

Essay

New Technology and Professional Work

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Abstract

Until recently, the main effect of technology on professional or knowledge-based work has been to augment and expand it, partly as described in Autor, Levy and Murnane's 2003 analysis. There are now increasingly instances of knowledge-based work being automated and substituted, developments that are more familiar from factory and basic administrative settings. Two widely-quoted studies, by Frey and Osborne (2013) and Susskind and Susskind (2015), point towards significant technology-driven job losses including in professional fields. Subsequent analyses indicate that while some occupations will disappear or be deskilled, others will be created. The argument made here is that the most significant effect will be occupational transformation, necessitating different types of skills in a net movement towards work that is more digitally-oriented but also complex, creative and value-based. These changes have implications that are already beginning to affect the way that professions are organised and how practitioners are educated and trained.

Keywords

Professions and technology, technology and work, Industry 4.0, Frey and Osborne, Susskind and Susskind

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 and the internal combustion engine. As has happened with previous technological advances, there is an expectation of widespread disruption to jobs, changes in the way that work is organised (e.g., Johannessen, 2019), and in some quarters a revisitation of ideas such as the 'end of work' (Rifkin, 1995).

A significant difference between the initial 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, to enable new ways of working, 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 about the effects of technological advances is that they are dependent on assumptions about how technology 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. There is a danger of descending into speculative futurology which can make for thought-provoking reading but is rarely a good basis for policy decisions or deciding on 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 and discussion on the impact of technology on work, and argues that while there will be implications for professions, making sense of these needs to consider more than the ability of emerging technologies to automate or substitute for tasks currently associated with professional occupations.

Technology and work: A summary

A widely-used model for conceptualising the effect of technology on work is that set out by Autor, Levy, and Murnane (2003). These authors propose three principal effects of introducing new technology. Firstly, it 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, unsafe or uneconomic. Secondly, it can *automate* them, as has happened with much assembly-line work, removing or reducing the need for human input. Finally, it

can enable them to be *substituted* by alternative means of achieving equivalent ends, as has happened with telephonists and typists. To apply their model, Autor and colleagues divide work into four types, namely, 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 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 technologies such as 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). In addition, some apparently non-routine cognitive activities, particularly those relating to analysis, diagnosis, and some types of research and drafting, now appear within the scope of automation or substitution (Brynjolfsson & McAfee, 2011; Casserta & Madsen, 2019; 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 limits to automation or substitution, both due to technological limitations or "bottlenecks" and in relation to social acceptability (e.g., Arntz, Gregory & Zierahn, 2016; Frey & Osborne, 2013). "Bottlenecks" occur where it is difficult or impossible to emulate or bypass human activity; Collins (2018), for instance, discusses the limitations of computers in relation to social and contextual intelligence, and argues that a qualitative leap in machine learning is necessary before significant advances will be made in this area.

A more recent perspective on Autor and colleagues' model is provided by Nokelainen, Nevalainen and Niemi (2018), who modify their two dimensions to routine-complex and instrumental-meaningful. Routine instrumental work is most susceptible to technological automation or substitution. In the longer term, much complex instrumental work will increasingly also be displaced, as there is no additional value provided by having it performed by people and the only limitations are the capability and affordability of technology. Routine meaningful work (typically straightforward tasks where there is social value through human interaction) might ideally be done by people, but there may be economic pressures for automation. As Share and Pender (2018) indicate for social care, in some cases there can be benefits from tasks being done by machines; in the current coronavirus pandemic, for instance, there are obvious benefits relating to infection control. In complex meaningful work, including "ethical decision-making, artistic, philosophical,

therapeutic and caring tasks” (Nokelainen et al., 2018, p. 21), intrinsic value is provided by the activities being carried out by people, making it relatively resistant to automation or substitution; ultimately, the potential for displacement is not principally a factor of technological capability. Nokelainen et al.’s conceptualisation has the benefit of building on the work of Autor, Levy and Murnane (2003), while avoiding the latter’s assumptions about technological limitations based on complexity; it offers a more resilient model in the light of subsequent discussions such as those of Susskind and Susskind (2015), Crookes and Conway (2018), and Blease et al. (2019).

One of the most widely-reported recent studies of the potential impact of technology on work is that of Frey and Osborne (2013; 2017). Their quantitative study examined 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, Gregory and Zierahn (2015) attempted to apply the same methodology in Germany, and Arntz and colleagues (2016) across the OECD countries. By taking a finer-grained approach which looked at tasks and activities within jobs, both groups concluded that while many jobs include 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. However, a caveat is necessary in that all of these studies focus principally on activities that can be automated or directly substituted for. They pay less attention to wider-scale substitution, where activities that may themselves not be easily performed by technology—Susskind (2018) for instance gives the example of lawyers representing clients in court—nevertheless may be at least in part substituted by different, technology-facilitated approaches that achieve equivalent ends.

The second objection to using Frey and Osborne’s conclusions as a prediction of labour market impact is that they treat occupations as fixed in the face of advancing technology (Frey & Osborne, 2013, p. 39). This doesn’t take account of the likelihood of new areas of work emerging (De Groen, Lenaerts, Bose, & Paquier, 2017); of jobs and occupations being transformed rather than eliminated (Bonin et al., 2015; Gifford & Houghton, 2019); or 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 create work, as well as transforming it where workers take on different, hard-to-automate responsibilities and tasks (Bonin et al., 2015; CEDEFOP, 2017). More subtly, the boundary between complementarity and substitution 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. Quantitatively, however, the predictions are of a continuing hollowing-out of middle-level occupations, where more easily automatable and substitutable jobs in administration, manufacturing, construction and the like 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 (among others, Frontier Economics, 2018). Predicting the long-term impact on the labour market is extremely difficult as it depends in addition to 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, Coombs, Taneva, & Barnard, 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 difficult 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 some 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, usually including attainment at degree level or above), 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. Technology has typically made practitioners

more efficient and better-informed, enabled them to carry out new tasks, increased communication and accountability, and in some cases increased their exposure to market forces and client or patient choice. Its structural effects have nevertheless tended 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 straightforward 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 and software engineering, 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, and societal, economic and legislative pressures appear to have had greater effect in for instance the reform of 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" and cross-professional groups such as family mediators, vocational rehabilitation practitioners and physician associates (Lester, 2009; Lester, 2016).

The emergence of technologies that are able to automate, enable substitution of, 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 and Susskind (2015) are informative about the kinds of changes that are taking place and that *might* happen here. Their basic analysis accords with that set out in the previous section in that 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 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 challenges both to individual professions and to the professional ideal of ethically responsible, self-regulating practitioners.

Susskind and Susskind's conclusions differ in some important ways from those presented by, among others, Bonin et al. (2015), Frontier Economics (2018), Hislop et al. (2017), and McKinsey (2017). 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), as well as taking

greater account of the potential that technology provides for substitution. Nevertheless, they make assumptions that mean that their conclusions need to be treated with caution. They view professional work as essentially technical-rational, emphasising the application of expert knowledge to convergent matters, and they also place it in a transactional, market-driven context. While many professionals do focus 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. They are also largely dismissive of professional ethics, suggesting that these can be substituted by organisational, contractual and market arrangements (Susskind & Susskind, 2015, p. 233 et seq.). 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 and Osborne's 2013 analysis, there is underestimation of the opportunities created by technology, both directly and by transforming jobs by removing tasks that are better-performed electronically. Even if highly knowledgeable workers become no longer essential for many 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, increasing demands for goods and services, and unanticipated events continue to create existential threats. A recent British study of the impact of artificial intelligence on work (Gifford & Houghton, 2019) indicates that artificial intelligence systems are, at least at present, creating and expected to create more opportunities for work than they are 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.

An example that illustrates the continuing need for human interpretation and decision-making is what has been described as the "black box" issue (e.g., Casserta & Madsen, 2019; Remus & Levy, 2017). This refers to situations where the logic used by computers in producing outputs or predictions is not transparent, enabling, for instance, harmful or unethical factors to become unintentionally embedded into decision-making or into the legal system. An example of this is provided by recruitment selection, where even highly complex algorithms that are set up with full awareness of discriminatory factors can nevertheless result in decisions that are biased against underrepresented groups (Bogen & Rieke, 2018). The problem is not that individual "black box" issues cannot be overcome, but that they can arise unpredictably and therefore require an ongoing need for human oversight. Collins (2018) points here to the danger of a "surrender to machines," accepting computer outputs as authoritative without considering the possibility of errors, misinterpretations and malfunctions.

On balance, it is likely that a significant proportion of professional tasks will become susceptible to automation or substitution, and as Susskind and Susskind argue, some will be

done more effectively, efficiently and consistently by machines. Areas such as medical diagnosis (Blease et al., 2019), legal drafting (Susskind & Susskind, 2015), routine research and data analysis (Pandit, 2018), and the assembly and auditing of accounts (Conway, 2018) 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,” which may increasingly approximate to Nokelainen and colleagues’ (2018) complex and instrumental work. This kind of work is likely to become increasingly commodified, with the likelihood of practitioners becoming displaced in one way or another. Displacement may be into standardised and increasingly price-sensitive work (the province of what Johannessen, 2019, terms the “precariat”) or out of the field altogether, but it can also involve movement into complex and meaningful activities which as suggested above are likely to become more necessary and critical. Overall, therefore, a gradual qualitative shift in professional work can be posited to activities that are complex and meaningful, typically employing creativity, contextual interpretation, value-based decisions, and interpersonal negotiation (e.g., Conway, 2018; Flood, 2019; 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 will be influenced by 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 some personally-provided services analogous to the growth in interest in craft-produced goods and foods. Several scenarios then emerge. On a rough continuum, these start from (a) minimal impact because the profession’s work is not widely susceptible to automation or substitution; (b) relatively straightforward transformation, where enough non-susceptible work emerges to accommodate the majority of practitioners, with or without significant reskilling; (c) major disruption, with a mix of transformation and job losses; and (d) 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.

Professional organisation and education

The above analysis, even if not as extreme as Susskind and Susskind's conclusion, still suggests some far-reaching implications for how professions are organised and for the education and training of professionals.

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 groupings will need to be rethought if they are not to become redundant. Professions define themselves in various ways; for some the idea of a body of knowledge is central, some newer groupings have coalesced around occupational functions, 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 or skills, 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. Further factors include deskilling, in some fields making professional modes of organising less useful to practitioners and their clients or employers; the growth of new technology-oriented occupations that may be too dynamic to allow traditional forms of professionalisation to appear; and the evolution of relatively new fields, such as those concerned with the environment, with ethics, and with human-machine interaction, into clearer professional groupings (though not necessarily formal professions).

Implications for 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 existing 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 related risk-related and ethical matters. 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 more than 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, with areas such as ethics, sustainability, interpersonal, and intercultural skills becoming more important (Penprase, 2018). On the other hand, care is needed to avoid losing the skills and expertise that enable practitioners to recognise problems and intervene effectively when technology malfunctions, is sabotaged, or produces suspect answers (Billett, 2018).

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.

Alongside this, there are likely to be implications for 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 are nevertheless necessary and contribute to the employer’s business. As Susskind and Susskind (2015) argue, not only is this generally inefficient as a training process, but if in future many of these tasks are automated or become unnecessary, work-based training will need to become more focussed, particularly where it is accompanied by commercial pressures to bring the novice practitioner up to speed more quickly. Studies by Eraut (2008) and Allen and colleagues (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. An emergent example is provided by degree- and master’s-level apprenticeships in the UK, where academic and workplace learning are specified through an apprenticeship standard and delivered in a way that (at least in the best examples) is genuinely integrated rather than through simply running off- and on-job training in parallel (Kuczera & Field, 2018; Lester & Bravenboer, 2020).

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 job losses in some areas, broadly offset by the emergence of new occupations. More significant, however, is occupational transformation, with 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 governing bodies, whether these are state-backed regulators or independent associations, 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, practitioners can be inhibited from developing their roles in new directions and educational institutions from developing 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.

Acknowledgements

An earlier version of this paper was presented at the Universities Association for Lifelong Learning’s Work and Learning Conference, University of the Arts, London, on 28th June 2019.

Part of the literature on technology and work was reviewed for the Erasmus+ Strategic Partnership project Digi4VET, for which the author is the UK partner and scientific co-ordinator. Digi4VET is designed to support preparedness for and use of new technology in vocational education and training. The project is led by SBG Dresden in Germany, and supported by funding from the European Commission via the Bundesinstitut für Berufsbildung (BIBB). European Commission support does not constitute an endorsement of the contents of this article, which reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained in it.

Essay history

Received: 23 Apr 2020

Accepted: 17 Jun 2020

Published: 26 Jun 2020

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