in education, as discussed later.

The Education Foundation was founded in 2011 and describes itself as 'UK's first cross party, cross sector education think tank, with a passion to help create a more open and connected education system' (Education Foundation 2011). Its work is focused on education reform; technology and innovation; and policy changes affecting the education and learning sector. It runs an 'ed-tech incubator', an accelerator program for educational technology start-ups, and supports 'the rise of the teacherpreneur' – 'pioneering teachers to develop solutions from their own experiences using new technologies that are free or inexpensive' (Education Foundation 2013a). The Education Foundation is a partner alongside NESTA in the Next Gen Skills program to promote coding skills in schools, and one of its co-founders became an advisor in 2014 to the Year of Code, a government-backed scheme promoting programming.

Together, I refer to these organizations as educational intermediaries that contribute to increasingly dispersed, heterogeneous and sometimes unstable networks of governmental, civil society and business actors and interests. They consist of think tanks, policy labs and social enterprises that increasingly criss-cross public, private and third sector borderlines and mobilize resources and ideas from across academic research, political thought, design, media

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and digital R&D in order to stimulate and motivate educational change (Williamson 2013). Sometimes described in the educational policy literature as 'ideas brokers' that produce, circulate and distribute policy ideas, educational intermediaries contribute to 'policy networks' that accommodate a blurring of the boundaries between the state, commerce and civil society, and the dispersal of responsibilities between actors from all sectors (Lawn and Grek 2012). They are interorganizationally networked, often with a flow of staff, partnerships and associations between them. Moreover they are all interdiscursively connected; ideas and discourses are routinely shared among the network; and they reference one another in publications and talks. The analysis below traces how ideas and discourses related to software are now being produced and circulated by these intermediary actors in their imagining of digital governance in public education in England. Of course, this represents only a selection of the various policy institutes and think tanks operating in the area of education in England. Policy Exchange, Civitas, the Centre for Policy Studies and the Centre for Market Reform of Education are prominent examples. However, their emphasis is more explicitly on reform through new kinds of free schools and new markets in education and would require more detailed analysis elsewhere.

The rest of the article is organized in three main sections. First, it articulates the overall vision of digital governance promoted by intermediary organizations across public services, including education, in England. Second, it examines how a series of initiatives focused on network-based learning – utilizing various social media and social network sites as pedagogic platforms – have been promoted as new ways of acting on learners' capacities. Third, it examines how intermediary organizations have begun to promote the power of database-driven processes of 'big data' collection, analysis and visualization in 'knowing' learners, before offering a discussion of these developments for the governing and shaping of learner subjectivities.

Software in digital governance

Why are software, algorithmic processes and computer code important to intermediary organizations? NESTA, Nominet Trust, Demos, Education Foundation and Innovation Unit documents all talk of digital forms as models for reinventing public services, including education. To give more of a sense of the overall reformatory vision being promoted by these intermediary organizations, this section provides a series of examples. Former Demos founder and current NESTA chief executive Mulgan (2005), for example, writes of the 'co-evolution' of computational technologies with decentralized 'matrix models' of 'e.governance' that involve civil society organizations participating in all public services facilitated by software. More recently writing in a NESTA publication, Mulgan and Leadbeater (2013) advocate digital platforms for new models of governance:

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> We have embraced vast new system for creating, sharing, processing and analysing information from the Internet and the world wide web, through to new generations of mobile phones, and social media to the possibilities of cloud computing, the semantic web, and the Internet of Things. These digital platforms could allow us to create more distributed, networked systems to achieve feats of coordination previously associated with large hierarchical organizations. (Mulgan and Leadbeater 2013, 30)

The authors embrace the notion of using 'big data' sources to track and trace individuals as they go about their daily lives online. These data include transactional data, such as that generated through online shopping, using transport and making entertainment choices; and personal and behavioral data shared on blogs and social networks like Facebook. Leadbeater (2011), who has worked in a variety of roles with Demos, NESTA, Innovation Unit and the Nominet Trust, considers the potential for 'government by algorithm', an approach to governance involving systems to mine and analyze 'big data' and algorithmic methods to create 'more effective and intelligent public systems' (Leadbeater 2011, 18).

As political scientists Margetts and Sutcliffe (2013, 139) point out, this big data not only offers scope for understanding human behavior, social structure and citizens' civic engagement; it can 'also be used for algorithmic and probabilistic policymaking' and 'for more coercive modes of governance, whether by introducing conditionality into public policy and services or simply exerting "nudges"'. The arguments of Mulgan and Leadbeater, and the approaches that the organizations to which they are attached appear to endorse, represent a form of 'digital governance', which Margetts and Dunleavy (2013, 6) describe as 'the adaptation of the public sector to completely embrace and imbed electronic delivery at the heart of the government business model'. Digital-era governance, they argue, is a response to technological developments such as analyzing 'big data' from 'transactional processes', 'peer production' and 'network effects', and to new popular ideas of 'crowdsourcing', 'cognitive surplus', 'wikinomics' and 'democratization' (Margetts and Dunleavy 2013, 7). Key features of digital governance include: automated 'zero-touch' technologies; behavioral policy and persuasive 'nudge' technologies; big data analysis; co-production or co-creation of services; database-led information processing; digital by default public service transactions and interactions; intelligent center – real-time government data-pooling; network-based communications; open data; and social web development within online government (Margetts and Dunleavy 2013).

Most significantly, Margetts and Dunleavy (2013) argue, digital-era governance is an organizational response to the coupling of network-based communications and database-led information processing software. On the one hand, networks allow for forms of governance through a 'social web' of communication with individuals – governance with a voice. On the other hand, database software allows for forms of governance through an 'intelligent center'

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gathering and pooling information about individuals – governance with a brain. This is what Ruppert (2012, 117–118) calls the 'technocratic infrastructure' of 'database government', a shift from the 'qualitative' governance of the social to the 'quantitative' governance of the 'informational'. In digital governance, network-based and database-led software has been governmentalized. Intermediary organizations, as examined further below, are now aiming to exploit these network-based and database-driven modes of governing, particularly those that afford 'zero-touch' interaction with learners, big data analysis and behavior-changing techniques.

Networks and databases are thus the dominant forms of software facilitating the reinvention of governance. However, neither networks nor databases are neutral devices, but are entangled in normative imaginings of the future and reconfigurations of subjectivity. In relation to the former, 'networks provide a diagram on the basis of which reality might be refashioned and reimagined: they are models of the political future' (Barry 2001, 87). Likewise, a 'database way of thinking' about governing seeks to intervene, through 'personalized packages of public services', in 'both who people are and who they are possibly becoming' (Ruppert 2012, 128, 130). In this sense, it is important to acknowledge that governance is not merely a structural matter of dispersing responsibilities among state and non-state actors. Instead governing needs to be understood in terms of the practices and techniques through which organizations, agencies and authorities seek to act upon and shape the actions, thought and behavior of individuals. As Rose (1999, 4) argues, 'to govern is to act upon action'. Education is a key site for governing young people's capacities to act in this way; pedagogy is itself a form of governing. For Pykett (2012, 1) 'governing through pedagogy' refers to the techniques deployed by both state and non-state actors, including schools, universities, civil society organizations, commercial companies, the media and government departments, to 'manage, administer, discipline, shape, care for and enable' individuals. Adopting these understandings of governing as those techniques, including pedagogy, exercised to 'act upon action', it is possible to understand software as one element among many techniques of contemporary schooling that are infused with the aim of sculpting learners' conduct and subjectivity. The governmentalization of software in digital governance means that code acts upon action.

According to Margetts and Dunleavy (2013) central government is lagging behind both the private sector and civil society in the digitization of governance. This is a key point for my argument that through their deployment of discourses concerning networks and databases in digital governance, intermediary organizations such as NESTA, Demos, the Innovation Unit, Education Foundation and Nominet Trust are seeking to make education a particular target for reform. At the heart of this effort are both an aspiration to distribute educational governance among a wider network of cross-sectoral relationships and an aspiration to use software to influence and shape the behaviors and subjectivities of young people in schools.

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Social networks

Digital governance is constituted by network communication technologies and database-driven information processing. This section examines how the form of the network has been deployed by intermediary organizations as a model for reinventing public education, with a particular emphasis on the Innovation Unit's Learning Futures pedagogic initiative, the Education Foundation's Facebook for Educators program and the NESTA/Nominet Trust partnership Make Things Do Stuff. Technically, networks are understood as a complex 'algorithmic mosaic of calculations carried out to allow communication to occur in the presence of many others' (Mackenzie 2010, 68). But beyond this, networks today figure in a discursive reimagining of modern life. As Barry (2001) argues, networks are routinely mobilized as a model of the future, as demonstrated by the emergence of discourses such as 'network enterprise', 'policy networks', 'network governance', 'network society', 'social networking' and 'networked learning' across different social fields. Constituted technically by the processes coded and expressed in algorithms, and by new and emerging codes of social conduct, networks have both a material basis in computer code, calculation and algorithmic structure, and a basis in social, political, cultural and economic discourse. Learning Futures, Facebook for Educators and Make Things Do Stuff are illustrative of this interweaving of the social and the technical in relation to networks in education.

The Innovation Unit endorses the idea of an 'innovation ecosystem' for education (Hannon, Patton, and Temperley 2011; Innovation Unit 2012a). In such an educational ecosystem school is imagined as a 'base camp for enquiry' that is supported beyond school by the internet, mobile technologies and a 'vastly increased number of education providers', many accessed virtually (Innovation Unit 2012b). Its Learning Futures initiative is based on a model of a network of 'extended learning relationships' including teachers, tutors, experts, mentors, coaches, peers and families as well as industry, local businesses, cultural institutions, community organizations and the internet (Innovation Unit 2012b, 11). In this innovation ecosystem, education is reimagined through the use of social networking sites for peer-to-peer learning and collaborative research; online chat, instant messaging and email to strengthen the student–teacher relationship; digital portfolios as a continuous performative record; and the use of Twitter hashtags to collate research sources (Hampson, Patton, and Shanks 2012). The Innovation Unit implicitly promotes a form of 'network governance' where outsider organizations are involved in educational provision, including companies whose principal business is software. Learning Futures constructs learner subjects that can be characterized as networked learners participating in a connected ecosystem of learning at home, at school and online.

While Learning Futures folds a variety of social media software into its reformatory vision, the Education Foundation has focused specifically on promoting the social networking site Facebook in schools. *The Facebook Guide for*

Educators was produced by the Education Foundation (2013b) in a project commissioned by Facebook. The report claims that Facebook has the potential to make education more 'open', more 'connected' and more 'social':

> Facebook's community of 1.1bn users give it unparalleled power as a tool for research and collaboration between students and young people and . . . to support the way young people, teachers and other educators collaborate, access and curate new learning. Facebook tools such as Timeline, Groups and Graph Search have the potential to revolutionize the way homework is planned, completed and reported on – it's Homework 2.0. (Education Foundation 2013b, 2)

The report reflects great optimism in social media software to transform education. Its dominant discourse is one of 'communication', 'creation' and 'curation' rather than centralized control of learning. It makes the school curriculum appear to be an outdated relic of an era of enclosures that is at odds with the emergent possibilities of open networks, interconnected systems, interactivity and participation facilitated by social media. The 'algorithmic mosaic' of calculations and connections constructed by programmers and computing corporations that actually constitutes a social media network is rendered hidden and invisible by these claims. Discursively framed by the Education Foundation in this way as easily and routinely criss-crossing the technical and the social, the network model reflects a 'typically modern political fantasy' (Barry 2001, 16) in which networks are thought of as solutions to problems as varied as community fragmentation, technical literacy, entrepreneurial freedom, social and political relations and the challenges of globalization. Learning Futures and Facebook for Educators both turn on the idea of the network for the reinvention of the curriculum and are fashioned on the network as a model for solving a whole series of social, political and economic problems.

Other intermediary organizations have drawn on the ostensibly participative nature of networked social media to advocate new forms of software-mediated education. NESTA and the Nominet Trust, in partnership with the internet company Mozilla, launched an initiative called Make Things Do Stuff in 2013 that promotes various forms of programming and 'digital making'. The Education Foundation also became involved in 2014 in an advisory role with the Year of Code campaign to promote programming skills. The Make Things Do Stuff initiative is described as an 'open movement' and is partnered with a range of technology companies, education businesses, third sector organizations and government – a clear example of cross-sectoral network governance (Cave and Rowell 2014; Williamson, forthcoming). The Make Things Do Stuff website states that: 'In a world where everything from fridges to cars, bank accounts to medical diagnoses are becoming powered by computing, understanding how digital technologies are made (and how to make your own) is vital to full participation in society' (Make Things Do Stuff 2013b). In response to this context of a computer-mediated present,

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> Make Things Do Stuff aims to mobilize the next generation of digital makers. We want to help people to make the shift from consuming digital technologies, to . . . hacking, re-mixing and making things with technology . . . . Make Things Do Stuff will enable people to . . . navigate a path that will take them from being a digital consumer, to being a digital maker. (Make Things Do Stuff 2013a)

It mobilizes the pervasive discourse of 'user-generated content', 'co-production', 'crowdsourcing' and 'prosumption' associated with social media as a model for reimagining an education system in which learners are not merely passive consumers but active and participative producers. In software studies, Manovich (2013) argues that social media is ultimately premised on the simplification and programming and software development, so that the production of media has been 'democratized' to the everyday lay expertise of participation in social media.

Questioning the apparent democratization of media production, however, Beer and Burrows (2013, 49) argue that network-based social media – Facebook, Twitter, YouTube, Wikipedia and so on – have facilitated the increasing participation of people in the formation of media content, leading to the 'significant phenomena of the growing amount of "laboring" people are undertaking as they "play" with these new technologies: creating profiles, making status updates; distributing information; sharing files; uploading images; blogging, tweeting; and the rest'. The idealization of networks for learning, as illustrated by Learning Futures, Facebook for Educators and Make Things Do Stuff, is an outgrowth of this proliferation of technologies of co-construction, crowdsourcing and prosumption, a kind of training for new practices of media production in a highly networked social media culture.

Beyond these popular yet vague discourses, it is important to understand participation in social media networks as participation in the principal information and communication infrastructure of contemporary life. Beer (2013) has argued that information and communication networks are now part of the physical and material infrastructures that orchestrate the economic, political and cultural patterns of social existence, yet for most of the time they remain hidden and invisible as part of the taken-for-granted background of our lives. These are what Kitchin and Dodge (2011, 6) call 'coded infrastructures' that are deeply embedded in how we live, work and act. Coded infrastructures such as computer networks are monitored and regulated by software and they are subject to the commercial interests of for-profit communication corporations. They are also programmed in ways which enable much greater automation and autonomy from human oversight, as online recommendation systems and tailored search engine returns clearly exemplify. Therefore, according to Beer (2013, 27) 'these infrastructures are coming to be more lively and active', with 'some constitutive implications for people and places'. In this sense, it is necessary to see the social media networks being promoted in education not as neutral, depoliticized spaces, but as being shaped,

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patterned, ordered and governed by 'lively' and commercialized coded infrastructures. Social media network infrastructures are the hybrid progeny of software code and codes of social conduct.

The active liveliness of the network infrastructures underpinning social media raises the question of the possible effects on people and social relations. Are network infrastructures influencing a reconfiguration of sociality and subjectivity? In the imaginings of networked learning proffered by education intermediaries there is a perceived symmetry between the networked infrastructures of the present with the apparently natural sociality of people. The Education Foundation report on Facebook in education is indicative. The report is premised on an affinity between 'digital and social learning':

> Education systems around the world are undergoing a revolution in teaching and learning, with the advent and maturity of new technology driving new forms of engagement between students, teachers and the wider world, powered by the web. Digital and social learning often starts from the perspective of where young people are accessing knowledge and learning for themselves. That learning is typically interactive, student centred, collaborative and on demand. It is often outside of school hours, in non-formal settings and increasingly peer to peer via their own friends and networks. Teaching and learning is and will become much more social. (Education Foundation 2013b, 4)

Here the individual is understood as a social learner who is addressed as a participant in new digitally mediated social configurations. It is based on contemporary discursive preoccupations with crowdsourcing, peer-to-peer sharing, open access, smart mobs, collective intelligence, participatory cultures and so on, yet elides and glosses over the material, economic and political particularities of the technical infrastructures ordering the social networks of social media.

Facebook for Educators, like Make Things Do Stuff and Learning Futures, presents an image of the human actor as an ideally socially networked creature on the basis of which the learner is now to be addressed and governed both as an individual subject and as a social actor. The networks of social media are mobilized by them as models for understanding human sociality. Rose (2013) has offered some notes towards an understanding of emerging forms of 'governing sociality'. With social media, he argues, new images of what actually constitutes 'the social' are emerging. The 'social' is no longer understood in terms of society, but in terms of social media connections. The CASM at Demos is a good example of an attempt to understand the contemporary social world through social media; it conceives of the social world as being materialized and enacted through the coded infrastructures of network providers. However, Rose (2013) goes on, these conceptions are mirrored and strengthened by the growth of expert commentary around the 'social brain', 'social learning' and 'social networks' which imply a particular conception of individual and social conduct. For example, Facebook is built upon particular understandings of people as socially networked beings. The kinds of social

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possibilities programmed into the Facebook software and other social media sites tend to emphasize the idea of horizontally connected friends. Facebook's 'people you may know' algorithm seeks to optimize users' sociality by establishing a kind of algorithmic normality for social relations. The algorithmic normalities of Facebook thoroughly govern the guidance for educators offered by the Education Foundation – the Facebook model of sociality is translated into the ideal model of social learning by this guidance. In this sense, the socially networked learner in Facebook for Education is actually being imagined in relation to the new technical infrastructures of private for-profit telecomms providers, twinned with expertise about such things as 'social learning', the 'social brain', 'social networks' and so on. The idea of the 'social brain' of the 'social learner' connected to others via 'social networks' is a particular image of the individual and of sociality that is not natural and pre-given but an expertly constructed accomplishment. The conduct of the learner is to be governed and shaped according to a system of thought about sociality that is programmed in to the Facebook networking environment.

Public services and government techniques are increasingly being planned in the light of such expert understandings. The Innovation Unit, Education Foundation, Demos, Nominet Trust and NESTA are contributing to the distribution of such thinking in public education. The kind of networked, rapid, agile governance they advocate also, moreover, involves the collection of quantities of data from learners, as examined next.

Database pedagogies

In recent years there has been an explosion of interest in database-led technologies of 'big data', 'data mining', and 'data analytics'. These techniques utilize the 'data traces' left from individuals' online interactions, whether from a social networking site like Facebook, internet banking and shopping or from an online government service, and subject them to analysis using data processing algorithms. From a software studies perspective, database-driven technologies are significant since 'the sociotechnical instantiation of many aspects of the contemporary world depends on database architectures and database management techniques' and the socio-algorithmic processes of 'ordering, sorting, counting and calculating' involved in making big data intelligible (Mackenzie 2012, 335, 338). In this section, I examine how intermediary organizations have promoted 'big data' and 'learning analytics' in their reinvention of education.

'Big data' has become the source of much optimism in publications produced by intermediary organizations. To offer a brief sample from these texts, Nominet Trust has published a report on the use of 'big data' to support 'social organizations' and the third sector (Ross 2013); NESTA has produced a number of documents on big data techniques as a way of 'sampling society' and reconfiguring services (Davies 2013); and the Innovation Unit has made big data techniques of data mining into part of its 'radical efficiency'

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reform package for public services (Gillinson, Horne, and Baeck 2010). Demos has been especially active around big data, with a series of reports (Leadbeater 2011; Bartlett 2012; Wind-Cowie and Lekhi 2012) and most recently its establishment of a CASM. CASM is dedicated to 'social media science' utilizing 'taught algorithms' to explore 'the "datafication" of social life':

> To cope with the new kinds of data that exist, we need to use new big data techniques that can cope with them: computer systems to marshal the deluges of data, algorithms to shape and mould the data as we want and ways of visualising the data to turn complexity into sense. (Miller 2014, n.p.)

Underlying its commitment to 'social media science' is a belief that the behavior of citizens – both conceived individually and socially as a population – can be mined, analyzed and predicted through their 'data traces' in order to make it possible to develop new policy ideas or governing solutions. Through the data trails left from their interactions and transactions in networked infrastructures, people can be made visible, knowable and thus amenable to governing intervention. This is a form of digital governance in which data are increasingly to be processed by software, including software that has the autonomy to analyze individual and social behavior and on that basis to anticipate or even predict their future behavior. 'Machine learning' is the term to describe 'intelligent' software systems that build statistical models from users' data to predict their actions, behaviors and attitudes (Mackenzie 2013). Algorithms that can be taught to anticipate and predict how people act, or machine learning, have been positioned as a major component of the new techniques of governing promoted by educational intermediaries. All of these organizations promote big data as a key technique of governing education – making learners visible, knowable and amenable to pedagogic intervention.

A specific software development related to database technologies is the promotion by intermediaries of 'learning analytics'. Learning analytics is an educational outgrowth of machine learning and predictive data analytics software. It utilizes data to interpret a learner's activity, provide real-time feedback, and adapt and 'optimize' that learner's future behavior accordingly (Timmis et al. 2013). The Innovation Unit, for example, has supported the use of analytics to collect data in order to 'know' learners, sort and aggregate them on the basis of personal and behavioral data and respond with an algorithmically generated 'playlist' of appropriate personalized pedagogy (Hampson, Patton, and Shanks 2012). Through its partnership with the commercial education technology company Promethean, the Innovation Unit supports analytics systems that

> focus on learner activity through mining clicks, attention/focus 'heat maps,' social network analysis, and recommender systems. Learning analytics extends these basic analytics models by focusing on curriculum mapping, personalization and adaptation, prediction, intervention, and competency determination. (Looney and Siemens 2011, 9)

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According to the report, these systems can be used for 'automated or human intervention, personalization, and adaptation' (10). The Nominet Trust, too, has produced a series of blogposts on learning analytics, including a proposal for a customizable educational web browser which could provide a personalized 'dashboard' to visualize students' data (e.g., Knight 2012). Indeed, learning analytics is routinely packaged up in the discourse of 'personalized learning' and a wider emphasis by these intermediaries on practices of data mining and analytics in the semi-automated personalization of public services (Williamson 2014).

Likewise, NESTA has advocated 'adaptive learning technologies' which use student data, algorithmic learning analytics and feedback mechanisms to adapt and personalize learning:

> Adaptive learning technologies use student data to adapt the way information is delivered to a student on an individual level. This data can range from online test scores to session time (how long users spend on a single exercise) to records of where a user has clicked or touched while figuring out a problem. Based on this feedback, the programme will understand which content to point the user at next – planning a personalized learning journey. (NESTA 2013a)

Another NESTA document claims adaptive analytics provide 'the means to shift away from a one-to-many model of teaching, so that every child has a "digital tutor" that is responsive to their interests, their prior-conceptions and achievement'; and the potential for 'intelligent online platforms that can use data gathered from learners to become smart enough to predict, and then appropriately assist and assess, that learner's progression to mastering the concept being taught' (NESTA 2013b). Based on socio-algorithmic techniques of machine learning, psychometric learner profiling and predictive modeling, the aim of learning analytics is to create 'smart' pedagogic systems, or what might be termed database pedagogies. These database pedagogies can include automated messages which provide brief and simple nudges or fully automated intelligent tutoring systems. Learning analytics promises the socio-algorithmic production of data-based personalized pedagogies.

In this area, NESTA has specifically supported Beluga Learning which applies data-based learning analytics, adaptive software and artificial intelligence technologies to learner data. Beluga makes use of two types of learner data: 'intelligent data' such as curriculum data, semantic data and linked data that is often collected by educational institutions; and 'off-put data' from students' own social media programs. It conducts 'smart analysis' on both of these sources of data in order to create an academic and psychometric profile of each individual user which can be compared and matched with an entire population of user profiles:

> The data is allowing the software to make a real-time prediction about the learner and changes the environment, . . . the pedagogy and the social experience . . . . This

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> process occurs continually and in realtime, so that with every new piece of data collected on the student, their profile changes and the analytical software re-searches the population to compare once more . . . . The content and environment then adapt continually to meet the needs of the learner. (Beluga Learning 2013, 5–6)

Beluga is smart 'adaptive learning' software that is able to 'behave with an intelligence' in order to adapt and personalize education. When machines make decisions about education through learning analytics software systems such as Beluga, they introduce certain kinds of systems of thought and models of the world that have been programmed in algorithmic processes into education.

Database-led learning analytics and adaptive software systems such as Beluga and others promoted by NESTA, the Nominet Trust and the Innovation Unit exemplify what software researchers Kitchin and Dodge (2011, 85) have termed 'automated management'. This term captures how new software systems can be coded to collect and process information about people and things in ways that are increasingly automated (technologically enacted), automatic (the technology performs without prompting or direction) and autonomous (making judgments and enacting outcomes algorithmically without human intervention). Automated management is a form of governance that uses sources of data and analytics software to anticipate individuals' future lives. The codes and data processing algorithms of analytics software work by collecting, compiling and calculating data about people and creating profiles and classifications in order to sort and sift them. This constructs a digital shadow-profile, or a kind of data-based doppelganger, that can anticipate individuals wherever they go (shopping, traveling, working and learning) and may be used to modify how each person is treated. Through the kinds of learning analytics systems being promoted by NESTA, the Nominet Trust and the Innovation Unit, as well as more widely in the big data techniques of machine learning deployed by Demos, data processing algorithms are being positioned as a potential governing resource that can be utilized to anticipate learners' futures, and even intervene to activate their future behavior.

Databases are being positioned as powerful socio-algorithmic sources of social influence in education through emerging automated management software systems such as learning analytics. As Eynon (2013, 238) has identified, the 'big data' systems of learning analytics act as 'recommender systems' with significant social implications. Perhaps most significantly, Mackenzie (2013) argues that algorithm-based 'machine learning' and 'predictive analytics' software such as learning analytics are part of a world in which 'probabilistic outcomes' and predictions about the future now prevail. Machine learning, he argues, increasingly impinges on people's 'everyday actions, habits and practices' (Mackenzie 2013, 396). The consequence of such anticipatory techniques is what Mackenzie refers to as 'programming subjects in the regime of anticipation' – a process of subject formation which is based on an anticipatory knowledge of one's own future produced by software.

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There are clear issues for education and the formation of learner subjectivities raised by such an anticipatory regime. In her research on databases in children's services, Ruppert (2012, 125) has argued that 'database devices are based on the logic that the subject is made up of unique combinations of distributed transactional metrics that reveal who they are and their capacities, problems and needs'. Assembled from digital traces as a 'data double', the individual can be constantly combined and recombined in different configurations, with significant consequences for their future treatment (Kitchin and Dodge 2011). These anticipatory technologies work recursively and dynamically to identify individuals based on patterns and regularities; on that basis to make predictions and recommendations; and through those algorithmic processes, to shape and govern how they might think and act in the future. The data interact with people in ways that change them. As Ruppert (2013, n.p.). argues, 'such software systems or "algorithm machines" do not merely implement a policy or programme but are generative of both their subjects of governing and modes of intervention'. Recast in terms of learning analytics, such recommender systems can be understood as automating the production of personalized packages of pedagogies for learners. These pedagogies are formulated from distributed data about them, anticipate their future, and on that basis actively intervene to change their educational experiences and thus their future lives.

The governable subject of learning analytics is 'made up' as a data doppelganger to be utilized to predict future needs and program future pedagogic intervention, and consequently to make up the learner anew. In this sense, the database-driven 'algorithm machines' of governance in public education proposed by Demos, NESTA, the Nominet Trust, the Education Foundation and the Innovation Unit would not just work by identifying and categorizing individuals, but would be dynamically co-constitutive of new kinds of persons for futures yet to come. The learner 'made up' by these intermediary organizations is not just a recipient of new personalized learning, but to be algorithmically interwoven in a constant automated feedback loop of data collection, analysis and anticipation in order to predict and personalize future pedagogic provision. The conduct of the learner is to become the target of decision making that is in part delegated to the automated and algorithmic power of database software.

Conclusion

This article has traced the participation of a number of cross-sectoral intermediary actors in contemporary reimaginings of public education in England. It has explored how a tight interorganizational policy network including NESTA, Demos, the Innovation Unit, the Education Foundation and the Nominet Trust, are currently seeking to governmentalize software in education in ways that are consistent with emerging models of digital governance. In tracing their particular discursive construction of networked communications

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and database-driven software and infrastructures, the article has specifically mobilized conceptual resources from the nascent field of software studies to explore how these organizations aspire to govern and shape learners' actions, thoughts, conduct and subjectivities. They make learners the subjects of 'governing software'.

According to software studies, rather than being merely technical, software is a hybrid of lines of code and social codes of conduct. It encodes particular systems of thought, action and social interaction in the world that reflect the political, economic and cultural particularities of its production and the contingencies of its uptake. Through the projects and initiatives of educational intermediaries, emerging ways of conceiving and representing sociality, such as through the optimization and maximization of networks of horizontally connected friends on Facebook, are increasingly becoming normalized in techniques to govern learners. Through their imagining of social networks in education, these organizations contribute to emerging notions of learners as networked individuals whose 'social brains' are to be activated and optimized through new forms of software-mediated social learning. The 'social learner' addressed by these organizations is no naturally evolved kind of person, but an expert sociotechnical accomplishment with significant consequences for how learners are to be governed in the future.

Moreover, these organizations are all now seeking to mobilize the potential of educational big data, especially the socio-algorithmic 'recommender systems' and calculative techniques of machine learning to analyze and anticipate learners' future lives. Discursively packaged in terms of personalized learning, database-driven techniques of learning analytics have the potential predictive power to anticipate how learners will act, think and behave in the future, and on that basis to intervene in their learning and their future lives. Ultimately, in digital governance networks and databases are tightly coupled. By connecting people in networks, more and more data on their interactions and transactions can be collected, which can in turn be pooled in databases, made calculable and mined by machine learning software to generate anticipatory knowledge and predictive forecasts of likely future activity. These data can then be used to specify appropriate governing interventions – and if deemed necessary, according to the socio-algorithmic normalities programmed into the software, to reactivate the capacities of the individual.

The analysis presented here has necessarily focused on identifying the interorganizational and discursive consistencies, relationships and connections that constitute the network. More documentary and empirical detail is required to bring out more of the messiness, contingency and fragility than has been possible here. Moreover, the focus has been on reformatory aspirations, imagined futures and discursive production rather than on observable activity. The intermediary organizations examined demonstrate two emerging developments in educational governance that require further empirical documentation

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and analysis. First, they propose and promote the participation in educational governance of cross-sectoral organizations and new kinds of relationships that criss-cross sectoral borderlines and traverse boundaries between the fields of education, politics and digital R&D. Second, and as part of this shift to more dispersed governance, they sponsor and support the mobilization of network and database software to govern learners. Database software such as learning analytics and social media networks are part of the material infrastructure of contemporary digital governance, including emerging forms of socio-algorithmic, automated and anticipatory governance that requires 'zero-touch' in terms of human intervention. The intermediary organizations seeking to govern public education and other public services in England are ultimately concerned with anticipating and activating the capacities of individuals for futures that are still to come. It is a task of subject formation that is, at least in part, to be delegated to the massive data collecting capacities of social media networks and the predictive power of machine learning analytics software.

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