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Exploring the impact of digital technologies on professional responsibilities and education

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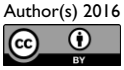

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Tara Fenwick
School of Education, University of Stirling, UK

Richard Edwards
School of Education, University of Stirling, UK

Abstract

Digital technologies in combination with 'big' data and predictive analytics are having a significant impact upon professional practices at individual, organisational, national and international levels. The interplay of code, algorithms and big data are increasingly pervasive in the governing, leadership and practices of different professional groups. They are reshaping the relationships between professional grouping and between professionals and their clients/users/students. New forms of accountability and responsibility are emerging as a result of these trends, raising important questions about culpability and decision-making in professional practice. However, to date, despite the introduction of many professional codes on the use of digital data and social media, these issues have received limited examination in research addressing professional education. This article aims to explore some of these trends, how they are manifested in different professions and what might be the educational implications. Our argument is that new digital technologies are reconfiguring professional practice and responsibility, but that the education of professionals has yet to adequately reflect these changes.

Keywords

Professional responsibility, accountability, professional education, digital technologies, analytics, algorithms, big data

Introduction

Digital technologies in combination with 'big' data and predictive analytics are having a significant impact upon professional practices at individual, organisational, national and international levels. These technologies and their associated analytics are proliferating across professional

Corresponding author:
Tara Fenwick, School of Education, University of Stirling, Stirling FK15 0HD, UK.
Email: tara.fenwick@stir.ac.uk

practices from medicine, law and education to urban planning and policing. They collect data through continuous sensing. They access massive data sets, such as administrative and health records, and link these with all sorts of unstructured data combed in real time from human digital activity. They work through algorithms to analyse this data on a huge scale for patterns, then calculate these patterns to identify problems and suggest solutions. Increasingly these technologies are being used to predict and plan, to recommend and, at times, to even make automated decisions. This interplay of code, algorithms and big data is increasingly pervasive in the governing, leadership and practices of different professions. It is also reshaping the relationships between professional grouping and between professionals and their clients/users/students.

These trends raise important questions about responsibility: the contribution of the skilled professional in these reconfigured practices, the role and position of professional judgement, and how responsibility and accountability are to be delineated with so many technological actors integrated into professional services. Digital technologies are part of the emerging knowledge infrastructures of daily life, the 'robust networks of people, artefacts, and institutions that generate, share and maintain specific knowledge about the human and natural worlds' (Edwards, 2010: 17). They represent a significant part of professional futures. Yet, despite some research on the effects of digital data and the coded governing of contemporary life in educational systems (e.g. Fenwick et al., 2014; Lawn, 2013; Williamson, 2015), there has been little detailed examination of the implications of digital technologies for professional practice, responsibility and education.

This article seeks to explore the issues arising with the emergence of digital technologies, predictive analytics and big data in professional work, with particular interest in questions of responsibility. What are the implications of digital analytics for practitioners' responsibility and accountability in their everyday work, as well as for the disciplinary knowledge underpinning their practice? What new capacities might be needed, and what dilemmas might be anticipated? How could we be educating professionals for forms of practice and decision-making that are increasingly 'code-threaded'? At the very least, what critical dialogues might we engage student professionals in regarding digital analytics in their practice? These are significant questions for professional educators as well as for the broader social science communities in a period of rapidly changing circumstances. This article will touch upon these questions rather than address each fully, as our intention here is to suggest an agenda for research and professional education that requires far more attention than can be achieved within the context of a single article (cf. Fenwick, 2016).

The article is, therefore, not intended to be a comprehensive literature review or a report of empirical data, but an exploratory essay drawing selectively on literature in professionalism and professional work, ethics, education and software studies. The argument is presented in four parts. First, we will outline some contested conceptions of professional responsibility and their ethical assumptions and practical implications. We will explore also some forms of calculation and distributions of accountability and professional responsibility associated with these trends and tensions within them. Second, we outline some of the work emerging that explores the work of algorithms, big data and analytics and their significance for social practices. Third, we explore selected ways in which digital technologies interplay with professional practice, in domains as diverse as policing, health and architecture. Finally, we will outline what we take to be some of the key educational implications arising from the discussion. While it may be rather easy to identify dystopian trends in critical evaluations of digital technologies, the position we take is one of creating useful future directions. These are likely to require a reconfiguration of professional practices, perhaps involving a reframing and refocusing of the specific dimension brought to sociotechnical, sociomaterial assemblages of practice by expert human practitioners. We are mindful of the lurking dystopias, while seeking ways to interlink the benefits of digital analytics with the significant issues that professional groups and services seek to address. Our intention is to raise questions about the framing

of future practice and research in relation to professional responsibility and education, deliberately adopting a broad approach to reflect the multi-professional and multi-disciplinary spaces within which these issues are being researched and discussed.

Professional responsibilities and accountabilities

While the notion of the professional is heavily contested, for the purposes of this article we may understand professions as 'the knowledge-based category of service occupations which usually follow a period of tertiary education and vocational training and experience … [and are] extensively engaged in dealing with risk' (Evetts, 2013: 781). Within the professions, responsibility is often treated as a defining set of obligations for the nature of professionalism itself: obligations to the client's interests as well as the needs of society broadly (Freidson, 2001). Much of the literature on the topic is characterised by normative moral declarations of what professionals ought to do, and what comprises professionals' responsible practice in particular fields. Prescriptions abound for codes of behavior as well as for methods to educate professionals to perform these codes. These prescriptions may be stoked by complaints and public concern about professionals' perceived irresponsible practice and the failure to regulate practices appropriately.

Conceptual discussions of professional responsibility are wide ranging, from causal (who caused the problem) to consequential responsibility (who takes the blame); and from attributed (who is held accountable) to distributed responsibility (how accountability is apportioned among agents). Moral responsibility invokes notions of both obligation and moral decision-making. Obligation calls forth a sense of duty to care for self and others extending beyond one's own self-interest, and an accountability to others for one's actions. In this sense, questions of professional responsibility have tended to focus on the actions and decisions of individuals, although questions about collective and organisational responsibility have become more common. The others to whom professionals are responsible can be interpreted broadly: other human beings, other collectives, such as community or national interests, authorities, tradition, animals or non-sentient beings of the natural universe, concepts or ideals. Moral decision-making to acknowledge and act upon one's professional responsibilities incites questions about the conception of the 'good', the attendant criteria or principles that should guide action, and the extent of one's freedom to decide. Within all of this, as Gibbs (2000) points out, some view a distinction between responsibility as felt and responsibility as acted.

In the field of ethics, critical debates have long swirled around the questions: who is responsible to whom, for what, and to what extent? Responsibility has been developed within a tradition of rational philosophy as a question primarily of ethical decision-making, invoking issues of universal laws and the problem of the contingent particular situation, as well as bonds and obligations that inhere in an individual, conceived as autonomous, intentional and capable of acting independently of others. However, Levinas (1981) and educational philosophers who have taken up his conception of the ethical subject (e.g. Biesta, 2006) have begun from a basic critique of the assumptions embedded in this rational tradition. Levinas counters the view that individuals act and reason as autonomous agents, and stresses the intersubjective relationships that enmesh human beings with one another beyond their conscious intention or rational application of moral principles. He also argues that ethical responsibility is moved not by rational decision-making but is enacted within moments of connection, participation with others that calls forth *response*.

These considerations shift the issue of responsibility from notions of individual felt duty to the active responding to others, broadly conceived, within complex webs of connection. A focus on response turns attention away from defining what is the good, and what ethical laws should guide action, *towards* questions about how response is excited, by whom or what, what forms it takes and

what are its consequences. Thus, responsibility is not necessarily a simply rational construct, but can be a phenomenal and relational dynamic. The meanings of professional responsibility are tangled with issues of ethics, where some seek a clear moral delineation of 'good' practice through codes of ethics and conduct to be followed, while others focus more on the responsiveness to circumstances. The latter entails a more (philosophically) pragmatic approach to issues of professional responsibility than a simple principled approach, that is, the rational application of ethical 'laws' and 'rules'.

There is growing research pointing to the pragmatic pluralism of professionals' obligations, and the tensions and conflicts in responsibility that they must negotiate. This web of commitments often necessitates what May (1996) has called 'legitimate compromises'. Professionals balance obligations to their employing organisations and their rules of practice, to broad social needs served by their profession, to the profession itself and the standards and regulatory codes governing its practices, to individuals for whom the professional adopts a responsibility, and to personal allegiances influencing a sense of the 'right thing to do'. Robinson (2009: 18) argues that these function as three different kinds of engagement in professional responsibility. One is a plural engagement, working through critical dialogue to navigate the responsibility of different roles. Another is a relational engagement, 'maintaining close awareness of the other'. A third is creative engagement, 'looking for a collaborative and negotiated response'. These may occur singularly, sequentially or even simultaneously.

According to empirical research, professionals' negotiations of these differing, and sometimes conflicting, responsibilities are becoming exacerbated by particular tensions between the claims of increased efficiency and accountability, and the best interests of clients, students and patients (e.g. Colley et al., 2007; Solbrekke, 2008; Stronach et al., 2002). Stronach et al. (2002) report that nurses and teachers appear to manage these tensions by juggling simultaneously the discourses of economy and ecology in practice. Colley et al. (2007) suggest that professionals must often choose to act in ways 'unbecoming' according to formal regulations, which are themselves risky.

These tensions signal the uneasy relations between professional responsibility and accountability. Responsibility may be described as the needs to which professionals are expected to respond, and in what ways, while accountability is more about how professionals are expected to justify the ways they perform those responsibilities. Many commentators such as Solbrekke and Sugrue (2010, 2014) are concerned about the increasing attention given by employers and government to professionals' accountability in ways that can distort core commitments of responsibility. Accountability in professional practice takes various forms: fiscal accountability, legal accountability (compliance with explicit regulations), bureaucratic outcomes-oriented accountability (duty to the organisation's mission), community accountability (duty to care) and professional accountability (duty to a profession's discipline and ethics).

These forms and effects of accountability are all made visible through systems of measurement. These measurements require a conversion of living events and their often unpredictable ambiguity into representations of particular scales, into data. In the process, qualitative judgements can be translated into measured technical data. These data are rendered in forms such that they can be scrutinised and assessed according to often conflicting accountability demands by various stakeholder interests ranging among professionals, government departments, employers and the general public. As Robson (1992: 700) explains, accounts essentially make living events visible; they provide a basis for calculation. These calculations afford a means for acting upon individuals and institutions to produce new processes. Over time, accountabilities have become increasingly calculated through the interlacing of algorithms and data and the analytics and visualisations of the practice they generate.

In relation to accountabilities, Callon and Law (2005) describe the linking and manipulation of data as an act of counting and judgement that typically follows a three-stage process. First, relevant entities are categorised, detached and displayed in a single frame. Second, these entities are manipulated and transformed to show (or create) relations between them. Finally, a result is extracted

such as a new entity, a ranking, or a decision. Calculation does not reside in human subjects and become projected through their efforts as acts of agency, but rather is enacted in 'material arrangements, systems of measurement and methods of displacement – or their absence' (Callon and Law 2005: 715). Increasingly this work is done through digital technologies.

Callon and Law (2005) reconfigure the concept of calculation in two ways that are helpful for understanding accountability. First, they offer the term 'qualculation' to capture the ways that arithmetic and qualitative accounts are melded in acts of calculation. Things have to be valued in particular ways, they must *qualify* for calculation, which involves qualitative processes. Acts of qualculation involve all sorts of ways to manipulate entities within a single frame, only some of which are arithmetic. Thus, rather than big data being technicist and reductionist, that is, ignoring issues of quality, in conceptualising them as practices of qualculation, we can trace the meshing and translation of values into the socio-technical practices of data collection and analysis. Second, calculation and non-calculation are mutually constitutive: they are interrelated, rather than existing in separate spaces. All calculation comes about with and against non-calculation, and vice versa. In other words, in making certain things visible, certain things are made invisible. The most important boundary is not between the acts of counting and the acts of judgement, but between arrangements that allow qualculation, and other arrangements that make it impossible. In the context of digital technologies and big data, this entails the capacity for the values in professional codes to be translated into the binary logic of lines of code.

In our discussion, this points to the ways in which digital technologies are not simply technical solutions to enhancing the quality, efficiency and effectiveness of practices, but can also be powerful value-embedded socio-technical interventions in the attempted shapings of practices, accountabilities and responsibilities. What is made visible and invisible is the result of work and does not exist a priori to its enactment. They are neither determining nor determined, as qualculations are not simply internalised but become part of the web of relations through which professional practice is enacted, in the process contributing to different enactments of responsibility.

Solbrekke and Sugrue (2014) suggest that responsibility and accountability are two logics used in assessing professional work, both of which are concerned with the quality of practice. However, while the first is framed around professionals' own judgement, the second focuses on professionals' compliance with externally determined indicators of performance. Thus, 'best practice' becomes performed and defined differently within each of these logics. On the one hand, the logic of accountability frames practice through economic concerns for standardised, measurable priorities and rationales, and economic processes of external audit and counting. On the other hand, the logic of responsibility frames practice within a language of values and integrity, contextual nuance and relationship, and processes of situated judgement and negotiated standards. For Solbrekke and Sugrue, this logic of responsibility elicits more proactive activity, while that of accountability prompts more reactive behaviour. There is a dynamic interplay between these logics with their approaches and priorities affecting one another.

We witness well-developed research on professional responsibility and accountabilities. What happens to these then when digital technologies are introduced into both the practice of professionals and their accountabilities, when qualculation takes hold? What professional decision-making is informed by digital technologies or supplanted by them? How are responsibilities and accountabilities being delegated and distributed by and to digital technologies? What possibilities and risks emerge through these developments? We explore such questions in the next section.

Digital technologies, big data and analytics

So ubiquitously and insidiously are digital technologies permeating all aspects of life that some claim we now live and work in 'code/space' (Kitchin and Dodge, 2011). It is difficult to separate

how we think from the logic of the software through which we form and represent our thoughts. Nor can we disentangle our actions from the materials with which we work, generated through automated analysis of massive information sets to which we contribute continuously. Digital technologies and people are becoming interdependent, constituting one another, with emergent effects; they do not just mediate existing social forms, but are integral to practice.

Critics such as Kitchin (2014), Naughton (2012) and Pariser (2011) have been calling attention to the wide-reaching and accelerating consequences of these forces, claiming that professionals, professional educators, researchers, policy-makers and the public are just beginning to realise the enormous challenges being posed by digital technologies, software code and standardised data. Yet professional education curricula and pedagogy seems to be standing aside from these transformations, often continuing to develop practitioners' knowledge and skills without much attention even to the new educational materials appearing on learning analytics (Buckingham Shum 2015). Where digital technologies are part of professional education, they tend to be treated as tools: useful to master, but clearly subordinate to the knowledgeable professional. Yet the industries that are marketing these digital technologies, and the practitioners, policy-makers and consumers eyeing their potential, are already moving towards a future that could quickly marginalise or even exclude professional intervention in many arenas. For some, this is part of the democratising of knowledge and expertise and a challenge to professional deference. For others, it represents the denial of human expertise and expert judgement.

The development of digital technologies is linked to the use of big data. Big data is a widely used, if problematic, term that refers to various types of data sets collected in massive volume at high velocity that tend to be exhaustive in scope, use very fine-grained resolution, and combine wide-ranging types and contexts of data (Kitchin, 2013). What marks their increased role in professional practice are their digital forms and the capacity for them to be searched, sorted and analysed digitally by the algorithms of software code (Halford et al., 2012). The results are ever-expanding masses of data and database formats that can be manipulated to produce measures of performance, analytics to predict behaviours and actions, and capacity for automated decision-making. In a recent report for the UK's Economic and Social Research Council, Ruppert and her team (2015) argue that it is these new social practices that need investigation. Rather than focusing on the oft-cited big data characteristics of volume, velocity and variety, these authors direct our attention to the specific novel socio-technical practices through which data is born, given meaning, then exercised in all sorts of ways (searched, cleaned, mashed, curated, staged, traced, shared, re-purposed, etc.). These exercises enact data in ways that order, change, reproduce and govern social life.

This is an argument also made by Mackenzie (2015) in his examination of some of the practices of prediction through machine learning. He suggests that 'the production of prediction is not automatic, although it is being automated. But as machine learning is generalized, the forms of value that circulate in the form of commodities alter. Prediction changes the social reality of value forms' (Mackenzie, 2015: 444). Thus, while these digital analytics are producing possibilities for 'evidence-informed' policy and practice in ways unimagined in previous eras, Ruppert et al. (2015) suggest that we think about big data itself as having social lives. We tend to overlook these social-technical lives, which raises new vulnerabilities, risks and problems in how they become enacted. It is here that research on the development of knowledge infrastructures and ontology building begins to give insights into such lives (e.g. Edwards et al., 2013). It is also the case that some of these lives are imagined and marketed rather than practised and experienced.

Kitchen (2014) identifies that big data are collected through at least three ways. First, through intentional surveillance operated by humans, such as assessment records of students or patient record information accumulated through a range of measures, tests, electromagnetic scans and biotechnical feedback. This produces what Kitchen calls 'directed data'. A second

means is through embedded sensors in objects, environmental measuring instruments, click-streams measuring students' and staffs' digital activity, scanners that read objects, and machines that record their own uses as well as the items passing through them, such as diagnostic machines. These sensors and scanners produce 'automated data'. A third way is through gathering 'volunteered data', which we ourselves post on the web or social media. This data often is processed not by human actors, but by algorithms in software code. However, humans and technologies are not so easily separated: they participate together in practices of generating, manipulating and curating data. Through processes of tagging, classification, calculation and generalisation, knowledge is being enacted, along with identities, categories and relationships. These elements are being represented through what Manovich (2013) calls media hybridisation and the 'deep mix' of media platforms, logics and techniques. Ever new data formats, new interfaces and new ways of creating media are emerging from this deep media hybridising. This is why Manovich claims that software is 'taking command'.

In effect, digital technologies, data manipulated by algorithms, alongside the explosion of software code mediating much of our analytics, knowledge, communication and decision-making, are organising new standards of decision-making and governing. In the process, Berry (2011) argues that different forms of delegation, aggregation and quantification are being enacted. While his analyses focus on social life more broadly, it is their implications for professional practices that are of interest here.

Digital technologies, professional practices and responsibilities

Increasing amounts of research in the professions is exploring the issues raised by the introduction of digital technologies and the use of big data and analytics. In medicine, for example, electronic patient records (EPRs) are being implemented in hospitals across most developed countries. Critics such as Greenhalgh et al. (2014) have shown empirically how the software of these EPRs not only limit the categories for diagnosis and description of patients to pre-given databases, even reducing diagnostics to pull-down menus, but also turn expert practitioners into data entry workers. In other words, argue these researchers, such data systems are fundamentally changing clinical work in ways that were not fully considered before implementation. Meanwhile in the rapidly growing area of *m*health (mobile technologies for health care), new technologies such as the *Remotoscope*™ app, designed to work with anyone's mobile phone to diagnose ear infection at home, are moving rapidly from prototype to market. Such products are likely to increase convenience and responsiveness of service. But are algorithmically calculated, data-driven diagnostics as reliable and consistent as services performed by human professionals? Available studies are careful in their conclusions. For example, in researching a new algorithm running on mobile technology for managing children's illness in sub-Saharan Africa, Shao et al. (2015) found that it resulted in better identification of children with viral infections and an 80% drop in unnecessary prescription of antibiotics – overall, better clinical outcomes than standard practice. However, success depended on the deployment of the technology by professional clinicians specifically trained to follow its protocols strictly.

Higher education is another sector that is employing algorithmic analytics to address a host of issues. For instance, analytics can be used to determine which students may pose a retention problem as the basis for targeted assistance. Students can be assigned a dropout prediction score, which is shared with staff who can then monitor student activity and provide resources to keep them enrolled (Harris 2014). Educators are becoming interested also in the possibility of improving student attainment through predictive analytics that match teachers and students, reshuffle student work groups and 'recommend', like Amazon, resources and classes to individual students. To help predict students' employment paths and suggest suitable curricula, these analytics also are being

linked with projected labour skills demands, demographics, aptitude tests and markers of students' online engagement (time spent viewing pages, content highlighted, etc.).

This all appears valuable as part of educational interventions, but relies on the validity and reliability of the analytics embedded in the qualculations. Questions are raised when the analysis and educational prescription are delegated solely to the decisions made by digital technologies. Any student data will contain complex mixes of culture, class, sexuality, etc. that, however good the digital technology and analytics, often cannot be registered or can be manipulated or gamed. Laurillard (2012) shows that much student data is collected as by-products from other interactions. While useful, it needs additional interpretation from professional educators. Here is an opportunity, Laurillard argues, for educators to collaborate with technology specialists to capture data that will address issues of most educational concern, and to use it to improve specific educational practices. In other words, the production of prediction and the qualculations themselves need re-translation through professional decision-making in the enactment of practice.

In education more broadly, Williamson (2015) draws attention to new phases in the calculation and classification of complex matters of learning, pedagogy and context. Educational governance in the UK increasingly is being actively displaced to technical centres such as Education DataLab, which deploys analytics to manipulate masses of data from the National Pupil Database in order to generate 'actionable policy insights'. In particular, Williamson focuses concern on the incorporation of citizens and the persuasive, almost seductive, authoritative power of data visualisation being employed by these technologies. His example is Learning Curve produced by Pearson Publishing:

> The user of the Learning Curve is solicited to perform independent analyses by tweaking variables, adjusting statistical weightings, and generating new visualisations. As a result, the user is solicited not quite as the consumer figure of school comparison websites cited earlier, but more as a 'prosumer' who does not only consume content but also produces it. … These logics of 'prosumption' elide distinctions between popular and expert knowledge practices. (Williamson, 2015: 15)

In this way, what becomes enacted through digital technologies as governing knowledge in education is presented benignly as co-created fun, scripting its users' involvement and obscuring its actual functions in ways that they are not encouraged to examine.

A comparable range of digital technologies and visualisations are being implemented also to support 'predictive policing'. For example, Motorola's Real-Time Crime Centre Starter Kit links wide-ranging data from sources such as sensors, alarms, multiple video systems and computer-aided dispatch with software analytics. Motorola's representative explains that the technology 'allows agencies to implement predictive policing tactics and leverage existing technology to provide relevant and timely intelligence to improve closure rates, help stop a crime in action and proactively identify potential incidents before they occur' (Cipriano, 2014). These sorts of technologies increasingly build in public involvement so that citizens can monitor activity in their neighbourhoods and feed it into the software for analysis to generate predictions and recommended actions. The power of such predictions is one of the questions raised by Mackenzie (2015), as the generalisations might be said more accurately to produce anticipations over which human judgement still needs to be maintained rather than precise predictions. It is in the collapsing of anticipations into predictions that professional responsibility is delegated to digital technologies.

In the context of architects and other professionals working with built environments, Jaradat et al. (2013) document how dramatically professional roles are changing as large integrated data systems are used increasingly to design, construct and maintain buildings. The client is becoming increasingly 'professionalised', new conflicts are appearing across professional groups, and

new kinds of professional accountabilities are emerging. For example, workflow approvals are often delegated to digital mechanisms, while professionals running the projects may bypass the fuss and unwieldy structures of uploading the required documents and continue to rely on phone calls and emails to negotiate fast-changing details between engineers, contractors and architects. New specialists dealing with document control and integration are becoming part of the building design and delivery processes, who may exercise different standards of judgement in assessing work quality than the design professionals. The proliferation of different design professionals – architects, servicing engineers and so forth – all mediated by digital technologies, create new issues of standardisation and transfer of the digital data and potential for conflict and work arounds in the practices of qualculation. The handover of digital data can create frustration at a system's inflexibility, or the errors and misinterpretations that can occur with multiple users interacting with the same data at once.

Digital technologies are not necessarily digital in the ways that professionals need to be. They tend to work from simplistic premises: that problems are technical, comprise knowable, measurable parameters, and can be solved through technical calculation. They rely on practices that enable qualculations through a binary logic of generalisation and either/or. Barocas et al. (2013) also show that algorithms reflect what they term 'a profound deference to precedent', acting on the past to make decisions regarding the future. Digital technologies work through identifying past patterns and cycles of anticipation, which can be self-reinforcing and reproductive, augmenting path dependency and entrenching existing practices. They can act as filter bubbles, simply reinforcing past patterns of behaviour (Pariser, 2011). Complexities of responsibilities and values, ambiguities and tensions, culture and politics and even the context in which data are collected are not necessarily taken into account.

Many warn that the growth and unexamined nature of these sorts of analytics, as they permeate professional practice, are creating particular forms of rationality, and potentially new epistemological orders (Kallinikos, 2010; Kitchin, 2014). There are new ethical as well as legal issues when professional responsibility becomes delegated to algorithms (Barocas et al., 2013; Ruppert et al., 2015). 'Smart' machines such as diagnostic technologies and robotics are powerful augmenters of practice but, as Marcus and Davis (2014) argue in the case of health care, they should supplement, not replace, professional judgements: only human professionals can listen to patients with nuanced understanding of complexities. Digital technologies do not attune or intuit, and, to date, they are not considered conscious agents that can bear responsibility for decisions.

Bearing this in mind, it is sobering to read about technological developments that are allowing increased delegation of professional decision-making to digital analytics. In human resource management for instance, Sullivan (2013) reports that Google is using big data and algorithm-based decisions in its practices: 'people analytics' for the twenty-first century. A hiring algorithm is used to predict which employees are most likely to succeed after recruitment, both to shorten the total interview time and to ensure that the selection panels do not 'miss' top talent: this is 'scientific' recruitment. One algorithm targets 'diversity problems', analysing root causes of 'weak diversity' and suggesting solutions. Another algorithm predicts which employees are likely to become a 'retention problem', alerting management so that pre-emptive action can be taken. These 'forward-looking' predictive models use technology-driven processes to identify and address 'people management' problems and opportunities.

In the law profession, Susskind (2013) has tracked the ways technology-driven processes have proliferated in legal services, with a corresponding rise of technology-driven entrepreneurs: legal knowledge engineers, legal data technologists, risk managers and project managers. Online personal legal services are increasingly common, just as e-services have become more prevalent in many professions, using software that analyses problems and presents solutions. These 'democratising'

developments have been debated for some time in law journals, where the benefits of affordability and convenience are weighed against the concerns about risk, quality, trust and accountability (Cho, 2006; Figueras, 2013). Susskind predicts a radical reconfiguration of the profession of law, delivered through diverse internet-based global legal businesses, online document production, virtual courts and online dispute resolution. Segrist (2015) goes further, to argue that big data and predictive analytics are actually changing the responsibility of an attorney.

As these sorts of examples show, across professional work in health care, education and many other areas, new digital technologies are reframing practices in different ways. Predictive analytics are used to assess conditions and prescribe remedies for students or patients or clients, to produce client and professional service records that can be integrated with other data to make decisions, and to plan and even automate service provision in areas such as health, social care, education and policing. Some of this is for great benefit, as better and more quickly generated data can assist improved decision-making to enhance practices. However, what we and others are suggesting is that aspects of these trends have implications for professional accountability and responsibility that require further exploration. The coded objects, infrastructures, processes and assemblages of digital technologies participating in reconfiguring professional practices are not simply tools to enhance practice, but pose questions as to the nature of future professional work and the values embedded in and evidenced by such work.

How then should we think about professional responsibility when algorithms are embedded in the production of predictions? How do we understand the professional as a responsible actor when capability is delegated and distributed? What does it mean for professionals to work responsibly with big data sets of varying quality and with reductionist algorithms? What responsibilities do and should professionals have within different regimes of coded accountability and governing? What practices of qualculation enhance the value of professional work? Professionalism and professional discretion and responsibility are important aspects of professional education. Perhaps we need to rethink how it is enacted in particular digital assemblages, working through particular digitised problems. Then we might reimagine ways for professionals to learn strategies of responsibility in these different contexts even as their own position is reconfigured in the production of these assemblages.

Educational implications

This article has drawn attention to a number of issues for professional responsibility posed by new digital technologies and analytics that we argue deserve more attention by educators and educational researchers. While our purpose is not to provide detailed pedagogical recommendations for these particular issues, even if such recommendations were available in current literature, we do wish to suggest educational approaches that might be implied by the foregoing discussion. These may not be new or original suggestions, but we offer them in the spirit of inspiring further thinking, practice developments and research around educating professionals for responsibility in work contexts increasingly reconfigured by new digital technologies, analytics and big data.

Critically examine new digital analytics being introduced in particular fields and how they influence knowledge and practice

As we have indicated in this article, empirical studies are appearing showing the impact of new digital technologies and analytics in different fields of professional work, and what benefits as well as problems are occasioned. Students in the professional arenas should be introduced to these. They also might interview experienced practitioners about how these resources are actually being

used, or examine promotional material for these products. Students can examine and discuss all these critically from the perspective of implications for professional responsibility. What happens in practice? To what extent are particular digital analytics foreclosing nuances and complexity that are important to professional analysis and problem-solving? What issues of trust, risk and quality are raised? What do the practices of qualculation and the production of prediction entail and with what implications for knowledge, practice and responsibility?

The object is to educate new professionals to develop a critical attunement that can see past the persuasive apparent 'precision' of solutions produced by digital technologies, qualculation and predictive analytics, and to question their limitations as well as identify their possibilities. More broadly perhaps, the aim is to prompt students' sense of responsibility to engage with these technologies as part of the assemblages of practice, and not just to accept them as black boxes that only computer specialists can understand.

Learn more about the effects of computational processes

Students in all professions could be encouraged to learn more about computational processes that produce certain forms of knowledge and the logic that structures thinking. 'Learning to code' has become an arena of debate in education more broadly, with some claiming that the challenge for curriculum is to teach students either 'to program or be programmed' (Naughton, 2012). The argument is that it is possible – even urgent – to make visible the hidden work of software code by developing enhanced computer skills in all students.

In much professional education, however, learning to code is not practical: expertise relies on specialism and each professional domain has its own arena of discrete capability. It is also the case that learning to code is considered by some as an inadequate response to the work of digital technologies. The developing field of software studies and the work from which we have drawn for this article indicates a far more intricate interplay in coding processes of technical and professional issues with sociological, ethical, political and computational questions (e.g. Berry, 2011; Edwards et al., 2013; Kitchin and Dodge, 2011; Manovich, 2013) than lessons in learning to code are likely to appreciate.

For professional practice, it is the capability of the team harnessing different expertise that is central. However, students within professional education could discuss the effects of digital technologies. Who generates the technologies and their outputs? Who should be able to understand the code and big data, and at what level? How are issues of values and ethics translated into lines of code and with what implications? Students also could look more closely at how algorithms built into common software such as Facebook shape the way that they express and represent themselves, interact with others, form preferences, make decisions and become drawn into particular social groups and patterns. As students move into professional work, they could become more attuned to making the computational work decipherable and more visible in relation to their practices.

Learn to collaborate with designers

In general, as writers cited here such as Laurillard (2012) have argued, it makes more sense for professionals and student professionals to learn to collaborate with computer scientists than to try to become computer scientists. This is something that our own colleagues have begun to do, in our case through a series of workshops involving social scientists, professional educators, practising and student professionals, and computer scientists (Code Acts, n.d.). Halford (2015) convenes projects linking social and computer scientists, and argues this is the most important area for educational attention. She claims that most disciplines still remain aloof from engaging

with computational experts, for all sorts of understandable reasons, including the vast differences in language, logics, purposes and approaches. This is despite the proliferation of expertise and resources among people, the internet and social media (MacKenzie 2015). However, Halford argues that until public service professionals learn to collaborate with computer scientists, digital technologies may well continue to be designed within the vacuums of technological innovation for its own sake rather than for the complex contexts of social worlds and responsibilities, contributing to the reductionism that then becomes a focus of critique. Furthermore, collaboration with coders helps professionals understand the possibilities as well as limitations of qualculations, semantic webs and big data, and address explicitly issues of responsibility and accountability within these changing knowledge infrastructures. For the computer scientists, although co-production has been a frequent aspiration in the development of digital technologies, the capacity for professionals to have a clear understanding of what is required and how it can be produced and developed is also critical. This requires very different forms of cross-disciplinary curriculum and cross-professional working to those that mostly exist now.

Learn the issues and capacities needed to integrate new data analytics and technologies effectively into responsible practice

Examples cited in this article, such as the inevitable proliferation of online (professional) services and machine diagnostics, suggest that professionals need to be pragmatic as well as critical about these new technologies. In other words, practitioners need to decide when and how to embrace them. Embracing means neither accepting and using new technologies without question, nor standing aside and allowing 'smart' machines to get on with it. As with the example of new mobile-based algorithms for health care, the responsible use of these technologies relies upon trained professionals.

Furthermore, as the example provided by Jaradat et al. (2013) showed, the new forms of big data being introduced into professional work demand new systems for transferring data between clients, operators and various groups of practitioners. The recommendation from Jaradat et al. (2013) is that professionals need to understand the potential points for error or misinterpretation at various interfaces in this data integration, as different forms of data and different purposes for interpreting it must be reconciled. Professionals also need to assume accountability themselves for examining these points in order to better manage data flows and critically examine the issues in meanings, metrics and ethics that arise. In order to do this, professionals who may not ordinarily work directly with data systems need to understand more about data itself and how these systems work, the translations of qualculation and production of predictions, and how to link with other professionals and institutions to integrate practices responsibly using this data across professional roles.

Explicitly debate the implications of new digital technologies for professional responsibilities and accountabilities

These questions about the potential expansion of professional responsibility to critically interfere with and more actively engage with digital technologies and analytics raises the broader issue of professionalism and accountability in this realm. How should we think about professional responsibility when algorithms produce predictions and make decisions? How do we understand the professional as a responsible agent when capability is distributed? What does it mean for professionals to work responsibly with 'dirty' big data sets and generalising algorithms? What forms of responsiveness are appropriate to the messiness of practices enmeshed within the binary code of software? Professionalism is an important aspect of professional education: we need to rethink

how it is enacted through its entanglement with digital technologies. Then we might encourage new professionals to reimagine principles and pragmatics of responsibility, to develop purposes and learn strategies for using digital technologies thoughtfully and responsibly in these brave new worlds. Their promise might be of more accurate, consistent and clear analytics to reduce complexity and improve decision-making. However, while the complexity, responsibilities and accountabilities may be reconfigured, we would question if they are simply reduced. Digital analytics and technologies are increasingly powerful and sophisticated actors in professional practices that are, as in the industrial revolution of the nineteenth century, transforming work knowledge, divisions of labour and work identities. However, they also bring opportunities for different forms of professionalism. They do not negate professional responsibilities and accountabilities, providing simple technical solutions to complex social issues. They do highlight the need for a more informed debate in professional education surrounding digital technologies and professional responsibility, one to which we hope this article is a small contribution.

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Author biographies

Tara Fenwick is Professor of Professional Education and Director of ProPEL (research in professional practice, education and learning) at the School of Education, University of Stirling. Her most recent books include *Professional Responsibility and Professionalism: A Sociomaterial Examination* (Routledge forthcoming) and *Reconceptualising Professional Learning* (with M. Nerland, Routledge 2014).

Richard Edwards is Professor of Education at the School of Education, University of Stirling, who has published extensively in educational theory, globalization and lifelong learning. His current research focuses on changing knowledge infrastructures, informal learning, citizen science, and the effects of digitization.