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Political computational thinking: policy networks, digital governance and 'learning to code'

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Reflecting political shifts toward both 'network governance' and 'digital governance', the idea of 'learning to code' has become part of a major reform agenda in education policy in England. This article provides a 'policy network analysis' tracing the governmental, business and civil society actors now operating in policy networks to project learning to code into the reformed programs of study for computing in the National Curriculum in England. The insertion of learning to code into the curriculum provides evidence of how the education policy process is being displaced to cross-sector 'boundary organizations' such as 'policy labs' that act as connecting nodes to broker networks across public and private sector borderlines. It also examines how the pedagogies of learning to code are intended to inculcate young people into the material practices and systems of thought associated with computer coding, and to contribute to new forms of 'digital governance'. These developments are evidence of a 'reluctant state' deconcentrating its responsibilities, and also of a computational style of political thinking that assumes policy problems can be addressed using the right code. Learning to code is seen as a way of shaping governable citizens that can participate in the dynamics of digital governance.

Keywords: computing curriculum; computational thinking; learning to code; governance; policy networks; policy labs

Education policy has become a significant site for the analysis of changing styles of governance and political thinking (Grek 2014). This article documents how emerging forms of both cross-sectoral 'network governance' and technology-enabled 'digital governance' have combined in a significant area of policymaking in education. Since 2010, the idea of 'learning to code' – learning the skills of computer programming – has grown from a minority concern among computing educators, grassroots computing organizations and computer scientists into a major curriculum reform discourse in England. Originally articulated by campaigning groups including Computing at School and learned societies such as the Royal Society, 'learning to code' has been actively promoted in England by cross-sector organizations – among them Nesta (the National Endowment for Science, Technology and the Arts) and the Nominet Trust – that are increasingly participating in new kinds of network governance in education. These new forms of governance are characterized by being decentralized, horizontal and nonhierarchical, and are made up of various networks, public–private partnerships, flexible alliances, couplings and combinations of interests from across diverse sectoral positions and local, national and global spaces (Kutay 2014; Ozga, Segerholm, and Simola 2011). Organizations like Nesta and Nominet Trust participate as 'connective nodes' in such networks and alliances,

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mobilizing their connections across public, private and civil society sectors to translate disparate activities around agendas such as learning to code into major policy concerns.

In England, the result is that learning to code has become an important educational policy agenda. This is evidenced by the disapplication of the subject 'ICT' (Information and Communication Technology) in the English National Curriculum in September 2014, which critics claimed overemphasized functional skills for using computers, and its replacement with new 'computing' programs of study focused instead on computer science concepts, programming skills and 'computational thinking' (Department for Education 2012; Peyton Jones, Mitchell, and Humphreys 2013). Computational thinking is a distinctive way to 'tackle problems, to break them down into solvable chunks and to devise algorithms to solve them' (Computing at School 2014a, 5), and, as argued below, its implantation in the curriculum reflects an emerging style of political thought and governance.

At the same time, learning to code is related to the growing recognition of the significance of digital technologies in the practices of contemporary government. The rapid rise of 'big data', 'algorithmic regulation', 'data analytics' and even 'smart cities' that are orchestrated through technical infrastructures reflect how software code and algorithms have been put to work in disparate social, political, cultural and economic contexts, across governmental, civil society and industrial sectors, and in scientific, social science and humanities disciplines (Kitchin 2014a). As part of this, a form of computational thinking is emerging in relation to contemporary techniques of governance. It assumes many social, scientific, governmental and human problems can be treated as technical problems to be solved or optimized through the application of the right code, algorithms and data, twinned with the necessary expert techniques of programming, algorithm design and software development (Kitchin 2014b). In this context, strategies of 'digital governance' have become central to how governments aspire to manage relationships with citizens (Margetts and Dunleavy 2013). Digital governance involves shifting services into new digital formats that will allow governments to continually gather huge reservoirs of data on citizens' everyday activities, interactions and transactions – data that can then be mined, analyzed and used as insights to shape services – whilst simultaneously encouraging citizens to become responsible participants in the coproduction and provision of those digital services (Williamson 2014a).

The shift in political ambition toward digital governance is underpinned what I term *political computational thinking*: a contemporary style of political thought that 'takes technical change as the model for political invention' and is preoccupied with the 'models of social and political order' technology seems to make available (Barry 2001, 2). A style of thinking refers to particular ways of thinking, practicing, making explanations, conceptualizing problems and proposing solutions in a given professional or disciplinary community. Political computational thinking is a style of thought, then, that aims to translate social phenomena into computational models that can then be solved by being formalized as step-by-step algorithmic procedures that can be computed as proxies for human judgment or action. It is in the context of the emergence of political computational thinking that interest has coalesced around learning to code. Although this is not an entirely coherent and stable network – but a messy hybrid of intentions, ambitions and interests – learning to code is being positioned in part as a pedagogic relay for inculcating the capacities considered necessary for citizens to participate in the computational dynamics of an increasingly digitized social and political order. At its core, digital governance depends on a compact between government acting as a 'platform' and citizen participation in the design and delivery of its services (O'Reilly 2010).

The intention behind this article, then, is to trace how cross-sectoral policy networks of actors, working through network governance, are contributing to the formation of techniques of digital governance; a task they seek to accomplish by promoting learning to code as a means toward the production of digital citizens who can participate in these new governing strategies. That is to say, through their participation in learning to code, individuals are to be sculpted as governable citizens enabled with the appropriate digital capacities to become active citizens in the emerging dynamics of digital governance. In this sense, education is an important space for researching the emergence of digital governance. Learning to code has been translated from a grassroots campaign into a relatively stable and coherent policy agenda in a remarkably concentrated period, yet the actors mobilizing it into education policy, the material practices of coding promoted through its pedagogies and its wider connections to changing techniques of governance remain under-researched. In this article, I trace the policy developments, discourses and cross-sectoral and interorganizational connections that have translated learning to code into education policy as a situated example of network governance. I also undertake an analysis of learning to code in the context of shifts in the work of government, particularly by exploring its consonance with emerging ideas about applying computational solutions to political problems, ideas that exemplify emerging digital governance approaches. The learning to code agenda and its interweaving into the new computing curriculum provides evidence of both emerging forms of cross-sectoral network governance in education policy processes, and of emerging strategies of the digital governance of the state.

Policy network analysis

Methodologically, the article provides a 'policy network analysis' of the actors participating in the circulation of key discourses and imaginaries around learning to code. As Ball and Junemann (2012, 14) articulate it, the method of policy network analysis seeks to identify actors, their associations and relationships, and their power and capacities to contribute to policy decision-making. Adopting these methods, the article is based on mapping a set of social relations around the learning to code agenda, and an investigation of each of the actors identified by conducting detailed web searches for their key documents, resources, social media products and media coverage. From this mapping, I have selected for the analysis presented in this article a sample of over 30 reports, pamphlets, Web sites and other documents, spanning the period 2010–2015, and I have analyzed how the documents articulate these intermediaries' ideas, discourses and aspirations around learning to code.

The framework for the analysis applied to these organizations, documents and discourses draws on 'translation' from the field of science and technology studies, particularly as such ideas have been mobilized in studies of policy and governance (e.g., Rose 1999; Freeman 2009). Such studies seek to trace how it is possible for techniques of government expressed in one place to become linked with 'action at another, not through the direct imposition of a form of conduct by force, but through a delicate affiliation of a loose assemblage of agents and agencies into a functioning network' (Miller and Rose 2008, 35). As Freeman (2009) reinforces, translation does not imply the imposition of direct authority, but the indirect means by which actors explore differences in interests, in order to then derive shared practices and values by translating the concerns of others' in their own terms. Through persuasion, negotiation and 'the dynamics of translation, alignments are forged between the objectives of authorities wishing to govern and the personal projects of those organizations, groups and individuals who are the subjects of

government' (Rose 1999, 48). It is thus through translation that shared interests and linkages are assembled and stabilized between political agencies (as well as other agencies) and the aspirations of individuals, who all come to construe their problems in allied ways. In many cases, in order for translation to occur, key mediators and experts are required to act as relays to forge these alignments between the aspirations of authorities and the aspirations of citizens. This is a mode of operation that Rose (1999, 49) terms 'government at a distance', whereby political aspirations are channeled through nonpolitical mediators to make their problems seem intrinsically linked with the problems faced by citizens themselves.

Intermediary organizations such as Nesta and the Nominet Trust, as detailed next, act as seemingly nonpolitical mediators that have translated diverse perspectives on learning to code from across government, civil society and business into a relatively stable network of affiliations. The result of these translations has been the replacement of ICT with new computing programs of study. This curriculum reform event is not simply a direct governmental imposition, but the product of negotiations, persuasions, compromises and conflicts that have, at least temporarily, been juxtaposed and stabilized into a sufficiently coherent network of affiliations to be enacted as a shared project.

Policy intermediaries

The main focus is on the organizations Nesta and the Nominet Trust, and on how they have established networks between governmental, civil society and commercial actors to promote and campaign for learning to code to be embedded in UK education. Nesta was established as the National Endowment for Science, Technology and the Arts with an £80 million endowment by the UK New Labour government in 1998 but became independent in 2011 with a remit to innovate in public services (see http://www.nesta.org.uk/about-us for full organizational details). Nesta works with various philanthropic organizations as well as with commercial businesses, civil society organizations and in collaboration with government departments. 'Digital education' is one of Nesta's key themes, and its activities around learning to code are all managed within its 'Public Innovation Lab' that seeks to 'solve social challenges' through the application of new technologies. Nesta has become particularly closely intertwined with the work of central government under the leadership of Geoff Mulgan (a former government policy adviser and the cofounder of the 'radical center' think tank Demos) since 2011. In 2014, Nesta became a joint partner with the UK government Cabinet Office to run the Behavioral Insights Team (often known as the 'Nudge Unit') to apply behavior change theories to public policy, and in 2015 teamed up with the Cabinet Office's Open Policy Team to explore how emerging technologies might act as a 'digital platform' for the functioning and organization of government (Maltby 2015).

The Nominet Trust was established in 2008 as the philanthropic outgrowth of Nominet, the commercial Internet registry that maintains the .uk register of domain names (see http://www.nominettrust.org.uk/who-we-are). The Nominet Trust invests in projects 'using the internet to address big social challenges' and describes itself through the discourse of 'social investment', 'social innovation' and 'social technology entrepreneurship'. It also commissions reports on key areas such as 'digital making' and the politics of computing, and represents a messy mix of advocacy for the digital economy, support for grassroots organizations, the social economy and civil society, as well as journalistic and academic commentary on aspects of digital culture.

Organizationally, these are neither solely governmental nor commercial actors, but straddle sectors and broker projects and connections between them as 'boundary organizations' (Grek 2014). Nesta and the Nominet Trust both act as connecting nodes for a variety of partnerships and networks that breach sectoral borderlines and traverse disciplinary and methodological boundaries. They are prototypical of emerging organizational forms that Nesta documents describe as 'public and social innovation labs' ('psilabs') or 'innovation teams' ('i-teams') (Mulgan 2014a; Nesta 2014a). The 'psilab' or 'i-team' is a hybrid organizational format combining elements of the political think tank, disciplinary expertise in social and political science, and innovative digital R&D for solving social and public problems. Nesta's own 'public innovation lab' and the Nominet Trust's emphasis on 'social tech' are evidence of how such organizational reconfigurations are enabling them to position themselves as solution-providers for public and social policy problems, primarily conceived in terms of their dominant style of computational thinking.

In terms of their political positioning, these organizations crisscross the borderlines between the public and private sectors and are contributing to new forms of 'network governance' and 'policy networks' in public education in England. 'Network governance' is characterized by decentralization, mobility, fluidity, looseness, complexity and instability, by the crisscrossing of sectoral borderlines and the hybridization of ideas, discourses and materials from bureaucratic, academic and media fields, techniques formerly exemplified in the work of think tanks (Shaw et al. 2014). While conventional policy instruments have not been completely overturned, the shift to network governance in education is evident from the entry of new participants into policy processes, changes in prevailing policy discourses and changes in the relationships between the state and nonstate, nonpublic sector organizations (Ball and Junemann 2012). Within this turn to network governance, educational policy networks have emerged as important interorganizational and cross-sectoral sources of influence, as 'social mechanisms that can work across social, governmental and geographical boundaries' and 'build bridges that bring together a diverse range of actors, including governments, businesses and civil society' (McGann and Sabatini 2011, 67). Policy networks are thus sociospatial arrangements in which acts of translation are particularly apparent, as diverse interests, practices and problems are brought into alignment, with key actors such as Nesta working as intermediaries to broker social relations and mutual affiliations.

The concepts of network governance and policy networks are not uncontentious: Jessop, Brenner, and Jones (2008) have queried the ways that networks and other horizontal, interdependent, rhizomatic, topological and transversal connections have been conceptualized as the basis of many sociospatial relations. However, Ball and Junemann (2012) claim that in England education policy certainly is now being dispersed to and enacted by increasingly heterogeneous and sometimes unstable networks of governmental, civil society and commercial actors, which constitute a blurring of the distinction between public, voluntary, philanthropic and for-profit provision. As Lingard and Sellar (2012, 48) have argued, this reflects a wider political agenda in the UK that 'has placed renewed emphasis on civic society … as the primary locus of response to social problems rather than state intervention'. Williamson (2014b) argues that it is part of a governmental strategy to locate 'nonideological' solutions to educational problems, in the context of what Ball (2012, 102) terms a 'reluctant state' that is 'both shuffling off old responsibilities and defining and distributing new ones' to a messy patchwork of outsourced providers, commercial actors, 'hero entrepreneurs', philanthropic groups and other nonstate actors.

In this context, 'psilabs' such as Nesta and the Nominet Trust act as hybrid, boundary-bridging organizational forms within sociospatially connected policy networks of both governmental and nonstate actors. Through brokering and mediating relationships, alliances and partnerships, they combine elements of entrepreneurialism, commercial contracting, philanthropic 'giving' and policy think tankery with innovative methods of digital R&D. Through such networks they are now seeking to do parts of the work of the reluctant state, with a particular focus on the application of technical solutions. In seeking to demonstrate how education is increasingly being governed through networks of 'policy labs' and 'social innovators', the rest of this article analyzes how Nesta and the Nominet Trust have promoted the practices of learning to code, and some of the translations orchestrated in doing so.

Constructing the computing curriculum through learning to code

Today there is a growing interest in teaching computer programming to young people, evidenced most clearly in the introduction of new computing programs of study in the National Curriculum in England in September 2014. In this section, I analyze how learning to code has been discursively constructed and circulated by cross-sector intermediary organizations, including Nesta and the Nominet Trust, to translate governmental, commercial and civil society sectors into shared concerns.

Learning to code campaigns

Some of the first support for the idea of learning to code and for enhancing programming and computer science in the curriculum in the UK came from Computing at School. Computing at School is a member-led subject association for computing teachers initiated at Microsoft Research in 2008, which is chaired by a senior Microsoft researcher and is funded by Microsoft, Google and the British Computing Society (also known as the Chartered Institute of IT). The Computing at School 'white paper' of 2010 was among the first documents to argue for the replacement of ICT in the National Curriculum with computing. The paper from Computing at School (2010) argued that 'computing is the study of how computers and computer systems work, and how they are constructed and programmed', and it suggested that a new computing curriculum would include the study of 'how computers work', how algorithms, data structures, systems and networks are used to solve computational problems, as well as teaching the knowledge and skills of programming. Computing at School has also argued strongly for an emphasis on 'computational thinking' in the computing curriculum, as a 'philosophy that underpins computing' or a framework that consists of processes of decomposition, pattern recognition, abstraction, pattern generalization and algorithm design (Computing at School 2014a).

However, it was in 2011 when Nesta published a report entitled *Next Gen* (Livingstone and Hope 2011) that the key messages about computing and learning to code took on policy significance. *Next Gen* demanded more 'rigorous teaching of computing in schools' and recommended putting computer science into the national curriculum for schools in England. The report did not originate, however, from a concern with the teaching of computing in schools. Rather, it was commissioned as a review of the skills gap in the videogames and visual effects industries, which have long been seen as economically valuable and innovative sectors of the UK digital economy. The authors, Ian Livingstone and Alex Hope, are industry leaders in the videogames and visual effects

sector, and the report was commissioned by Ed Vaizey, then Conservative Party Minister for Culture, Communications and the Creative Industries.

After an initially sluggish political response, the importance of *Next Gen* was signaled after Google chief executive Eric Schmidt used the platform of the MacTaggart Lecture at the Edinburgh Television Festival in 2011 to express his dismay that computer science was not taught as standard in UK schools. This was a message repeated by Google executives in a global lecture circuit urging governments to support young people to learn to code in order to produce a skilled workforce for a digital economy (Cave and Rowell 2014). One of the coauthors of *Next Gen* has argued explicitly that it was Eric Schmidt's MacTaggart Lecture that mobilized political support for Nesta's report and its curriculum recommendations (Livingstone 2012). At around the same time, the impetus to replace ICT with computing in the curriculum was supported by a Royal Society (2012) report entitled *Shut Down or Restart* that was directly commissioned by Microsoft, Google and university computer science departments. The Cambridge academic and *The Observer* newspaper columnist John Naughton (2012) contributed to the debate with a high-profile series of articles including a 'Manifesto' for reintroducing computer science in schools. The subsequent formation of a 'Next Gen Skills coalition' consisting of members from Nesta, BCS, Google, Microsoft, Computing at School and Raspberry Pi finally convinced the Department for Education and then-secretary of state for education Michael Gove to support the disapplication of ICT and its replacement by a new computing curriculum (Livingstone 2012).

Besides the proliferation of reports, speeches, manifestoes and coalitions around programming and computer science in schools, the learning to code movement has been propelled into public visibility through a number of high-profile projects and start-ups. Perhaps most notable is 'Code Club', a volunteer-based initiative that places computer programmers in after-school clubs in primary schools to teach young children basic programming and coding techniques. Code Club was established in April 2012 and has grown into a nationwide network of clubs in over 2000 UK primary schools (at the time of writing in early 2015), as well as a Code Club World network. Code Club is sponsored and promoted by Nesta and the Nominet Trust with funding from their 'Digital Makers Fund', is supported by corporations including Microsoft, Google, ARM, Samsung, Mozilla and TalkTalk, and is also supported by the Department for Education, the Cabinet Office and the Canary Wharf Group investment company (itself a major investor in smart cities technologies through the 'CogniCity' initiative also launched by Ed Vaizey in his later position as Smart Cities Forum co-chair and Minister for Digital Economy; Mitchell 2014).

Code Club is one among many start-up initiatives that, during 2013, were increasingly clustered and networked together as part of a concerted campaign to promote young people to learn to code. In May 2013, the Public Innovation Lab at Nesta, in partnership with the Nominet Trust and the Internet company Mozilla, launched an initiative called Make Things Do Stuff to promote various forms of learning to code, programming and 'digital making'. Its activities are distributed among a wide cross-sectoral network. The initiative is described as an 'open movement' and is directly partnered with technology companies, education businesses, third-sector organizations and government. These include the commercial companies Facebook, Microsoft, O2, Mozilla and Virgin Media; the start-ups Codecademy, Code Club, Raspberry Pi, Technology Will Save Us, Coding for Kids and Decoded; campaigning initiatives including Computing at School, Next Gen Skills and Young Rewired State; and HM Government, the Scottish Government and the Teacher Development Trust. The Chancellor of the Exchequer, George Osborne MP,

launched the initiative in May 2013 claiming that 'this campaign is backing the entrepreneurs of the future and helping ensure that Britain is equipped to succeed in the global race' (HM Treasury 2013). Echoing this political discourse, the Nominet Trust chief executive claims there is a 'serious and economic imperative' besides the 'fun and learning that digital making offers young people', namely that the 'UK and global jobs market are crying out for digital skills and we need to make sure that the next generation can meet this need' (Nominet Trust 2013). The Make Things Do Stuff campaign is the hybrid progeny of educational, governmental, commercial and grassroots discourses and the actors and organizations that actively promote them.

Other campaigns have featured a more overtly entrepreneurial ambition. In the US, the 'Hour of Code' campaign was established in 2013 by code.org, 'a non-profit dedicated to expanding participation in computer science by making it available in more schools'; its 'vision is that every student in every school should have the opportunity to learn computer programming' (Code.org 2014). Code.org was founded by the entrepreneurs Ali and Hadi Partovi, twins with a long history of 'angel investment' and venture capitalism in Silicon Valley, has been partnered with or sponsored by donations from Microsoft, Google, Amazon, Dropbox, Facebook and many others, as well as by philanthropic individuals from across commercial computing and venture capitalism. Back in the UK, the 'Year of Code' campaign was established in January 2014 – to coincide with the introduction of the new computing curriculum in England – to help people 'learn code and create exciting things on computers' (Year of Code 2014). The Year of Code Web site provides links to a range of start-up organizations and activist campaigns related to learning to code, as well as an extensive network of partners, again, from across government, commercial media and civil society – many with overlapping links with Nesta and Nominet Trust's Make Things Do Stuff initiative. Year of Code is chaired by Rohan Silva, a former senior policy advisor to Prime Minister David Cameron, and an 'entrepreneur-in-residence' at Index Ventures, an international venture capital firm dedicated to technology entrepreneurship. The executive director and advisors of Year of Code are almost all drawn from the fields of entrepreneurship, venture capital and computing. Its only explicitly educational advisor is from the Education Foundation, an 'independent think tank for education' that advocates and champions digital innovation in education and acts as a partner with other technology companies, notably Facebook, to introduce their products in schools. The Education Foundation is also a participant in the Next Gen Skills coalition established by Nesta to support the recommendations of its *Next Gen* report.

The heavy weighting of the Year of Code toward venture capital, ed-tech lobbying and entrepreneurship has drawn a number of criticisms, not least for blurring the lines between public policy and commerce in important social agendas (Cellan-Jones 2014). As Naughton (2014) has argued, 'Year of Code is a takeover bid by a corporate world that has woken up to the realization that the changes in the computing curriculum . . . will open up massive commercial opportunities'. As if to demonstrate the commercial attractions of the new computing curriculum and its links with the learning to code movement, the chief executive of Codecademy (a Make Things Do Stuff partner organization) claims to have 'struck oil' as the new computing curriculum introduced in England is 'forcing an entire country to learn programming' (Dredge 2014).

The development of Hour of Code in the US and Year of Code in the UK is evidence of how initial grassroots movements and start-up activities, such as Computing at School and Code Club, have been translated by increasingly powerful cross-sectoral intermediaries like Nesta into major policy agendas and from there absorbed into the entrepreneurial mission of venture capital companies. Cave and Rowell (2014, 260–61) describe the

various activities surrounding the learning to code movement and the reform of the computing curriculum as a 'lobbying tool for technology firms with a clear, vested interest in digitizing learning, as well as enthusing a new generation of coders'. Singling out the roles of Nesta and the Education Foundation, in particular, they argue that this campaign of business-backed think tanks and education technology lobbyists has now 'got what it wanted' in the shape of computer science in the curriculum, as well as political acceptance by the Department for Education for technology to be integrated and embedded across the whole curriculum, thus supporting a strong UK educational technology market. Learning to code is also embedded in concerns about the capacity of businesses and government agencies to make use of big data sources and more intelligent, connected devices, as outlined in a report by the government Design Commission (2014), which recommends further governmental support for the teaching of code in the curriculum as well as digital making and shared 'makerspaces/hackspaces' in schools, colleges and universities. The role of Nesta and the Nominet Trust has been to translate and configure these diverse interests across activist, governmental and venture capitalist settings, redefining their different concerns as shared problems for which learning to code initiatives have then been proposed as the solution.

Learning to code in the computing curriculum

The relationships, partnerships and connections detailed above demonstrate that there is a clear cross-sectoral policy narrative in evidence in relation to the growth of learning to code initiatives. These entanglements of computer companies with government via intermediaries such as Nesta and the Nominet Trust have influenced the 2014 replacement of 'ICT' with 'computing' in the National Curriculum in England. In contrast to the basic functional skills of using computers that critics claim were characteristic of the ICT curriculum, such as how to use a word processor or a database, the computing programs of study explicitly focus on programming and coding along with 'computational thinking' and core knowledge from disciplinary computer science (Department for Education 2013).

It is important, however, not to assume a simple unidirectional narrative of policy influence. The Department for Education has retained a strong steering capacity throughout the development of the new computing curriculum. It granted responsibility for drafting the new curriculum to the Royal Academy of Engineering and the British Computing Society, in association with Computing at School, in summer 2012. The main coordinators of the group have described the huge effort to form likeminded coalitions of organizations and individuals around the notion of computing as the 'fourth science' in schools, followed by a highly concentrated period of multistakeholder consultation, that all culminated in the production of draft computing programs of study in late 2012 (Peyton Jones, Mitchell, and Humphreys 2013). However, the final version of the draft was finalized by senior BCS executives rather than by the entire consultative team, and then between submission of the draft in December 2012 and its publication by the Department for Education for public consultation in February 2013, several major revisions were made. As commentators pointed out at the time, the computer science elements and the teaching of programming skills had been amplified in the published programs of study, while elements on creativity, criticality and 'digital literacy' had been entirely deleted, to the dismay of many contributors to the draft (Berry 2013; Twining 2013).

Despite these misgivings, with its introduction in September 2014, the computing curriculum has been accompanied by a number of developments from both public and

private sector organizations. The BBC, for instance, has launched a major campaign around coding to support the computing curriculum in 2015. A key part of 'Make It Digital' involves the distribution of a handheld 'coding device' called a 'Micro Bit' to over a million secondary school children in the UK (BBC Media Centre 2015). Nesta is a key partner in the initiative and helped launch it with the publication of a report on the state of 'digital making' across the UK in early 2015 (Quinlan 2015). In addition, Computing at School (2014a) has devised its own booklet offering guidance for teachers on computing in the National Curriculum, and the Department for Education has subsequently awarded funding (alongside Microsoft, Google and others) for Computing at School to support a 'Network of Teaching Excellence in Computer Science' to grow teaching capacity in advance of its implementation, while Microsoft has also funded Computing at School to develop a 'Quickstart Computing' series of teacher training session (Computing at School 2014b).

All of these cross-sectoral and sociospatial intersections of governmental and commercial activities, many of them orchestrated and brokered by intermediary organizations such as Nesta, demonstrate that learning to code is no longer simply an after-school activity run by volunteer programmers, as originally envisioned by Computing at School, Code Club and other likeminded grassroots and start-up organizations. As these entanglements between government, businesses, intermediaries, lobbyists and educational organizations demonstrate, learning to code has become the focus for the development of complex new cross-sectoral alignments and networks, culminating in 2014 with a new computing curriculum that makes learning to code a learning outcome for all schoolchildren in England. Campaigns such as Year of Code and Make Things Do Stuff, and the various projects, initiatives and organizations they represent, exemplify the kind of cross-sectoral policy networks that are increasingly participating in educational network governance in England. The learning to code policy discourse is not merely a government product, but the hybrid and ultimately contingent result of disparate computing specialists, entrepreneurs and investors, journalists, policymakers, lobbyists and corporate computing companies, all brokered by boundary organizations such as Nesta and the Nominet Trust. It demonstrates clearly how educational governance is increasingly being displaced to actors from outside of the educational sector itself that can span boundaries between governmental, business and civil society organizations and practices, and that work by translating diverse concerns and aspirations into networks of affiliation, partnership and allied interests.

The hidden curriculum of learning to code

Despite its rapid growth and its insertion into the computing curriculum in England, the underlying assumptions about learning to code, and the political agendas to which it has been attached, remain under-researched. At least one close commentator on the development of the new computing curriculum has pointed out that in fact learning to 'code' and 'programming' are not quite the same thing, although they have been largely conflated in curriculum documentation as the process of addressing problems through computational thinking and by constructing algorithmic procedures that can be formally expressed in code (Berry 2014). The neglect of critical attention about learning to code is significant in that it reflects particular forms of understanding. So what, as it were, is the 'hidden curriculum' of learning to code?

Coding regimes

Learning to code carries into the classroom a specific set of assumptions about knowledge and forms of knowing and doing. Programming code is not just a technical procedure but is related to systems of thought about the way the world works, and about how it might be modeled in order to further shape people's interactions with it. As Kitchin and Dodge (2011, 33) have argued, coding is a 'disciplinary regime' with established 'ways of knowing and doing regarding coding practices'. Code, in other words, projects the 'rules' of computer science and its system of computational thinking into the world (Lash 2007). Kitchin and Dodge (2011, 26) argue that the material practice of programming is 'an expression of how the world can be captured, represented, processed and modelled computationally with the outcome subsequently doing work in the world'. In other words, programming code captures ideas about how the world works and translates them into formalized models that can be computed through algorithmic procedures, which can then augment, mediate and regulate people's lives. In this sense, code and the programming practices that construct it can be seen as materializations of a computational style of thinking that apprehends the world as a set of computable phenomena.

Moreover, the material practices of learning to code assume a certain image of the desirable individual learner. As Mackenzie (2006) argues, the work of computer programmers is premised on notions of flexibility, speed, virtuality, just-in-time-production, teamwork and other aspects of 'immaterial labor'. Make Things Do Stuff, *Next Gen*, Code Club and Year of Code all anticipate learners' entry into a digital economy for which the work of programmers stands as a prototypical practice. Thus an emphasis on learning to code is part of what Barry (2001) describes as a political preoccupation with sculpting a mind and body with the technical skills, knowledge and capacity to meet the demands of new flexible work routines. In this sense, learning to code may be interpreted as a material practice of 'algorithmic ideology' (Mager 2012), a kind of inculcation into the codes of conduct, practices, assumptions and knowledges that underpin contemporary digital forms of production and consumption.

Taking such points as cues, learning to code can be understood as embodying a host of assumptions and working practices based on ideas such as computational thinking, statistical modeling, systems thinking, scientific rationality and procedural algorithmic logics that have their origins in the working practices of the programming profession. These are very specific kinds of social practices imbued with 'particular values and contextualized within a particular scientific approach', reflecting often reductionist, functionalist and technicist modes of thinking that see the world in computational terms rather than in relation to cultural, economic or political contexts (Kitchin 2014a, 5). At its most basic, such practices amount to the fantasy of technocratic 'solutionism' where the right code and algorithms may be seen as the solution to complex problems (Morozov 2013; Kitchin 2014b). Learning to code thus seeks to inculcate learners into the systems of computational thought and conduct associated with the professional regime of programmers and the 'culture of code' in which its assumptions, knowledges and practices are embedded (Hayes 2015).

Ignorant expertise

It is clear that for its advocates at Nominet Trust and Nesta coding is positioned as a rewarding, desirable and skilled occupation. Yet this depiction glosses over the fragility, complexity and mundanity of much coding work in the digital economy. As Mackenzie

(2006, 14) notes, coding may be undertaken by 'a programmer, webmaster, corporation, software engineer, team, hacker or scripter …. The figure of the programmer often vacillates between potent creator of new worlds and antisocial, perhaps criminal or parasitic'. More prosaically, the work of coding is often precarious, dull, routinized and monotonous, as well as difficult, frustrating and dysfunctional (Kitchin and Dodge 2011). Owing to intense ongoing innovation in the field, programmers are always struggling to learn and adapt to constant change and experience a high degree of 'ignorant expertise' and confusion about what they are doing (Ullman cited in Kitchin and Dodge 2011, 35), particularly in relation to the wider possible social effects of the software they produce (Thrift 2005). Coders simply do not always know the effects of the code they are writing, and nor do they acknowledge how their own worldviews, ideologies and assumptions are embedded in the kinds of interactions and forms of doing that they make possible.

As a result, the learner participating in Code Club, Year of Code, Make Things Do Stuff, or the like, is being solicited into a system of thinking, knowing and doing associated with coding practice that is not always as systematic, objective and expert as it is widely represented as being by learning to code advocates. Learning to code is premised on a fantasy of the material practices associated with coding that simplifies and glamorizes the reality of disciplinary practice in the commercial digital sector, whilst seeking to bolster the skills base for the digital industries that are seen as important value-creating sources of the near future. Not all supporters of learning to code initiatives share this commercial and economic enthusiasm, however. In August 2014, one cofounder of Code Club was forced to quit over demands from its board that she refrain from criticizing the 'corporate mass surveillance' practices of commercial sponsor Google (Sandvik 2014). Others question the long-term utility of children learning to code. Some reports suggest, for example, that a great deal of programming work will be automated in the near future by advances in 'machine learning' (Frey and Osborne 2013), and that the idea of learning to code is being made obsolete by developments in 'cognitive computing' (Wakefield 2014). Such claims cast the political and economic logic of learning to code campaigns and policies around the new computing curriculum into doubt.

Prosumption

Whilst acknowledging their own economic logics, Nesta and Nominet Trust also justify Make Things Do Stuff through a wider cultural argument about people producing and not simply consuming technology:

> 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 making and building their own. Because when all kinds of different people start hacking, re-mixing and making things with technology, the possibilities get really interesting. 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)

Coding clubs and related digital making activities promote 'participatory' practices of 'coproduction', 'personalization' and 'prosumption' in new social media practices, as its advocates at Nesta and Nominet Trust suggest (Make Things Do Stuff 2013b; Quinlan 2015). 'Prosumption' registers the alleged blurring of production and consumption as consumers of digital media increasingly also become its producers, as social media – Facebook, Twitter, YouTube, Wikipedia and so on – enables users to create and post

content and perform their own customizations and remixes of existing digital material. While prosumption is presented by its advocates in highly positive terms, its critics claim the increasing participation of people in the formation of media content is leading to the 'significant phenomena of the growing amount of "labouring" 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' (Beer and Burrows 2013, 49). Prosumption firmly embeds people in what Beer and Burrows (2013) term the social media 'infrastructures of participation' that are subject to the commercial interests of for-profit telecommunication corporations.

Ideas such as prosumption, coproduction, personalization and so on have long been adopted by organizations such as Nesta. It has put such practices at the center of its reformatory ambitions for 'people-powered public services' and new 'conversational' forms of 'sociable governance' – all evidence of the emerging governmentalization of social media as governments seek to capitalize on the information about citizens contained in its massive data sets. Learning to code is a direct outgrowth of this concern with citizen-centric coproduction, personalization and prosumption, albeit as part of a messy mix of commercial, economic and civil society discourses and arguments. Consequently, learning to code is not a neutral or depoliticized material practice, but shaped, patterned, ordered and governed by powerfully commercialized coded infrastructures. The hidden curriculum of learning to code is one that embeds young people in such coded infrastructures, encourages prosumerist behaviors of digital making and inculcates the algorithmic ideologies associated with the culture of coding.

Again, as these linkages make evident, Nesta and the Nominet Trust play an intermediary role in translating diverse interests, ways of thinking and practices into a shared set of interests. Learning to code is configured simultaneously as a benefit to the economy, a career choice and an 'empowering' form of social media participation. Behind each of these lines of thought lie different actors from across the sectoral spectrum of public, private and civil society, whose diverse concerns have been shaped into a shared interest in learning to code as a solution to their perceived problems. The computing curriculum is the contingent product of acts of translation, juxtaposition and stabilization around learning to code. While many claims around learning to code can be contested, these contingencies in the production of the computing curriculum have been hidden. Consequently, as the computing curriculum is enacted in English schools, it will partake in the shaping of young people's own digital capacities and modes of citizenship according to lines of thought that have been aligned across sectoral borderlines and ambitions.

Political computational thinking

What do these entanglements and translations around learning to code tell us about contemporary political styles of thinking and governance? It is especially important to note that the prosumerist orientation to learning to code and digital making is closely related by both Nesta and the Nominet Trust with discourses around 'hackathons' for public service design and 'government hacking' events. 'Hack' events put teams of computer programmers together, using code-sharing tools, to engineer solutions to government and public sector problems (Merrett 2014). These include both local and national 'festival of code' and 'hack the government' events intended to design 'projects that help improve local and national services and make use of open data' (Rewired State 2014). The voluntary prosumer is the ideal subject for a governmental context where the state is seeking to deconcentrate its responsibilities and, as Nesta

documents describe it, to enable more 'people-powered public services' and coproduced solutions facilitated by 'people helping people' (Colligan 2014). In this context, government agencies seek out solutions from wider publics. This can be accomplished partly through analyzing massive data sets of public participation in digitized government services, but also by inciting citizens with the relevant technical skills to coproduce new services. Encouraging the 'culture of coding' of prosumption and the DIY software ethos associated with social media through the promotion of learning to code is seen as a way of fostering the technical people-power required for 'digital governance' (Margetts and Dunleavy 2013). As noted earlier, technical change is often positioned as the model for political invention (Barry 2001). It is thus clear that recent sociotechnical shifts around prosumption, learning to code and DIY digital making are being translated by Nesta, among others, into models for participatory forms of digital governance, designed to promote citizen engagement in its computational dynamics.

People-powered services and digital governance look set to benefit from the increase in coding skills and computational thinking that learning to code initiatives will provide. The Nominet Trust's 'Social Tech Guide' provides ample evidence of how technology entrepreneurship, twinned with practices of coding and hacking, has been positioned for 'social good' (Nominet Trust 2014). Likewise, Nesta documents describe projects such as 'local government digital making' and 'coding for civic service' that involve a mixture of coding skills, design skills and user experience to explore 'solutions to challenges' – thus merging 'what is (technically) possible and what is (politically) feasible' (Bell 2014). For example, based on an 'iterative, user-centered, and data-driven approach to government' designed by the Code for America (2014) initiative, Nesta has established a sister program, Code for Europe, that places '"code fellows" (data technologists and designers) in city halls to create new citizen-led digital services, often built on open data', and to share 'digital services so cities can connect with their citizens in cost-effective and engaging ways' (Nesta 2014b). These projects apply what Nesta terms a 'code for *x* model' (Bell 2014) where it appears that computer code can be applied as a solution for almost any social or public problem.

These 'coding for *x*' projects are all about applying technical engineering to the task of human, social and political engineering, and represent the embedding of computational thinking – the expression of problems in the language that computers can understand – in the main style of political thought in contemporary governance. Education, and learning to code in particular, are seen as enabling these new computational forms of governance. A clear UK example of such thinking is in the Future Makers program, part of the government-funded Glasgow 'Future City' initiative. Future Makers is facilitated by CoderDojo, another volunteer-led programming club financially and organizationally supported by Nesta and Nominet Trust through the Make Things Do Stuff initiative and Digital Makers Fund. Part of the wider government imaginary of smart cities that are both data-driven and citizen-centric (Department for Business, Innovation & Skills 2013), Future Makers proposes that learning to code will enable children to develop the necessary 'future city literacies' to participate in and contribute to the future functioning of the city itself. Nesta, too, has explicitly aligned both its 'coding for *x*' and its learning to code initiatives as part of a smart cities agenda (Mulgan 2014b). At governmental level, the links between learning to code and smart cities are illustrated by Ed Vaizey MP commissioning both Nesta's *Next Gen* project and co-chairing the Smart Cities Forum as Minister for Digital Economy. In this sense, children are learning to code in order to become the

'computational operatives' of emerging smart cities that depend on the participation of digitally literate citizens to 'function optimally' (Gabrys 2014, 38).

Even more recently, Nesta has partnered with the government Cabinet Office to explore the idea of 'a new operating system for government', based on the notion of 'government as a platform' articulated by web entrepreneur Tim O'Reilly (2010). The idea of government as a platform assumes that successful technology innovations can be used as models for the redesign of government services; for example, making government data open and accessible as a platform for the creation of 'civic apps'. Through developing this approach, Nesta and the Cabinet Office aim to anticipate how emerging technologies such as 'data science, predictive analytics, artificial intelligence, sensors, applied programming interfaces, autonomous machines, and platforms' might in the next five years become 'ingrained into how government thinks of itself', 'redefine the role of government, and even create a different relationship between state and public' (Maltby 2015). This way of thinking of government as a digital platform that redefines the state–public relationship exemplifies the shift toward techniques of digital governance, and the style of political computational thinking that underpins it. The overall digital making, learning to code and hacking discourse is embedded in, and constitutive of this emerging mode of political computational thinking. Via Nesta and the Nominet Trust, learning to code has been positioned as equipping young people with the computational capacities required to become solutions-engineers and hackers participating in the computational dynamics of the future city and the digital techniques mobilized to govern it. The current political preoccupation with learning to code is reflected in how government is itself learning how code and computational thinking can be applied as a digital operating model to enable public and social problems to be hacked and solved.

In this sense, learning to code is part of a political aspiration to govern through techniques of digital governance, where citizens themselves require the digital skills to take part in increasingly people-centered and citizen-led digitized services. In order to achieve this, individuals are to be shaped as governable citizens whose own interests and aspirations align with those of the authorities that seek to govern. Nesta, in particular, plays a powerful translational role in configuring such affiliations between the state and its citizens. Through Make Things Do Stuff and the various citizen-centered hacking events it promotes, it seeks to persuade citizens of the value and utility of learning to code for everyday civic participation. At the same time, Nesta has persuaded government of the value and utility of learning to code to support the digital economy and enable new forms of digital governance. The promise of digital governance is to be achieved by sculpting governable citizens whose capacities must be activated and enabled to participate in the emerging computational dynamics of the state itself.

Conclusion

Computational thinking is emerging both as problem-solving technique for students of computing and as a contemporary style of political thinking. Through the translational expertise of intermediary organizations like Nesta and Nominet Trust, computational thinking has been positioned as a shared interest of both schoolchildren and government. Children can learn to code as voluntary prosumers participating in the circuits of social media, and are from there sculpted with the capacities to become the governable citizens of a state that itself relies on the voluntary, DIY and productive capacities of digitally

enabled citizens. The technical shift toward participatory social media has been translated into a model for emerging techniques of digital governance. Ultimately, the accomplishment of digital governance depends upon education, with learning to code clubs and the computing curriculum positioned to shape citizens into a governable state. Conceptualized in terms of 'translation', learning to code and the computing curriculum have been made consonant with emerging techniques of digital governance and the style of political computational thinking that underpins it.

Through documenting and analyzing the recent growth of learning to code initiatives and its intersection with the new computing curriculum in England, this article has shown, firstly, how education is increasingly being targeted by intermediary organizations that represent particular kinds of agendas and have the capacity to translate interests from across the commercial, civil society and governmental sectors into shared projects. The introduction of the new computing curriculum in England in 2014 demonstrates how the networking together of commercial, civil society and governmental interests, largely brokered by boundary organizations such as Nesta and the Nominet Trust, is now exerting considerable influence on educational policymaking. Indeed, as prototypical 'psilabs', Nesta and the Nominet Trust are increasingly combining elements of entrepreneurship, lobbying, commercial contracting, philanthropic giving and think-tankery, along with digital R&D, in their offer to a 'reluctant state' that Ball (2012) claims intends to deconcentrate and delegate its responsibilities to diverse nonstate providers, though not to withdraw its responsibilities altogether.

Secondly, the article has explored how, through learning to code, young people are being inculcated into the material practices and codes of conduct associated with the culture of code, ways of viewing the world and politics of computer programmers – particularly the technically solutionist assumption that technical engineering, algorithms and coding solutions can be applied for 'social good' and to 'hack' human, social and public problems. This shaping of students' digital subjectivities prepares them as the ideal participants for the 'digital governance' of the reluctant state, as citizens with the technical skills, computational thinking and solutionist mindsets to 'hack' solutions to problems of contemporary governance on behalf of the government. This emerging solutionist state is one in which political computational thinking, based on a technocratic logic that all social phenomena can be formalized into computable models, has become the main governmental style of thought; and it delegates its problems to active citizens with the technical literacies to 'code for *x*', using open government data as a platform for the creation of new digital services. Learning to code is organizationally and discursively anchored into the culture of government hacking through Nesta and the Nominet Trust in a symbiotic relationship that might be articulated as 'learning to code to code for *x*' in the digital governance of the solutionist state.

In conclusion, learning to code acts as a kind of inculcation into new ways of interacting with an increasingly computationally dynamic world, as channeled through the systems of thought and cultures associated with programmers. The new computing curriculum in England canalizes many of these practices and systems of computational thinking directly into the material and discursive apparatus of classroom practice. The computing curriculum is both a product of network governance and constitutive of a shift toward forms of digital governance that will require the digital literacy of citizens to contribute as both consumers and coproducers of digitized services. Through learning to code, young people are being configured in the conduct of coders and made into

governable citizens who are learning to code the digitized future of the reluctant but solutionist state.

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