Some implications of new technology for professional work, organisation and training

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Abstract

Until recently, the main effect of technology on professional or knowledge-based work has been to complement and augment it, as described in Autor *et al*'s 2003 analysis. More recent developments are starting to result in knowledge-based work being automated and substituted, developments that to date have been more familiar in factory and basic administrative settings. Two widely-quoted studies, by Frey and Osborne (2013) and Susskind and Susskind (2015), suggest that there will be widespread technology-driven job losses including in professional fields. Subsequent analyses indicate that while some occupations will disappear or be deskilled, others will be created, but the most significant effect will be occupational transformation, necessitating different types of skills in a net movement towards work that is complex and meaningful. These changes have implications that are already starting to become apparent for the way that professions are organised and how practitioners are educated, trained and accredited.

Introduction

A popular interpretation of emerging technological advances is to posit a 'fourth industrial revolution' (Schwab 2016) or 'second machine age' (Brynjolfsson & McAfee 2014). This can be seen as a step-change from the initial emergence of computerisation and automation, analogous to the impact on the water- and steam-powered industrial revolution of electrification, the assembly line and the internal combustion engine. Technologies that are combining to produce this revolution include advanced artificial intelligence and machine learning, nanotechnologies, mobile robotics, large-scale connectivity (the 'internet of things'), cyber-physical systems, and the maturity and increasing availability of technologies such as virtual and augmented reality. As has happened with previous technological advances, there is an expectation of widespread disruption to jobs and in some quarters a revisitation of ideas such as the 'end of work' (Rifkin 1995).

A significant difference between the initial emergence of the computer age and current advances is that the latter are expected to have a widespread impact on the nature of professional and knowledge-based work, and potentially on the organisation of professions themselves. The main effects of computerisation on professional jobs have so far been to enhance what practitioners do or make them more efficient, and to create new fields of work associated with the technology itself. To date, large-scale disruption to employment has tended to occur in lower- to middle-skilled occupations, particularly in manufacturing and in basic administrative work, leaving professional work largely unaffected. Increasing technological capability is now predicted to encroach

significantly on knowledge-based work, with consequences for professions, their organisation, and the education and training of practitioners (e.g. Susskind & Susskind 2015).

A difficulty with making predictions of this sort is that, beyond the base level of what technology is capable of doing, they are dependent on assumptions about how it can be transferred into the workplace (and used by the populace in general), the economics of technological substitution, choices made by actors from governments and multinational corporations through to individuals, and the way in which work and its organisation is able to evolve. While some short-term forecasting is possible, along with foresight into medium-term trends, there is also a danger of descending into speculative futurology which can make for thought-provoking reading (cf. Toffler 1980) but is rarely a good basis for policy decisions or deciding on more practical matters such as the design and content of professional courses. A common tendency ('Amara's law) has been to overestimate the effects of technological changes in the short term, but underestimate (and mispredict) them in the longer term.

The remainder of this paper examines current evidence for the likely impact of technology on work, and considers some implications for professions and professional education.

Technology and work: a summary

A widely-used model for conceptualising the effect of technology on work is that of Autor *et al* (2003). Their basic proposition is that technology can enhance or augment jobs, when it makes work more effective, efficient or less difficult, or enables tasks to be done that would otherwise be impossible or uneconomic; automate them, as with much assembly-line work; or enable them to be substituted by alternative means of doing things, as has happened with telephonists and typists. Autor *et al* divide work into four types, viz. routine manual (e.g. picking, sorting and other rule-based tasks), non-routine manual (such as driving and janitorial tasks), routine cognitive (e.g. book-keeping, filing and retrieval, and processing procedural transactions), and non-routine cognitive (activities that require the use of mental models and abstract thinking). They conclude that routine manual work is most susceptible to automation, and routine cognitive work to substitution. Technology tends to complement or augment non-routine cognitive work, while there is limited opportunity to substitute, automate or complement non-routine manual tasks.

Since Autor *et al*'s paper, advances in artificial intelligence, machine learning, optics and mobile robotics are making automation of increasingly non-routine manual tasks possible, as well as providing improved complementarity (for instance through the use of augmented reality and global positioning systems); while some apparently non-routine cognitive activities, particularly those relating to analysis, diagnosis, some types of research and drafting, and even strategic planning, now appear within the scope of automation or substitution (Brynjolfsson & McAfee 2011, Frey & Osborne 2013, Susskind & Susskind 2015). In part this is being made possible by focusing on what computers can do most effectively, such as processing vast amounts of information ('big data') or making precise measurements very quickly, rather than attempting to create algorithms that emulate how humans would go about a task (cf. Dreyfus & Dreyfus 1986). Nevertheless, most writers agree that there are limitations to automation or substitution, both due to technological limitations or 'bottlenecks' and in relation to social acceptability (e.g. Arntz *et al* 2016). Frey & Osborne (2013) identify technological bottlenecks where there are likely to be difficulties in emulating or bypassing

human capacity; these are principally concerned with creative and social intelligence, and to an extent complex perception and manipulation. Another perspective on this is provided by Nokelainen *et al* (2018), who modify Autor *et al*'s four types of work to routine and instrumental, routine and meaningful, complex and instrumental, and complex and meaningful. Even complex but instrumental work will increasingly be susceptible to technological automation or substitution, as there is no additional value provided by having it performed by people and the only limitations are those imposed by the current state (and affordability) of technology. In complex and meaningful work, including "ethical decision-making, artistic, philosophical, therapeutic and caring tasks" (*ibid* p21), intrinsic value is provided by the activities being carried out by people, making it relatively resistant to automation or substitution.

In their widely-quoted study Frey & Osborne (2013, 2017) conducted a quantitative analysis of the impact of technology on jobs, examining 702 occupations from the United States occupational database O*NET. According to their analysis, 47% of US occupations do not contain significant technological bottlenecks and therefore are at risk of automation over the next decade or two given foreseeable developments in technology. However, subsequent analyses of their approach suggest that it contains two significant flaws. Bonin *et al* (2015) attempted to apply the same methodology in Germany, and Arntz *et al* (2016) across OECD countries. By taking a finer-grained approach which looked at tasks and activities within jobs, both groups concluded that while many jobs included automatable activities, the proportion of occupations that are likely to disappear is around 9%, rising to 12% in countries with a large manufacturing sector such as Germany. Not dissimilarly, McKinsey (2017) suggest that 60% of occupations have at least a third of their tasks capable of automation, but only 5% can be fully automated.

The second objection to Frey & Osborne's conclusions is that they treat occupations as fixed in the face of advancing technology. This ignores the likelihood of new areas of work emerging (De Groen *et al* 2017), of jobs and occupations being transformed rather than eliminated (Bonin *et al* 2015, Gifford & Houghton 2019), and substantial differences in the make-up of nominally the same occupation in different workplaces (Autor & Handel 2013). In addition to automation, substitution and complementarity, technology can also result in the creation of work and in its transformation, where workers take on or expand hard-to-automate responsibilities and tasks (Bonin *et al* 2015, CEDEFOP 2017). More subtly, the boundary between automation or substitution and complementarity can be fuzzy, for instance where efficiency is increased to the point where less workers are required, sometimes accompanied either by upskilling or deskilling of those who remain (Fischer & Pöhler 2018).

The most striking qualitative headline from the above is the extension of automation and substitution into areas of cognitive and complex manual work that have hitherto seemed immune to it. Self-driving vehicles appear to be a commercial proposition in the near future, while artificial intelligence is likely to encroach increasingly on knowledge-based work. Quantitatively however the predictions are of a continuing hollowing-out of middle-level occupations, where more easily automatable and substitutable jobs in administration and manufacturing are lost, balanced by growth in professional and managerial work, personal service occupations, and non-routine but low-skilled and often temporary or on-demand manual and customer-facing work (e.g. Frontier Economics 2017). Predicting the long-term impact on the labour market is extremely difficult as it depends as much as technological capability on factors such as how the returns to technological

investment are distributed, the social, political and economic actions of decision-makers, and what new areas of work become necessary and valued. The current consensus is that predictions of 'the end of work' are very wide of the mark, and while the 'second machine age' will create significant disruption to jobs and to society more generally, its net quantitative effect is likely to be balanced with a mixture of job losses and gains (Autor 2015, Hislop *et al* 2017). What does appear inevitable however is that this disruption will extend to professional occupations much more than has previously been the case, affecting the day-to-day work and skills of practitioners but also extending to the way that professions are conceptualised and organised.

The potential impact on professions

The idea of 'a profession' is a difficult one to define precisely, as any characteristics that can be posited for professions are typically either found among at least some occupations that would not normally be regarded as such, or are lacking in fields that are widely thought of as professions (Lester 2017). The best that can be done is usually to posit a few attributes that epitomise what is intended. At a theoretical level, expert knowledge, the exercise of independent thought, and commitment to the field in a way that extends beyond any employment or contractual relationship are fairly widely-applicable principles (Hoyle & John 1995). Practically, some form of self-organising structure is typically present, with criteria for becoming a member of the profession (in modern terms often including an educational or competence requirement that can be equated to at least first degree level), and scope to eject members who practise incompetently or unethically (Belfall 1999). The purpose here is to focus on occupations that approximate to the above criteria as opposed to 'higher-level' or knowledge-based work more generally, although parts of the discussion will have this wider relevance.

As noted in the previous section, the main effect to date of advancing technology on professions has been to complement and enhance work, as well as to create new fields relating to the technology and its application. Augmentation has typically made practitioners more efficient and better-informed, enabled them to carry out new tasks, and increased communication and accountability, but its structural effects tend to have been limited and evolutionary within professions themselves. It has had more effect on ancillary occupations, for instance assistants who might have typed up practitioners' reports, managed their appointments, researched and collated data, or organised documents for processing. New fields have typically been accommodated within existing ones (such as the various branches of engineering, or the library and information field), or created new professions that so far have formalised themselves to only a limited degree. Some of these newer fields, such as computer programming, have evolved rapidly in parallel with the development of the technology, while others such as web design are partly rooted in technology and partly in pre-existing fields such as graphic design, communications and marketing. The structural effect on established professions has been minimal; societal and legislative pressures appear to have had greater effect for instance in the creation of separate regulatory bodies for the UK legal professions, the increasing diversity of professional entry-routes, the upgrading of nursing and social work to graduate professions, and the emergence of 'splinter' or cross-professional groups such as family mediators, vocational rehabilitation practitioners and physician associates (Lester 2009, 2016).

The emergence of technologies that are able to automate, or substantially reduce the time spent on, even quite complex professional tasks is however likely to have a more direct impact on professional

occupations, at least in the medium term. Susskind & Susskind (2015) are informative about the kinds of changes that are taking place and that *might* happen here. Their study is case-based, looking across eight fields of work and developing common themes and theoretical propositions. Their basic analysis accords with that set out in the previous section, i.e. certain types of professional work will be capable of being performed more effectively by machines, including much analysis, diagnosis, and retrieval and assembly of data. The implication of this over time is that professional work will move away from the acquisition and distribution of knowledge, and focus on areas such as making interpretive and moral decisions that are less susceptible to technology. A second major theme that they identify is the capacity of technology to empower consumers to access knowledge and make decisions that are commonly the preserve of professionals, potentially making available 'professional' expertise at minimum cost. In the longer term, they envisage substantial erosion of knowledge-based work and consequent widespread technological unemployment, along with major challenges both to individual professions and to the ideal of ethical, self-regulating practitioners.

Susskind & Susskind's conclusions differ in some important ways from those presented by, among others, Bonin *et al*, Frontier Economics, Hislop *et al*, and McKinsey. In part this can be explained by their analysis being more conjectural and extending over a longer timescale (up to five decades rather than two), but they also make assumptions that, as with Frey & Osborne's study, mean that their conclusions need to be treated with caution. They view professional work as essentially technical-rational, i.e. emphasising the application of expert knowledge to convergent matters, and they also place it in a transactional, market-driven context. While many professionals do spend much of their time on work that is transactional and technical-rational, this fails to recognise the importance or even presence of work that is creative, interpretive, concerned with divergent and value-based matters, and collaborative. Susskind & Susskind are also largely dismissive of professional ethics, suggesting that these can be substituted by legal, organisational and contractual arrangements. A result of framing work in this way is that aspects that are complex and meaningful or are more subject to technological bottlenecks are downplayed, leading to the potential for substitution or automation being overestimated. Secondly, and shared with Frey & Osborne's analysis, there is a lack of recognition of the opportunities created by technology, both directly and as previously discussed by transforming jobs so that they no longer need to include tasks that are better-performed electronically. Even if technology frees educated workers from technical-rational tasks, there is plenty of intellectually complex, creative and indeterminate or value-driven work that can be done, some of which is likely to become increasingly vital as rising populations and increasing demands for goods and services continue to create threats to wellbeing and existence. A recent British study of the impact of artificial intelligence on work (Gifford & Houghton 2019) indicates that advanced AI is, at least at present, creating and expected to create more opportunities for work than it is replacing or rendering redundant. Again, social, political and economic decisions are likely to play at least as important a role here as are purely technological capacities for substitution or automation.

On balance however, it is likely that a significant proportion of professional tasks will become susceptible to technological automation or substitution, and as Susskind & Susskind argue, some will be done more effectively, efficiently and consistently by machines. Areas such as medical diagnosis, routine research and data analysis, legal drafting, and the assembly and checking of accounts are obvious examples, but in principle any activity that follows an operational logic is susceptible – over time, anything that can be described as 'complex-but-routine', tending towards Nokelainen *et al*'s

(2018) complex and instrumental work. This suggests a gradual shift in professional work to those activities that are complex and meaningful (*ibid*), typically focusing on creativity, interpretation, value-based decisions, and interpersonal interaction (e.g. Valin 2018). This accords with an increasing focus for professionals on the 'swampy lowland' of divergent issues and wicked problems that are not subject to neat solutions (Schön 1983), with creative-interpretive activity (Lester 2017), and with relationships concerned with realisation (Schiff 1970) and co-creation (Reeves & Knell 2006). In common with what has been said above about work in general, the result is likely to be both job losses and gains, along with the deskilling of some professional work to technician-type or paraprofessional roles, and the upskilling of other aspects as the focus moves to consistently non-routine and complex-meaningful activities.

The effect of these trends on individual professions is likely to depend on a range of factors. The obvious one is the proportion of the profession's mainstream work that is complex-but-routine. Where this is relatively large, other things being equal there will be a high degree of technological disruption as many activities become automated or substituted. Whether this results in job losses or widespread deskilling then depends on further factors; the most significant one is whether enough non-susceptible work can be substituted so that the net result is job transformation rather than job losses. In addition there may be limits to acceptable technological decision-making in some fields due to safety or ethical concerns, as well as continued (or resurgent) markets for personally-provided services analogous to the growth in interest in craft-produced goods and foods. Several types of scenario then emerge. On a rough continuum, these start from minimal impact because the profession's work is not widely susceptible to automation or substitution; relatively straightforward transformation, where enough non-susceptible work emerges to accommodate the majority of practitioners, with or without significant reskilling; major disruption, with a mix of transformation and job losses; and atrophy, where there is no continuing outlet for the profession's skills and expertise in their current form. This is further complicated by the emergence of new fields, some fast-moving and ultimately at least partly substitutable (cf. the evolution of computer programming), which will interact with existing professions in potentially complex ways.

Some implications

The above analysis, even if not as extreme as Susskind & Susskind's conclusion, still suggests some far-reaching implications for how professions operate. Three areas are discussed here: the organisation of professions; accreditation and licensing; and education.

Professional organisation

A prominent theme in the discussions above is that some occupations will disappear, some will undergo transformation, and other new ones will appear. For professions this creates structural pressures, and suggests that some existing professional groupings will need to be rethought substantially or they will effectively be rendered redundant. Professions effectively define themselves in various ways; for some the idea of a body of knowledge is central, some particularly newer groupings have coalesced around occupational functions (a few linked to legally-reserved activities), while a trend over the last two decades or so has been definition around what might be termed a body of practice. This latter is broader than the idea of a set of functions, and encompasses underlying principles and how they are embodied in practices that can typically evolve

and be applied across an indeterminate range of contexts, in what has been termed a 'centre-outwards' perspective (Lester 2014, 2017). *Given the same level of occupational disruption*, functionally-defined professions are likely to be most vulnerable to change, while those that start from a body-of-practice perspective will be most resilient. Groups that are relatively specialised and have come into being or evolved to provide well-defined services are the most likely to become redundant, while those that take a broad view of their fields and can transcend occupational functions and bodies of detailed knowledge are potentially more resilient.

Beyond the atrophy of some smaller or more specialised groupings, the impact on professional organisation is difficult to predict. A shift towards complex-meaningful work supports a centre-outwards orientation, but it is less clear whether the current 'centres' – professions with different perspectives, training routes and bodies of practice – will remain necessary, or whether some will begin to group together and others to fragment. As an example, architects, surveyors and structural and civil engineers all work in broadly the same field, bringing different perspectives and areas of expertise; but when much of their complex-routine work can be done electronically and the related specialist knowledge is quickly and freely available, pressures may build for a more generic built environment profession, while alternatively some sub-groups may seek to distinguish themselves through alternative means of organising. Further factors include the deskilling of some tasks, which may result in professional modes of organisation becoming less useful to both practitioners and their clients or employers; the growth of new technical occupations that may be too dynamic to allow traditional forms of professionalisation to appear; and the development of growing fields, such as those concerned with the environment, with ethics, and with human-machine interaction, into clearer professional groupings, though not necessarily organised as formally as many of today's professions.

Accreditation and licensing

Currently one of the major functions of professions is to provide some form of formal recognition, whether through simple membership, statutory licensing, an accredited title, or in some instances certification for specific purposes. Recognition typically has two purposes, one inward-facing to provide the practitioner with a marker of achievement and belonging, and the other outward-facing as assurance that s/he is suitably qualified to act in the capacity implied. The scope of professional recognition can range from relatively soft endorsement, which may say little more than that the person has done some relevant training and is interested enough to join an association, to legally-required licensing for practice; and from qualification in a broadly-defined profession ('macro-accreditation'), often with an obligation through a code of practice not to undertake work that is beyond the practitioner's capability, through to certification for a closely-defined area of activity ('micro-accreditation' or badging).

The impact of the kinds of changes discussed above suggest two directions for accreditation. If the prediction of a continued move to a centre-outwards perspective is correct, then the current emphasis on macro-accreditation is likely to remain and be reinforced. It may also extend to a gradual trend towards broader levels of recognition. Conservatively this might mean qualifying as a lawyer rather than solicitor or barrister or as a built environment professional rather than a surveyor or civil engineer; the existing common accreditation umbrellas developed by the Engineering Council, Science Council and the Council for the Environment are informative here (see Lester 2009).

More conjecturally, particularly if initial accreditation becomes viewed less as licensing for specific activities and more as a general assurance of professionalism, this could extend to qualifying as a professional in a very broad field of work, analogous for instance with the common professional values put forward in the European Union (CEPLIS 2014).

The converse of this parallels what has been seen in information technology, where accreditation as a programmer or technician at a general level is less valuable than up-to-date experience or training on a specific language, application or operating system, i.e. a form of micro- or meso-accreditation. Formal micro-accreditation is currently typically used in safety-critical areas, and it is likely to be favoured for tasks that are technical, procedural, or rapidly superseded, but where some form of attestation is needed. Taking these two trends together, movement may result towards both broader macro-accreditation and where relevant short-life micro-accreditation.

Finally, a question arises where functions that were once the preserve of licensed or accredited human practitioners are taken over by machines. At present standards for equipment are typically defined directly by legislation, by a national, European or international standard, or through specifications set out by the purchaser. However, where a task is equally capable of being performed personally or electronically, there may in the future be a case for the same body setting both human and machine standards, analogous for instance to an electronic vehicle being able to operate to the same standards applied to human drivers.

Education and training

Implications for professional education and training are perhaps the most difficult to predict, as they are affected by all of the factors discussed above. There are some obvious implications in terms of the technology itself, so that practitioners will need to be increasingly technologically adept (including in fields where technology has to date played a limited role), including being able to work competently with risk-related and ethical matters arising from using technology.

As specific, detailed knowledge becomes easier to access via technology, continued movement is likely away from the learning of a 'body of knowledge' as the foundation for professional practice, and towards a concern more directly with practices (Boud 2016). Echoing a trend reported a decade ago (Lester 2009), increased emphasis will be needed on understanding the principles underlying the area of work in order to aid among other things knowing what knowledge and skills to acquire and apply, how to interpret information and develop practice in context, and how to interpret and maintain oversight of information and analyses provided by machines. This suggests a (continuing) shift away from purely technical-rational expertise towards creative-interpretive professionalism and critical judgement. However, care is needed to avoid losing the skills and expertise that enable practitioners to recognise problems and intervene effectively when technology malfunctions or is sabotaged (Billett 2018); being able to make these types of contextual judgement is likely to depend on knowledge some of which is deep and field-specific.

A second major need is towards increased flexibility of professional development, parallel with the expected evolution of professional fields. This may point to more interprofessional courses, different pathways to specialism, and overall a greater range of routes to qualifying that are less predicated on teenage career choices or constrained by 'silos' dictated by current professional

boundaries. These directions are an extension of what is already happening, although route flexibility is likely to become more common and extend to more professions that is currently the case.

A third area where there are likely to be significant implications is in early-career, work-based training. A common pattern in many professions is to serve a fairly loose form of apprenticeship as the final preparation to practise. In this model the time taken up by training is often balanced by the novice practitioner undertaking tasks that are initially relatively routine, but contribute to the employer's business. If in the future many of these tasks are automated or become unnecessary, this points towards work-based training becoming more focussed, potentially accompanied by commercial pressures to bring the novice practitioner up to speed more quickly. Studies by Eraut (2008) and Allen *et al* (2015) among others point to practitioners needing creative-interpretive skills increasingly early in their careers, generating pressure for more expansive and effective initial training. Putting these factors together suggests that early career training will need to be geared to developing deep insights and high-level practice relatively quickly. Up to a point this may favour models that combine academic and work-based learning, provided that they do so in a way that is genuinely integrative rather than simply running off- and on-job training in parallel (Lester *et al* 2016, Kuczera & Field 2018).

Finally, and importantly in the short to medium term, is the impact of work transformation on the skills needs of existing practitioners. Some of this will relate directly to working with technology, but particularly in professions that are subject to significant automation or substitution, there will be a need for practitioners develop areas of capability that enable them to complement rather than compete with technology. For practitioners who are used to applying expert knowledge to readily identifiable problems, this may be an uncomfortable transition that requires significant support.

Conclusion

The 'fourth industrial revolution' or 'second machine age' is widely predicted to have a significant effect on work, particularly as technology starts to automate or result in the substitution of more complex types of activity. On balance, current analyses suggest that this will result in substantial job losses in some areas, broadly offset by the emergence of new occupations. More significant however is occupational transformation, with its implications for both initial education and reskilling. Importantly, many professional occupations will be affected directly by automation and substitution, with human expertise becoming less essential for even some highly complex tasks. This does not however spell mass redundancy across these occupations, but it will see changes to the tasks, fundamental skills and modes of organising of practitioners. An increasingly nimble response is likely to be needed from professional bodies and higher education institutions. The former to some extent hold the key to adaptability, as where professional boundaries and entry-routes are maintained too rigidly it can be difficult to develop programmes that are capable of preparing practitioners for upcoming challenges. In the latter there are some good examples of programmes and frameworks that support learning for the kind of creative-interpretive practice discussed above, but there are also programmes that assume a largely 'business as usual' approach even in areas where there is a high likelihood of substantial change.

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