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Engineering and the Skills Crisis in the UK and USA: A Comparative Analysis of Employer-Engaged Education

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1 Introduction

Everyday living in the twenty-first century is underpinned by innovations in the field of *engineering*. Existing products are reengineered and new products created. Engineering underpins innovation in the delivery of services including developments in information and communications technologies (ICT). A successful national economy is one that has a balance between different industrial sectors. This balance includes

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financial services combined with the ability to create high-value-added products and services with a significant engineering element. The Industrial Revolution was founded on engineering innovations, and subsequently periods of rapid economic growth have been closely associated with engineering innovations including steam power, railways, electricity, chemicals, containerisation, logistic management systems, air travels, and computing (Kondratieff 1935). There is thus a significant engineering element that has played a facilitating role in the emergence and ongoing transformation of capitalism. Excellence in engineering is behind innovations in the development and management of infrastructure systems and low- and high-value business-to-consumer and business-to-business products. The term "engineering" has many different meanings. The field of engineering was initially divided into two—civil and military engineers; military engineers specialised in the destruction of works designed by civil engineers. Many different specialist engineering sub-disciplines have emerged including electrical, chemical, and mechanical. There are engineers who create, develop, or invent new products, and then there are skilled engineering-related occupations that are directly involved in the day-to-day fabrication of engineered products.

There are two types of engineered products. First, there are products that are mass produced in factories and, second, special projects that are customised to provide a solution to a particular problem, for example, the construction of a bridge, ship, or building. In 1990, Walter Vincenti, an aeronautical engineer based at Stanford, was asked the question by a colleague in economics "What is it you engineers really do". His answer resulted in a book entitled "*What Engineers Know and How They Know It*" (Vincenti 1990), and part of his answer was "What engineers do, however, depends on what they know". Organising is a key element of any definition of engineering, and Rogers defined engineering as "the practice of organising the design and construction of any artifice which transforms the physical world around us to meet some recognised need" (Rogers 1983: 51). In this context, organise means arranging including the development of new designs whilst "construction" also includes production, fabrication, or manufacture. The Rogers definition is more suited to civil engineering and the development of large projects that require customised construction rather than mass production. Absent from this definition is also anything connected with operational management including maintenance and sales.

The application of engineering practice to manufactured products has increasingly resulted in two outcomes (Bryson and Ronayne 2014; Bryson et al. 2015). First, there is an ongoing escalation in the value created by hi-tech or advanced manufacturing. Low-value manufacturing tasks are either undertaken in lower labour cost locations, or employees involved in the production process have been replaced by machines. High-value-added tasks including research and development have remained in developed market economies (Cohen and Zysman 1987; Bryson and Rusten 2011). Second, there has been an emphasis on the application by engineers of optimisation techniques that have removed raw materials from products and structures. This process has reduced the weight of raw materials embedded in manufactured and constructed products as the design process has focused on efficiency combined with effectiveness (Bryson and Rusten 2011). This shift is part of a transition towards a (Quah 1999; Bryson et al. 2004). The design of structures and products is becoming smarter with a focus on construction and manufacture to finer tolerances to reduce weight and also the cost of raw materials embedded in products or structures (Quah 1999). One consequence of these two outcomes is an increase in the productivity of employees involved in the manufacture or construction of engineered products (Select Committee on Trade and Industry 2002) combined with an escalation in the capabilities or skills required of individual employees (Bryson and Daniels 2008). It is important to distinguish between engineers that design and employees that are involved in constructing and manufacturing engineering products. This chapter focuses on the latter group. A consistent and persistent business and policy concern has revolved around a mantra of skill shortages in manufacturing-related engineering occupations (Leitch Review of Skills 2006; Kumar 2015; UK Commission for Employment and Skills 2016). These skill shortages have the potential to erode the competitiveness of manufacturing in higher labour cost locations. It is noteworthy that such an erosion or decline is unrelated to globalisation and is a purely local affect related to the operation of market imperfections in local labour markets and in educational systems.

Manufacturing-related engineering skill shortages are being experienced in the USA and the UK. In this chapter we compare two models of employer-engagement in the education of 14- to 19-year-olds. The first model, University Technical Colleges (UTC), is supported by the UK government and engages national employers in developing localised solutions to skill demands in science, technology, engineering and mathematics (STEM)-related occupations. The second approach, based in Chicago, USA, is the product of a coalition of manufacturing firms and organisations, the Chicago Manufacturing Renaissance Council (CMRC). The CMRC has supported the development of vocational education in the city via the establishment of the Austin Polytechnic Academy (APA) and a manufacturing-oriented curriculum and training programme within APA called Manufacturing Connect (MC). The APA provides specialist engineering-related education within a "normal" school environment. It pulls in small- and medium-sized enterprises as partner organisations to help inform curriculum design as well as provide work-based learning opportunities for APA students through summer internships, job shadowing, mentoring, and eventual job placement. These two examples offer alternative approaches to developing vocational education for the engineering sector.

2 Skills Gaps, Capabilities, and High Value Engineering

The referendum that was held on Thursday 23 June 2016 to decide whether the UK should leave or remain in the European Union is associated, on the one hand, with considerable political turmoil as 52% of voters stated their desire to leave the EU. On the other hand, the period after the referendum is associated with an attempt to develop a new industrial policy. The driver behind this new industrial policy is closely linked to the outcome of the EU referendum and involves a series of discussions regarding what constitutes an effective industrial policy (Livesey 2012; Clark 2013). Such a policy needs to be long term and must include skills or soft infrastructure, connectivity and related hard infrastructure investments combined with a focus on the wider framework conditions that support economic activity including labour market regulations, the planning system and taxation. A systemic or integrated approach must be developed to create an effective industrial policy.

The history of British industry is one in which manufacturing firms have attempted to overcome some of the constraints imposed upon their activities by their external environment by developing an integrated corporate strategy. For example, from the 1930s, the Smiths Group, formerly Smiths Industries, a British transnational diversified engineering firm with operations in over 50 countries employing around 23,550 staff, developed a skills and housing strategy. In June 1938, Smiths developed an in-house technical school on the understanding that the company's future was "not simply a question of building factories and installing plant—skilled and trained staff were equally vital" (Nye 2014: 97). In the 1950s, the firm found that national government housing programmes were failing to provide sufficient housing to support the company's demand for employees close to their factories. In September 1951, Smiths announced that it was going to develop 150 houses close to one of its factories and another 140 were planned. For Smiths, an increase in their workforce also involved strategies to provide training to enhance employee skills combined with attention to the availability of local housing. It is worth nothing that this firm's strategy was focused on the needs of the business but the policy altered "rather than being content to fund a large portfolio of houses, whether directly or through financing housing associations, 1952 would see a new desire emerge, to sell houses to their occupants wherever possible, to free up cash" (Nye 2014: 143). In this case, the firm was acting as a facilitator in the provision of housing for employees.

There is an ongoing debate in developed market economies regarding manufacturing (Loch, et al. 2007; Bryson et al. 2013; Bryson et al. 2015). On the one hand, manufacturing in relatively high-cost locations is being out-competed by companies producing products in emerging economies with lower factor input costs—land, labour, raw materials.

This has given rise to a well-established debate on deindustrialisation in which employment in manufacturing declines in developed market economies to be replaced by jobs in services (Cairncross 1979; Bryson et al. 2004). The deindustrialisation debate, however, confused a decline in manufacturing employment in response to productivity improvements with an absolute decline in manufacturing (Bazen and Thirlwall, 1991; Bluestone and Harrison 1982; Bryson et al. 2013; Bryson et al. 2015). Employment in manufacturing declined, but at the same time, output increased due to capital investments in machine tools and the application of new technology. The debate on deindustrialisation emphasised the emergence of a new spatial division of manufacturing in which countries with lower labour costs out-competed firms located in high-cost locations (Scott 1986). This is an account based on globalisation and the ongoing development of an international economy. On the other hand, the competitiveness of manufacturing firms located in high-cost locations is constrained by local factors including the availability of appropriately skilled labour and other factor inputs, for example, energy (Mulhall and Bryson 2013, 2014) and land (Kalafsky 2007; Bryson et al. 2013). This is to argue that the competitiveness of manufacturing firms is partly challenged by ongoing developments in the spatial division of labour, but also by local factors or market imperfections that play an important role in undermining the performance, productivity, and growth of manufacturing in developed market economies.

The skill sets required to support manufacturing have altered with the emergence of advanced or hi-tech manufacturing. The UK Leitch report on skills noted that:

> Over the past 20 years or so, the proposition of jobs requiring high skills has increased substantially, as technology and the global economy has changed. Technological change often leads to higher demand for skills and most employers that presented evidence to the Review expressed concern about shortages at intermediate and higher skill levels. Where establishments are undergoing high levels of technological change in their processes, skill needs are reported to have 'gone up a lot' for 42% of jobs, compared to only 25 per cent of jobs in other establishments. These

> changes will continue as the global economy restructures. Only if the UK is a world leader in skills can UK businesses be world leaders in the new global economy (Leitch Review of Skills 2006: 33).

Between 1980 and 2012 per capita world output increased by 1.7% and this corresponds to cumulative growth of just over 60%. This represented a major transformation in lifestyles, consumer behaviours, and labour markets. A relatively modest annual growth rate over a 30-year period involved transformational technological changes including the Internet, mobile computing, smartphones, health care, transport and digital services. According to Piketty:

> These changes have also had a powerful impact on the structure of employment: when output per head increases by 35–50 percent in thirty years that means that a very large fraction – between a quarter and a third – of what is produced today, and therefore between a quarter and a third of occupations and jobs, did not exist thirty years ago (Piketty 2014: 95–96).

The implication of this analysis is that a per capita growth rate of between 1 and 1.8% represents extremely rapid change. For the labour market the rapidity of this change has major consequences for vocational training and for the relationship between skills that exist within a national labour market and forthcoming demand.

In the UK, hard-to-fill vacancies have been a long-term problem. The 2015 employer skill survey of over 91,000 employers found that 6% of all employers had at least one skill-shortage vacancy and that there were "209,500 reported skill-shortage vacancies which was an increase of 43% from the 146,000 reported in 2013" (UK Commission for Employment and Skills 2016: 12). Moreover, since 2013 there had been an increase in skill-shortage vacancies among Machine Operatives (from 25 to 32% of all vacancies) and skilled trades were experiencing the highest density of skill shortages (43%) (UK Commission for Employment and Skills 2016: 13). A review of the state of engineering in the UK in 2015 noted that engineering firms are more likely to experience hard-to-fill vacancies for professionals (31.7%) and skilled trades (24.8%) and consequently "nearly half (48.3%) of engineering enterprises said that hard-to-fill vacancies meant they had delays in developing new products or services whilst 44.8% said they experienced increased operating costs" (Kumar 2015: V). A 2011 joint report by Deloitte Consulting and the Manufacturing Institute echoed similar concerns for the USA, estimating that 2 million highly skilled manufacturing would go unfilled from 2015 to 2025 as a result of sector-wide skill shortages (Deloitte Consulting LLP and The Manufacturing Institute 2011).

There is no question that skill shortages and hard-to-fill vacancies can have a tangible or measureable impact on firm performance including productivity (Christopherson 2012). What is subject to increasing debate, however, is the question of where to place responsibility for persistent skill shortages (Cappelli 2012; Osterman and Weaver 2014; Lowe 2015a). Some labour market analysts have skirted this issue altogether by outright dismissing claims of skill shortages (Sirkin 2011; Salzman 2013). They argue instead that manufacturing wages are set far too low, creating little incentive for skilled, yet underemployed individuals, to change jobs or seek out new employment opportunities that make better use of existing knowledge and expertise. By this same logic, raising wages should help address hard-to-fill vacancies or skill-shortage vacancies by attracting more employees with appropriate skills, qualifications, or experience (Cappelli 2012).

Others have taken a more pragmatic approach, recognising that immediate wage adjustments, in isolation, may not offer a long-term solution, especially as investments in skills must be balanced to reflect both current *and* future needs of local and national labour markets (Glaeser and Saiz 2004; Glaeser et al. 2012). One complicating factor involves an ageing manufacturing workforce, thus putting pressure on companies to recruit younger replacements and by extension, invest more heavily in their skill development. Yet, declining resources within manufacturing firms—itself a reflection of shrinking firm size—means that few but the largest corporations and establishments have the internal capacity to anticipate and prepare for emergent skill shortages (Berger 2013; Osterman and Weaver 2015; Lowe 2015b). External educational institutions are therefore expected to play an active role in addressing this emergent skills challenge. In the right context, they can also be critical to sustained and resilient economic growth. As Piketty argues "the lessons of French and US experience thus points in the same direction. In the long run, the best way to reduce inequalities with respect to labor as well as to increase the average productivity of the labor force and the overall growth of the economy is surely to invest in education" (2014: 307). Still, for educational solutions to be effective, we need to think more critically about what type of educational initiative is needed to support what type of economic actor and activity (Cappelli 2012; Lowe 2015b). Ongoing innovation continues to transform local labour markets implying that forecasting future skill needs is difficult and perhaps impossible for educational institutions to do alone. One option is for employers and educators to forge long-term partnerships to replenish current skill sets whilst also co-investing in future learning opportunities for the next generation of labour market entrants. This replenishment of skills involves employee retraining, but also attracting and training entry-level employees to work in manufacturing.

3 Employer-Engaged Education in England and Chicago

Engineering is suffering from shortages of the "right" entry-level talent. Preparedness for the world of work as well as a practical understanding of engineering is valued by employers and makes school-level graduates more employable. Schools and other providers of secondary education need to be responsive to local employers and engage with them to develop an appropriate curriculum for students. In that capacity, they can do more than simply serve employers the skills they claim they need. They can also mediate exchanges between job seekers and employers in ways that ultimately shapes employer skill demand and who gains access to jobs accordingly (Lowe 2015). This section explores two engineering training skill initiatives both aiming to address skill shortages and career progression for young, entry-level future employees that builds knowledge of the sector and trains students to potentially have future leadership roles in the industry. However, the approach is different in each case.

The national UTC model attempts to build awareness of the sector and a knowledge base needed for high value engineering. In contrast, the Chicago-based model focuses on youth employment within a high-poverty, inner-city neighbourhood with the goal of to delivering workplace ready, accredited skills for immediate entry into the workplace with progression to leadership roles. Both initiatives are responsive to employer needs but at different scales and over different timescales.

3.1 University Technical Colleges, England

The University Technical College (UTC) model was developed by the Baker Dearing Educational Trust (BDET) as a model of vocational education for 14- to 19-year-olds in England. The first UTC was established in 2010, the JCB Academy, with a further 47 opened since and seven further UTCs are due to open over the next 2 years (Baker Dearing Educational Trust, n.d.). A UTC is a specialist school providing a mixed academic and vocational education within the state-funded education system. Each UTC has at least one engineering specialism that is taught alongside academic qualifications within an extended working week and year (up to 40% additional time). Each UTC is supported by employer- and university-partners, a reflection of the desire not to separate vocational and higher education and maintain all progression routes for students. There are two entry points for students: at age 14, which is unusual in the English education system; and at 16, which is a normal transition point after mandatory state education.

The UTC model is a framework for vocational learning. A semi-technical syllabus incorporates vocational learning with traditional academic learning and qualifications. The aim of the schools is to improve the standard of engineering education to meet the needs of high value engineering businesses, as well as provide a progressive career route for young people. This is implemented through project-based learning incorporating traditional academic subject matter within a business and engineering context. The projects are supported in design and delivery by employer-partners. Employer-partners are organisations within the specialist field of the school that are affiliated to the UTC. They provide guidance on teaching content, support delivery of some classes, provide site visits for student groups, and lend their brand to the school to help student recruitment. Employer-partners tend to be large corporate organisations, such as Rolls Royce, JCB, National Grid, and Network Rail, although there are some instances of smaller firms partnering to provide employer-engagement. Each UTC is supported by a network of smaller, local organisations that primarily support student work placements.

The BDET own the model and brand "UTC". This is designed to provide consistency and standards in the vocational learning model across England, with the final aim for the UTC model to become an established route within the English education system. The framework provides an opportunity for nationally significant employers to engage with the initiative nationally (as a member of the BDET national employer panel) or locally with one (or several) UTCs (as a member of the management board or with direct education delivery). The brand provides critical mass providing employers with a unifying framework and parents and prospective students a signal of the quality and durability of educational provision. The UTC model aims to directly address the image problem facing manufacturing in the UK. The perception of a working life in the sector is negative, with careers seen as unstable, limited and dirty compared to more graduate-style service employment. New school buildings, cutting edge technology including the latest machine tools and innovative working practices (9–5 workdays with no homework and open working spaces for students and teachers) help develop a positive image of the future of engineering. This complements more traditional vocational education measures, such as work placements.

Each UTC is designed to reflect the regional industrial structure, through its choice of specialism, as well as to support overall educational provision in the area (supply of good school places). Employer-partners should be based locally and in theory reflects opportunities in the local labour market. However, the primary driver for employers involved in the UTC initiative is to increase awareness and interest in engineering careers rather than in creating a new direct supply of skilled employees to their businesses. The catchment area for the school is sub-regional (which is considerably larger than traditional schools) and is designed to reflect the industrial structure (and consequent skill need) of an area. Despite the growth in number of UTCs over recent years, coverage remains patchy across England. The South West, East Anglia and northern England have relatively few UTCs (two, three, and four, respectively), with the majority located in a central band between London and the North West (Baker Dearing Educational Trust, n.d.).

The UTC model does face some significant challenges. Recruitment is difficult because of the unusual transition point at age 14, logistical challenges of further travel to the schools and the unproven record of UTC performance. This is in part mitigated by the showcase of corporate employers and promise of improved employability of students graduating from UTCs in recruitment drives hosted by employers rather than targeted at local feeder schools. Performance is also mixed. As an indication of performance and standards achieved in the schools, the Office for Standards in Education, Children's Services and Skills (Ofstead) inspection results provide a benchmark for performance and safety across the country in all types of school. Although the initiative is relatively new, 15 of the 48 UTCs currently open have been inspected. The performance of UTCs has been mixed, with only six UTCs receiving a grade of "Good" or above and nine UTCs scoring a grade of requires improvement (7) or inadequate (2) (Ofstead 2016). Three of these UTCs have since closed following poor performance and recruitment issues. There is a tension for these schools between academic and vocational educational performance. Overall, Ofstead inspection reports were positive about the link to employers and equipment for students as it provided a clear progression route, enthused students to self-learn and provided a route to "worthwhile destinations" (Ofstead reports for UTC Plymouth and Liverpool Life Sciences UTC). In comparison, a low expectation of student capability was often cited as a weakness, as well as mixed standards of academic achievement across the schools. Notable was the poor rating of students' literacy skills, even in those schools identified with "Good" performance: literacy, reading, spelling, and grammar are specifically cited as areas of poor performance in 11/15 Ofstead reports.

3.2 Austin Polytechnic Academy, Chicago, USA

Manufacturing Renaissance (MR) was formed in 2005 to address the emerging skill shortage in leadership roles in the manufacturing sector as the ageing workforce began to retire. The MR is a coalition of government, community leaders, small and medium manufacturing companies (SMM), organised labour and education providers. It was considered that there was a need to support the industry by improving entry-level applicants available for employers and promoting leadership skills for young people. The Manufacturing Connect (MC) programme was developed by MR and has been incorporated into the local education system through one school, Austin Polytechnic Academy (APA). APA is funded by the state, but the additional MC activities (equipment and a full-time manufacturing teacher, which equates to around $50,000) are funded by fundraising by MR.

The aim of the MC programme is to address skill shortages in SMMs, but also enhance the education and career opportunities for school-leavers, who live in one of Chicago's most deprived neighbourhoods. MC provides three areas of skill development: technical, work-readiness, and leadership. These skills are developed through work-based learning and contextualised academic learning, as well as specific career-readiness and leadership development courses. In addition, students have the opportunity to acquire accredited metal working skills during the programme.

The MC programme relies on an extensive network of SMMs in the local area to provide students with tours, job shadowing opportunities and postgraduation work placement. Whilst MC has engaged more than 90 SMM in some capacity, a small subset remain active partners and part of a formal advisory group that helps design the programme curriculum and secure equipment donations for training purposes.

Based on the recommendations of partner firms, MC equipment is not leading edge technology. Rather it reflects that currently used by local firms and thus, sets realistic expectations for entering the manufacturing work environment. For the employers, working directly with secondary school students and the education system is a new route to acquiring employees. Traditionally, these firms recruit through word-of-mouth from their workforce. This has provided an informal training mechanism as prospective employees have an awareness of the sector and expectations from existing employees. This recruitment process has become more limited with an ageing workforce, and the MC programme provides an alternative route for recruitment and for students to develop an awareness of employment opportunities in engineering and manufacturing.

The outcomes of the initiatives are mixed. The number of APA students that participate in the MC programme varies between 25 and 75% each year. The factors contributing to low participation are complex, but programme staff acknowledge that APA's location in a high-poverty, high-crime neighbourhood is a contributing factor and where prospective students with strong academic qualifications, including engineering interests, seek out more prestigious educational opportunities outside the neighbourhood. Most MC participants gain some manufacturing work experience during the course of the programme (between 68 and 100%, depending on year between 2011 and 2016). There is greater variance in the number of students that leave with at least one accredited metal working skill (40–100%). The numbers that pursue a career in manufacturing, either through further education or in employment is much smaller, with the average at 20% (varies between 1 and 32%, depending on year). However, leaders of the MC programme do state that this number is higher 1–2 years postgraduation when students return to seeking a job in the sector.

4 Scaling Skills? University Technical Colleges Versus Austin Polytechnic Academy

The skill shortages being experienced by English and American manufacturing firms place limitations or constraints on productivity and growth. The manufacturing workforce of both countries is ageing, and an immediate problem exists with the replacement of retirees from the labour force. This implies that skills initiatives need to respond to both the need to replace retirees combined with demands for higher-skilled employees. The UTC and APA approaches are radically different, but both are relatively insignificant contributions to the skill problem facing high value engineering in the USA and UK. The focus of both initiatives is on hard-to-fill vacancies rather than the skill gap within a firm's incumbent workforce. The difficulty is in shaping the career aspirations of teenagers and in ensuring that there is a relatively direct relationship between educational providers and local employers. Both the UTC and APA go some way to ensuring that there is a direct relationship between some firms and some school students, but the definition of "some" is very restricted. It is also worth considering how a country's skill strategy is shaped by decisions made by relatively uninformed teenagers regarding the focus of their studies rather than shaped or influenced by the needs of a local labour market, by potential employers or government. Thus, millions of incremental decisions made by teenagers and their parents combine together to provide the skill base of a local or national economy and it is this process of incremental decision-making that leads to skill shortages. These decisions are not taken in isolation but are influenced by fashion, peer and parental pressure, individual interest and teachers.

Both employer-engagement initiatives are targeted at educating 14- to 19-year-olds by providing a foundation of contextualised learning that integrates academic with vocational education. Work-readiness and future leadership development are important for employers to meet the changing demands of working in high value engineering industries. However, how the initiatives position manufacturing is very different. An awareness of workplace culture and expectations is a key aspect for both, but the UTC model aims to showcase "corporate" engineering with cutting edge technology to attract new employees into manufacturing. This is based around the provision of best-in-class machine tools that may not yet be industry standard and a focus on understanding the manufacturing sector rather than acquiring a set of directly transferable accredited technical skills.

The APA/MC attempts to illustrate the reality of everyday working practices and experiences for most entry-level manufacturing employees. On the one hand, the APA provides accredited, transferrable skills that are recognised by manufacturing employers. In this case it is possible to argue that APA is more directly engaged with providing potential employees with some manufacturing-related skills compared to the UTCs. The UTCs educate students by providing some understanding of manufacturing, and this reflects a more indirect relationship between the school and potential employees. On the other hand, the APA develops student capability based around using equipment that is used by local manufacturing firms. This equipment includes older equipment that has been donated by manufacturing firms supporting the school. Once again this illustrates the more direct relationship between the APA, students, and the needs of potential local employers.

Both policies operate at different scales, but both attempt to meet the needs of local employers. The UTC model is being applied across England with UTCs being established with the support of large firms that have facilities in local labour markets. The MC programme is a bottom-up intervention that was launched as a single-school initiative, based in high-poverty neighbourhood in a large American city. MC has recently secured a contract with the Chicago public school system to replicate the programme at two other Chicago-based schools. In contrast to the original APA/MC experiment, however, MC staff will work with teachers and students at established high schools, avoiding some of the organisational challenges associated with launching a brand new school. In contrast, the UTCs are a top-down initiative that tries to facilitate or coordinate a local bottom-up solution to the provision of manufacturing-related education across England. This is a novel approach that reflects an interaction between predominantly large firms and an initiative that is designed to raise the profile of manufacturing employment as a potential career option.

There is a tension with the UTC model in that each school has to be evaluated by Ofstead to ensure that they provide an appropriate academic education. The initial assessments have highlighted academic weaknesses in the UTC model primarily because the evaluation emphasises academic rather than vocational criteria. This is not to argue that the UTCs should focus solely on vocational training, but that the Ofstead UTC inspections should acknowledge their distinctive approach as the schools try to balance academic with vocational training.

The difference between the UTC versus APA model is more than scale, but about approach with the APA providing students with recognised metal working qualifications compared to the UTC focus on more standard academic qualifications. There is another difference that is important. Both focus on providing students with an understanding of manufacturing workplace culture to try to ensure that students will consider developing a career in manufacturing. Nevertheless, the UTC focus is on training students in corporate engineering compared to the APA which is more focused on training students for work on the shop floor. For the APA this reflects the needs of local employers, but also the location of the school and its intake in one of Chicago's more disadvantaged communities.

Neither initiative has been around long enough for a rigorous and robust analysis of their local and regional impacts to be undertaken. Education is a long-term process with the evaluation of these initiatives dependent on following complete cohorts through the schools and on into the labour market or further study. It is worth noting that neither the UTCs nor the APA have been extremely successful in feeding students directly into employment in partner manufacturing firms. For many firms their involvement in these local skills-based initiatives appears to be more about corporate social responsibility or corporate philanthropy rather than about training potential employees who can be directly recruited by manufacturing firms. In this case, both the UTCs and APA are intermediate actors in the local labour market as students go on to further study. There is a tension between the ways in which the UTCs and APA position themselves to potential students and their parents as a mechanism for facilitating direct entry to manufacturing employment rather than as an intermediate actor in local labour markets.

5 Conclusions

There is no question that the relationship between available skills in a local labour market and employee need is complex and problematic. Local skill shortages might be overcome by encouraging migration. The Leitch review of skills in the UK notes that "migration generally has a positive effect, helping to mitigate skill shortages and fill jobs that cannot be filled domestically" (2006: 32). Nevertheless, migration as a solution to local or national skill shortages has preoccupied British politicians, Trade Unions, and the media, and this topic is central to the ongoing debate over the EU referendum and the vote to leave the EU. In the UK, across the media and politics, migration has become associated with competition for local jobs and housing and with pressures in local labour markets that are often considered to be problematic. Migration has, however, always played an important role in providing the USA and the UK with access to skilled people.

The skills gap being experienced by US and UK manufacturing firms raises the question of: Whose problem is this and who should be responsible for providing a solution? The solution might be considered to be the responsibility of government, firms, industrial sectors or individuals or some combination. There is a tendency for manufacturing firms to blame government on the assumption that the solution should be developed and paid for from taxation. Alternatively, firms should develop their own solution either working in isolation or in partnership with other firms. There is a blended solution that has been developed in the UK. In the spring of 2017, the way the government finances apprenticeships is altering. On 6 April 2017 an apprenticeship levy will be introduced that requires all employers operating in the UK with a payroll of over £3 million per year to pay 0.5% of their total pay bill as an apprenticeship levy minus an annual levy allowance of £15,000 per year. Firms will then be able to access funding to support the provision of their own apprenticeship schemes. This new system is similar to the UTC approach as it combines a top-down with a bottom-up approach and forces employers to invest in apprenticeship training.

The apprenticeship levy has the scale and the level of inclusion that is absent from the UTC and APA approach. The UTC and APA, however, are playing a very different role in local labour markets—educating students, and their parents, to appreciate or understand high value engineering and the ways in which value is created through engineering excellence. The difficulty is one of scale and scope. The UTC has more scale and the potential for wider rollout across England, but the scope is limited. This limitation is reflected in the emphasis that is placed on understanding manufacturing rather than in providing directly accredited transferable skills. The APA has a very limited scale, but a wider scope as it provides accredited transferable skills. In both cases, the number of students and companies involved is limited and insignificant compared to the scale of the problem. It is possible to argue that the UTC and APA are making a very minor contribution to addressing the skills gap in high value engineering in England and Chicago. Nevertheless, this contribution still matters as it provides an opportunity for transforming the life chances of some individuals and providing some potential employees for high value engineering firms.

Measuring and evaluating the impact of the UTCs and APA requires a longitudinal study based around following cohorts as they enter the schools and then progress on to entering the labour market. Both initiatives require time to become locally embedded. Employer-engagement in the education of young people adds value in the form of exposure to the engineering sector, preparedness for work, providing potential opportunities for employment, and ongoing career progression. This type of value is not identified in traditional measures of academic performance. There is a danger that traditional measures of academic performance undermines or distorts the advantages of including businesses in the classroom. The key questions are perhaps philosophical and revolve around "education for whom and for what?" Is the educational system intended to train or educate citizens for employment or to educate for life? These are not necessarily mutually exclusive propositions. There is reluctance to hardwire the educational system to the needs of local or national labour markets as this may be associated with social engineering to meet employer needs rather than the needs of individual citizens. The answer to these more philosophical questions is one of developing a balance between educating individuals for everyday living and providing labour markets with skilled employees. Part of the answer is based on exploring the tension between academic and vocational training. In this context, the emphasis must be based on developing a balance between different types of skills and qualifications and in ensuring that academic and vocational qualifications are considered to have equal status. An alternative approach is to argue that the changing nature of economic activity means that it is impossible to identify the future skill needs of local labour markets. Cumulative economic growth has transformed labour markets over the last 30 years producing new types of employment. The school system must provide students with a set of adaptable skills and an approach to learning and training that will provide everyone with the capability to respond to radical alterations in the labour market. The only known is perhaps continual radical change in the types of work that will be available over the next 30 years. Individuals, governments, and firms must develop appropriate strategies to respond to these transformations, and this response requires investment in time and training by all involved in local and national labour markets.

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