Industrial Standardisation as a Driver for Cross-national Convergence in Training Processes: Aviation Maintenance Apprenticeships in England and Germany.

Abstract

Purpose

The purpose of this paper is to address a gap in the comparative research literature on vocational education and training (VET) and skill formation systems. It examines the impact of international technical standardisation and regulation on the design, organisation and delivery of aviation maintenance apprenticeships in England and Germany.

Design/methodology/approach

The research design was informed by insights from economics, workplace and work-based learning, and comparative education. Academic experts in the fields of aerospace and aeronautical standardisation and regulation, VET, HRD, and business organisation were consulted. The generic occupation of 'aircraft mechanic' was selected as being the closest match for comparison. Interviews and non-participant observation in workplaces and training centres were carried out involving three companies in England and four in Germany.

Findings

Findings show that there is considerable convergence across the pedagogical approaches to aviation maintenance apprenticeships in England and Germany related to fostering of the capacity to take responsibility for the quality of one's work, to work in and lead teams, and to respond to and work with customers. Increasing international regulation and technical standardisation underpins a shared language about learning through practice in technologically advanced workplaces.

Originality/value

This paper is original because it turns the lens of inquiry to workplace processes to reveal the level of convergence in training philosophies and practices in an internationally highly regulated sector. It shows how international technical standardisation and regulation combined with increasing technological change is leading to pedagogical innovation. The findings have

implications for VET and apprenticeship policy at the national and international level. The research design could be developed and replicated in other sectors to stimulate a more grounded approach to the comparative study of apprenticeship.

Keywords

Regulation, standardisation, apprenticeship, convergence, training practice, pedagogical innovation.

Paper Type

Research Paper

1   Introduction

The far-reaching technologies heralding a fourth industrial revolution and the increasingly international management of production processes in the form of technical standardisation, regulatory frameworks and legislation are having an impact on the organisation of work and training (Guile and Unwin, 2019; Schwab, 2017; Bremer, 2008; Berger, 2005). Organisations within and across sectors respond differently to these external pressures, and this in turn affects the capacity of workplaces to create effective environments for learning (Unwin, 2017; Felstead *et al*., 2009). In parallel, there has been a concerted international effort by organisations such as the European Union and the OECD to bring greater convergence across national vocational education and training (VET) systems through the use of measurable competence standards and qualification frameworks to reassure global companies and facilitate labour mobility (Brockmann *et al*., 2011). Whilst researchers have been studying these structural developments for some time, very little attention has been paid to how far global standardisation has had an impact on learning processes within and across national VET programmes. Moreover, comparative studies often use institutional and cultural characteristics of VET systems as their key units of analysis to differentiate one country's approach from another, with far less attention paid to potential similarities and convergences in the way vocational training is conducted.

This paper seeks to address this gap in the literature. It presents findings from an exploratory comparative study of the impact of technical and regulatory standardisation on apprenticeship training in aviation maintenance in the UK and Germany at the level of the workplace. The

aviation industry has always been at the forefront of technological change, whilst also operating within a highly regulated environment. From a maintenance perspective, recent advances in 3D printing (or 'additive manufacturing'), predictive technologies, and hybrid power, as well as the increasing use of composites materials are transforming working practices and, hence, job roles and functions. The maintenance engineer is now seen as a 'digital troubleshooter' who can collect, interpret and apply the data collected through communication with aircraft sensors to identify components in need of replacement or repair (Price 2018). These advances are advocated in relation to increased efficiency across the industry, but also for increased safety.

The intention of the study was to work with companies that might be willing to cooperate with the research team to test the hypothesis that the impact was sufficient to lay the foundation for a larger investigation. From a political economy perspective, these two countries are regarded as being polar opposites in relation to training culture and institutional arrangements for VET. The United Kingdom (UK) and hence, by association, England, is defined as having a liberal skill formation system in contrast to Germany's coordinated skill formation system (Busemeyer and Trampusch, 2012; Hall and Soskice, 2001). This has resulted in a more robust and sustained commitment in Germany to ensuring consistency in the quality of apprenticeship training. This is particularly evident in Pilz's (2016) typology of training systems (see also Pilz, 2009; Ryan and Unwin, 2001). Busemeyer and Trampusch (2012, p. 4) remind us, however, that skill formation is a "dynamic and contingent process" (see also Unwin 2017; Thelen, 2004). As this paper argues, by taking a sector-level approach, it is possible to identify degrees of convergence which are overlooked in macro-level studies and which shed light on how vocational training itself is adapting and innovating in response to technological and workplace change. This type of research can generate findings that can then be used to inform policies at the national and cross-national levels.

2. Literature Review

There is a long tradition in international comparative studies of education and training systems of trying to detect evidence of convergence and divergence across countries. Some studies highlight convergence at the macro level in the way policymakers call for education to be more responsive to industry and to emulate countries that perform well in international tests such as PISA (Programme for International Student Assessment) (Bohlinger *et al*., 2015; Brown *et al*.,

2001). At the level of both policy and practice, the global expansion of Higher Education (Lauder, 2011) has encouraged some countries to improve the permeability between general and vocational pathways (Deissinger *et al*., 2013). However, national differences remain strong (Green, 2013; Jakobi and Teltemann, 2011). This is particularly the case in relation to the institutional, organisational and curriculum design aspects of initial vocational training systems (Pilz, 2012; Brockmann *et al*., 2011; Aarkrog and Jørgensen, 2008). It is striking that whilst much of this literature refers to the impact of globalisation on the demand for skills and on employment patterns and migration, this has not led to a growth in specific sector-based studies of how globalisation might be affecting practice within national vocational training systems.

Comparative research in the field of workplace and work-based learning has yielded a substantial literature exploring how different organisations within sectors and across sectors create, organise and nurture initial skill formation and continuing professional development. The literature also includes some discussion of the influence of technical standardisation on working processes and initial vocational training (Boreham *et al*., 2002), but tends to focus more on the generic underlying influences on workplace learning (Malloch *et al*., 2011; Billett, 2010). From their research using sector-based case studies in the United Kingdom (UK), Felstead *et al*. (2009) argue that any analysis of workplace learning needs to begin with the external and internal features of the productive system within which workplaces sit, including international, national or country-specific regulation and legislation. A recent study by Short and Harris (2017) identified a trend towards harmonisation of company-based training in the Australian railway sector. This echoes findings from research in the field of Human Resource Development (HRD) providing insights from alignment theory into the drivers for convergence between HRD and business strategies (see, for example, Gibb and Wallace, 2014), including the training strategies of multinational companies (Pilz and Li, 2014). Nevertheless, the research focus seems in such cases to be more on the company context and less on a sector-specific and international context.

One study that has addressed the issue of the impact of international standardisation on the organisation and quality of training within the aerospace sector and within a national VET system is also from the Australian context. Hampson and Fraser (2016) critically examine the decision of Australia's Civil Aviation Safety Authority (CASA) to adopt the European Aviation Safety Agency's (EASA) new regulatory requirements for the training of aircraft maintenance engineers, introduced in 2011. They argue that EASA's "licensing system seems

designed to be as neutral as possible about the training systems with which it articulates, allowing implementing countries to build their own relation with it" (ibid, p. 355). However, because Australia's market-based VET model gives training providers considerable freedom regarding design, content and assessment, the result has been the "fragmentation of training content and widespread inconsistency in assessment" (Hampson and Fraser, p. 356). Hampson and Fraser's study charts the disquiet both within the CASA and the industry about this change and the reduction in the numbers of maintenance engineers being trained. In addition to the findings, their study shows the benefits of focusing on a specific sector to address the question as to how far international regulatory and technical standardisation drives convergence in training and learning processes across countries. The influence of EASA regulations was also addressed by Guile (2011) in his study of the development of a foundation degree curriculum for the aircraft industry in the UK.

3. Regulation and VET programmes in context

The UK and Germany are both members of EASA whose role includes regulating the sector, formulating and implementing legislation, providing technical advice on improving flight safety, inspection, training, and standardisation for the uniform implementation of European flight safety rules. Importantly, EASA is responsible for the certification process for safety and environmental standards of aircraft, engines, and other components. As a result, the sector is strongly characterised by regulatory convergence at the macro-level. In addition to macro-level convergence, regulatory and also technical convergence is also present in production process. This can be seen in the way aircraft manufacturers operate on a cross-border basis and standardise products and maintenance procedures for technical convergence. As Bremer (2008, p. 6) notes, "Next to no other product fulfils the criterion of globalism as comprehensively as a civilian passenger aircraft for commercial use".

In respect of VET systems, the highly regulated German Dual System approach to apprenticeship, combines workplace training with vocational and general education in vocational schools generally over a two to three-year period. It is often held up as the gold standard when international comparisons are made (see inter alia Steedman, 2012; Brockmann *et al.*, 2008; Fürstenau *et al.*, 2014). In contrast, the UK's voluntarist approach is regarded as being weaker in terms of overall quality and consistency of processes and outcomes across occupational sectors and within workplaces and vocational education institutions (Fuller and

Unwin, 2013; Ryan, 2012; Pilz, 2009).[1] Some of the criticisms about the UK's VET system more generally resemble those made about Australia, notably the market-led approach as discussed above by Hampson and Fraser (2016). Yet, despite these national system level differences, engineering apprenticeships in the UK closely resemble the German dual-system approach in terms of duration, alternance between workplace and vocational educational institution, and strong employer and sector involvement. There are, however, three features which still distinguish the two countries' approaches: a) German apprenticeships are based on regulated occupations; b) German apprentices continue to study a broader general education curriculum than their UK peers; and c) the training of trainers and vocational teachers is more highly regulated in Germany. Nevertheless, engineering apprenticeships have high status in the two countries and, hence, employers are generally able to select young people with strong educational attainment and potential. Data for the UK show that the lifetime earnings differential is higher for engineering apprentices than their peers in other sectors (Cavaglia *et al.*, 2017). The aerospace and aeronautical industry within the UK and Germany is therefore particularly well suited for researching the impact of international technical standardisation and regulation on convergence in training in apprenticeship.

4. Research Design

The study presented here investigated the following research question: *To what extent is international technical and regulatory convergence in the aerospace and aeronautical industry leading to convergence of process and outcomes in apprenticeship training?* The research design was informed by insights from three theoretical perspectives. First, we employ the economic concept of productive systems, which Felstead *et al.* (2009, p. 18) explain are "constituted by the multiple, interlinked social networks through which economic activity is organised and commodities are produced and consumed". A productive system forms two interconnected axes: a) the structures of production (e.g. international/national/sectoral governance and regulation, organisational ownership, organisational structure etc.); and b) the stages of production (from the sourcing of materials through to the marketing, retailing and consumption of a product). As such a productive system is subject to both external and internal pressures and the interplay between them has an impact on the nature of skill formation and

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[1] Although there are some differences between the way VET is organized in the four countries that comprise the UK (England, Scotland, Wales and Northern Ireland), they all reflect the voluntarist approach and UK-wide standards apply to apprenticeship

development within workplaces and training centres. Second, we draw on insights from theories of workplace and work-based learning, including pedagogical approaches to skill formation and utilisation (see inter alia Lave and Wenger, 1991; Beckett and Hager, 2002; Billett, 2002; Fuller *et al*., 2007; Fenwick and Nerland, 2014). Third, we use the concept of convergence and divergence from comparative education (see inter alia Aarkrog and Jørgensen, 2008; Green, 1999).

In order to establish a robust basis for the research, we held a one-day workshop in Germany with academic experts in the fields of aerospace and aeronautical standardisation and regulation, VET, HRD, and business organisation. We then conducted an analysis of government documents relating to the national standards for apprenticeship training in Germany and the UK in order to select the most appropriate type of occupations for comparison. This enabled us to identify the generic occupation of 'aircraft mechanic' (with specialisms in production engineering, maintenance engineering, or engine technology) being the closest match.

To investigate our research question at the workplace level and in light of the exploratory nature of the study, we approached three companies in England and four in Germany.[2] In the case of one of the English companies, a further visit was made to one of its plants in Germany, which also trains aircraft mechanic apprentices. The selection was restricted to large companies with well-developed apprenticeship programmes. The companies reflected the breadth of the sector, taking in component producers and aircraft manufacturers in both countries as well as maintenance companies. All seven companies were willing to participate in the research due to their interest in sharing their knowledge and experience in order to learn more about innovations in and challenges for apprenticeship training in their industry. The research team also visited a vocational school in Germany to interview teaching staff.

To ensure that the details and characteristics of the companies, along with the diverse influences on their training activities, were appropriately recorded, a mixed-method approach was adopted in conjunction with a case study approach (Yin, 2014). The research question was

explored through non-participant observation of apprentices in the workplace, and semi-standardised interviews with apprentices, trainers, and managers. We adopted an "unobtrusive observer" role (Robson, 2002, p. 309) to enable descriptive narratives of the observation setting to be made. The descriptive narratives (enhanced by photographs of settings, where appropriate) enabled the physical reality of the working context to be captured and used in comparative analysis if necessary. To ensure that the data collection was relevant and structured, guidelines were developed for a semi-structured qualitative interview with training managers, trainers and apprentices, based on existing research findings (see above) and the findings of an earlier expert workshop with participants from both the UK and Germany. The interviews and observations in each company took between 6 and 20 hours and were conducted by at least three researchers. Ethical concerns and business sensitivities meant that neither video nor audio recordings were made *in situ*. Detailed field notes were therefore taken by all researchers and later shared to produce a single document which included a descriptive narrative, vignettes of apprentices, and verbatim quotes from participants in the study (where recorded in the field notes). All participants in the research were volunteers and were assured anonymity in any reporting of the findings.

5. Research Findings

We initially analysed the research findings by conceiving apprenticeship as a production model of training comprised of the following intertwined components: Input, Process and Output. This enabled us to ask to what extent our interviewees thought that international technical standardisation and regulation was having an impact on the different levels and stages of their apprenticeship programmes. This model is not intended to suggest a rigid correlation nor to portray apprenticeship as a static phenomenon. It was a pragmatic device in the development of our research to seek a way through the complexities involved in studying the drivers for and nature of workplace training.

Before we report the findings using the respective headings, it is important to note that our respondents, including apprentices, in all the companies continually emphasised i) the centrality of safety to every aspect of their work, both as individuals and for the companies as a whole, and ii) the common use of English across the industry. This emphasis, which was recounted during interviews, was also captured in the observational narratives of production contexts. There was a common *modus operandi* across the two countries about the implications

of knowing that everyday there are millions of people (both civilian and military) in the air who put their trust in these companies for their safety. The use of English as the *technical language of production* can be seen to serve the cause of standardisation and was evidenced in manuals and documents used on the shop floor. In terms of the progress of the research, German interviewees (including apprentices) were also willing to engage in discussions in English.

In presenting the findings, extracts from our descriptive narrative, vignettes of apprentices, and verbatim quotes will be used to illustrate the general point. To ensure anonymity, companies have been allocated a country-specific descriptor G or E, followed by a number.

Input factors

As might be expected, recruitment principles and practices were similar across the case study sites. This is due to the shared need to find apprenticeship candidates with the potential to flourish within such a technically advanced and fast-moving sub-sector of engineering. However, what was surprising was the level of experimentation involved in both countries to identify candidates who might not have achieved the highest level of prior educational attainment, but who stood out in other ways. A manager at company E3, for example, said that in an industry where innovation and creativity were central to survival, it was important to attract young people with "different ways of looking at the world", including those who might have Autism Spectrum Disorder (ASD). Every company runs a comprehensive recruitment process lasting between nine to 12 months. Each year, the target for recruitment is determined by the companies' workforce planning forecasts, including retirement projections. In this way, companies are collectively recruiting for the anticipated needs of the industry, although, at a national level, they are also in competition with each other for candidates. There was a shared view that many apprentices would stay within the industry. E1 reported that in one section of the company, 60-70% of the workforce were ex-apprentices. All of the apprenticeships were over-subscribed, despite the fact that the entry requirements in respect of prior educational attainment are high; for example, company G4 reported they received 800 applicants for 50 places, and company G3 reported 10 applications for every place. As a result, the companies have always invested time refining their selection methods. In recent years, there has been an increasing use of group-based problem-solving assessments alongside individual interviews and cognitive and dexterity tests. This reflects the priority they give to recruiting 'team players'

due to the collaborative nature of the production process. Company E3 emphasised that, in terms of selection: *"...it was not what you do, but how you think that was important".*

With respect to training, designated areas were evident in all the companies which enabled apprentices to practise and develop their skills in a 'non-production' context. As a trainer from E2 explained:

> *"The training department remains the best of both worlds: close to the production process, yet it can afford to be protective about the apprentices."*

When asked if the training centre staff were required to respond to external changes in maintenance procedures or protocol and alter their training plans, the response from one training manager (G2) captured the general approach adopted by the companies. In the training centre, their role was to:

> *"...respond to what the plant wants. The plant responds to the [changing] external conditions, including the customer needs and [regulatory requirements]."*

Each company was also operating with the respective national apprenticeship regulatory framework, but they stressed that this did not necessarily restrict them as they were able to creatively manage these frameworks. An over-arching sense of 'adding value' was apparent across all companies. G2 reported that the German training regulation framework (*Ausbildungsordnung*) gave the company enough freedom to shape the training program in response to the requirements of the customer and/or the technical regulatory framework. The training manager explained that in planning their program, trainers asked *"What **must** we do [during the apprenticeship] and what do we **want to do extra**?"* (G2). Similarly, in E3, training managers explained how the company was driven by the desire to offer what they described as a '*Gold Standard*' apprenticeship, by adding onto what was required by the existing apprenticeship framework. An example of this was in continuing to develop apprentices' skills in drilling by hand, despite the widespread introduction of automation and robotics in aerospace manufacturing. This practice enabled apprentices to not only develop their specific skills, particularly for legacy reasons, but also to enhance their knowledge and understanding of the nature of the aircraft being built. In this way, trainers felt the apprenticeship helped prepare apprentices for future work in, for example, coding and/or the management of the robot cell.

Process

As might be expected for an apprenticeship programme, a shared commitment to situated learning was apparent across all companies. Wherever possible, apprentices "*learn the job by doing, in context*" (E1) and, as one apprentice explained: "*We are building a real plane and not a model*" (G3). Given this commitment, companies demonstrated how they ensured that the training centres provided opportunities to: "*let the apprentice be creative and allow them to make mistakes",* as this could not be realised on the production line (E2). Additionally, the training manager at E1 spoke of the importance of striking the right balance between apprentices' learning and getting the job done: "*The fitters need a balance between doing their job and looking after an apprentice".*

To facilitate apprentices' inclusion in the production process, companies not only focussed on the development of apprentices' technical knowledge and skills, but also on: i) the development of apprentices as team members (to reflect the organisation of work); and ii) developing an inquiry-based approach to problem solving. For example, at E1, test stations at the purpose-built test facility were organised, planned and controlled by a team. Depending on apprenticeship rotations and shift work, each test being undertaken included an apprentice as a team member. In this way, apprentices learned, from the out-set, not only the importance of membership of a team, but also the process of collaborative problem-solving and solution finding. In relation to maintenance, a manager at E2 made it clear: "*In the machine shop, maintenance is being able to solve problems*". Similarly, at G1, the importance of developing apprentices' habits of mind alongside technical knowledge can be discerned from the following quotation from the training manager: "*There [are] no rules or pattern in damage, everything could happen. We need an open mind!".*

In discussions about apprentices' learning on placement, trainers explained how the sequencing and content of respective production and maintenance manuals shaped the work process: "*In the placement, the production line determines the training plan […] the apprentices' learning journey is guided by the (documented) work process*" (G1). There was, therefore, an obvious and strong relationship between manuals and the organisation of apprentices' learning while on placement across the companies. In addition to ubiquitous safety features, this was particularly evident where the quality assurance of products was concerned. Nevertheless, trainers recognised that the manuals were primarily technical and had no pedagogical elements. The training manager at G4 suggested that there was the potential for tension in this regard, as the author(s) of the manual expect them to be followed, literally. However, as he explained:

*"The manual is about what to do. The apprenticeship program is about **how to do it**"* (G4). Fostering apprentices' critical engagement extended, therefore, to the documents used in the production and/or maintenance of aircraft. The training manager at G1 explained that apprentices needed to learn how to *use* the right information in the right situation and this featured centrally in the development of learning activities at the training centre. This meant that whilst externally produced documents and procedures have "*an extremely high impact on training in the aircraft industry*" (G1), sole reliance on following a manual in training was seen as limiting.

In relation to receiving feedback on their workplace learning, all interviewees across both countries described the existence of feedback loops at all levels of the apprenticeship. Irrespective of the country context, observations of apprentices in the workplace was central to the feedback process. In the English companies, observations also provided work-based assessment opportunities. Conducted by certified and designated workplace assessors (and described as '*Gold Dust*' by a training manager in E2), observations have to be negotiated with the needs of the production line in mind.

While the processes used varied and the designation changed between countries and companies, every apprentice gained feedback on their progress whilst on placement. In Germany, given the apprenticeship regulatory framework, besides the officially appointed trainer (*Ausbilder/Ausbilderin*), experienced staff act as coaches (*Ausbildungsbeauftragte*) and train apprentices on the production line. The coach role brought experienced 'shop-floor' workers together with apprentices in specific areas of practice. At G3, coaches received in-house, certified training on how to work with apprentices. Indeed, G3 were beginning working with G4 to extend their respective training programmes and potentially standardise the training they provided for in-house coaches. At G4, each placement had an *Ausbildungsbeauftragte* who supervised between two and four apprentices at the same time for between four and six weeks to cover specific tasks.

In England, whilst practices varied across companies, structured feedback opportunities were also key aspects of the apprenticeship programme. At E1, an apprentice described how they learned to '*build relations with people on the shop floor*' who '*put you in the driving seat […] and trust you to learn*'. From these relationships feedback on practice was secured. This approach was encouraged by the company which saw it as part of the development of more

autonomous learners. At E2, a log-book of work completed was used to organise a monthly review with respective trainers. The training manager also explained how first year apprentices, who returned to the production line one day per week, were mentored by third year apprentices. This ensured that third year apprentices are encouraged "*to give something back*" and reflect on the development of practice when supporting those in their first year. At E3, more senior apprentices were also offered an opportunity to participate in what was described as 'reverse mentoring', where they provided feedback to experienced colleagues, thereby encouraging the adoption of peer-to-peer feedback principles across the company.

Output factors

Across all companies it was apparent that as the apprenticeship drew to a close the apprentices, along with company managers, were engaged in planning their futures in the industry. Invariably, final placements were in areas where there were skills gaps/high production targets and where future employment opportunities were most likely. For some, where employment was confirmed, it was explained that, *"in the last half year of the apprenticeship, the apprentices will work at the workplace where they will go after they have finished their apprenticeship programme"* (G 2). One apprentice at G3 spoke of taking up an opportunity to go to the company's location in France (under the EU's Erasmus initiative) for his final placement. He reported that he saw his future with the company and identified, totally, with the company with "*a passion*".

Regardless of whether future employment in the company was secured, clear progression opportunities were apparent, partly due to the highly regulated framework in which the industry operated. Despite the uncertain and competitive global market, it was not uncommon to hear managers as well as apprentices talking about a future in the industry. As one training manager (E3) explained: "*We cannot guarantee them (apprentices) lifelong employment, but we can guarantee them a career*".

Across the companies and, in particular, in the reflections of apprentices, completing the apprenticeship was seen as providing undisputed labour market currency. At E2, apprentices described how documentation kept during the apprenticeship also enhanced their position in the labour market as a record of jobs completed had been fully documented. Another apprentice at E2 saw completing the apprenticeship as an important career step and was keeping open the

option of, eventually, going onto university. But, in general, apprentices saw completion of the apprenticeship as the first stage in their journey to enter the generic occupation of 'aircraft mechanic'.

Post apprenticeship, the influence of the regulatory framework operated differently, depending on whether companies were maintenance-focussed or production-focussed and their designation by EASA. At G1 (a maintenance company) managers explained that, although the apprenticeship is the route to certification, in the world of aircraft maintenance the apprenticeship alone is not sufficient. The training manager explained:

> *After our apprentices get their German apprenticeship certification (Facharbeiterbrief), the certificate could go into the shredders directly. In our branches, it has no value, only the EASA regulations are important!*

In this context, post apprenticeship, employees worked towards gaining a CAT-A licence awarded directly by the EASA. The G1 manager estimated that the minimum training duration is three and a half years [Apprenticeship + CAT A licence]. Put simply, the manager explained: *"No CAT-A licence, no maintenance!"*. However, this process was not seen as a criterion of success for the apprenticeship, as the licence is achieved after it is completed. To reduce the post apprenticeship duration for gaining a CAT-A licence, the reform of the German training regulation framework (*Ausbildungsordnung*) in 2013 officially included the skill requirements of the CAT-A licence. As the German Federal Aviation Office (LBA 2013) acknowledges, the reform was also instigated to protect the German apprenticeship being displaced by the European licensing regulation:

> *"Without the reform, the training occupations in the aviation industry could be displaced in the medium term by the European licensing regulations for certifying personnel and the industry could lose the high level of qualified specialists that has been customary in Germany for a long time."*

In another German maintenance company (G2), with a different EASA designation, a clear internal progression route had been established to mirror EASA regulations and enable employees to work on different engine types within the company. This meant that, on completion of the apprenticeship, apprentices received their internal licence for engine mechanics level 1. Then, as they built experience throughout their employment, they moved

through various levels in the company allowing them to work individually, to inspect others and to complete engine maintenance at a customer's site.

On the production side, EASA regulations are delegated to companies and require rigorous internal quality standards. Although the process varies according to the company procedures, the processes end in the award of a personal 'stamp'. At company E1, the individual has to achieve their initial stamp at the end of the apprenticeship. This can take up to six months depending on the production cycle. Once this has been completed, the apprentice is a fully accredited employee and has completed the first step in the process of working towards autonomous practice. As a trainer at E1 explained: *"The stamp is the gold standard in our industry!"*. Similarly, in E2, in the post apprenticeship phase, the graduated apprentices needed to go through an internal q-card-certification system within two years to be qualified to work independently.

These internal quality processes and the 'stamps' awarded were a ubiquitous aspect of the production companies. The importance of the 'stamps' and their widespread significance in the accountability aspects of the safety critical aerospace industry should not be underestimated. As one employee at E1 explained: *"If I make a mistake, they can track me back by my personal stamp for 60 years to charge me*".

6. Discussion

Our research findings provide evidence to show how international regulations in the aerospace and aeronautical sectors have led to a close alignment between the input and output factors that frame the organisation and content of 'air mechanic' apprenticeship programmes in England and Germany. In terms of input, we have showed convergence across the following key input factors: recruitment of apprentices; a prescribed curriculum built round technical standardisation and regulatory requirements; the interplay between the company training centre and production; and the management of respective regulatory frameworks.

Our findings suggest that these factors are interconnected in relation to the companies' concern to adhere to the international regulatory and technical standards and remain competitive. Convergence was apparent in relation to the company-based training context and the extent to which the prescribed curriculum, built around technical standardisation and regulatory

requirements, framed the companies' approach to apprenticeship training. As one production company (G1) explained, this was because companies needed to demonstrate their capability in accordance with the provisions of Part 21 of the EASA regulations. This, in turn, framed their training.

In relation to process, the data showed convergence across the following key process factors: the underpinning approaches to pedagogy; the importance of problem-solving in the role of maintenance engineers; the application of appropriate technical information; and the centrality of feedback on learning. Our findings suggest that these factors are interconnected in relation to the companies' concern to adhere to the international regulatory and technical standards and utilise appropriate pedagogical approaches to skill formation and utilisation. The expectation that apprentices will make an active contribution to the teams in which they work also provides further evidence for the argument that the traditional notion of the apprentice as 'novice' is no longer appropriate in workplaces where learning is regarded as a relational process to which all participants contribute (see also Fuller and Unwin 2004).

With regard to output, our data also showed convergence across the two countries with regard to the following key factors: the labour market currency of the apprenticeship and its resulting qualifications; and internal company specific career progression and/or progression towards gaining an EASA CAT-A licence (the certification required to show a mechanic is qualified to carry out and certify routine maintenance on operational aircraft). Our findings suggest that these factors are interconnected in relation to the companies' concern to adhere to the international regulatory and technical standards.

In addition to analysing our data in relation to the concept of apprenticeship as a production model of training, our findings provide insight into the way that technical innovations not only affect production, but also have an impact on training content. Company E3 illustrated this with the example of the impact of the use of carbon-fibre. The technical changes in the production process need to be included in the training the apprentices receive. We have also shown how increasing international regulation and technical standardisation underpins a shared language about learning through practice in these technologically advanced workplaces. Fostering the capacity to take responsibility for the quality of one's work, to work in and lead teams, and to respond to and work with customers is central to the programmes and starts with the recruitment processes we have outlined.

Given the VET contexts in Germany and England and the contrasting demands placed on respective apprenticeship programmes, some differences are of course apparent, notably the role and status of workplace trainers and the nature and frequency of assessment opportunities. However, as we have shown, trainers and apprenticeship programme leaders have creatively managed these different contexts to ensure that apprentices develop knowledge, skills and understanding to meet the full range of critical competences required by the industry.

As Fuller and Unwin (2013) have shown in other contexts, the collective difficulties and challenges in developing an apprentice's knowledge, skill and understanding whilst maintaining a production schedule remain - irrespective of country. In the aeronautical context, these challenges include arriving at a balance between meeting production targets whilst producing a 100% reliable engine or identifying problems and finding solutions to maintenance issues, and bringing on new recruits. There is also the challenge of providing a training programme for apprentices which will serve them as they respond to the introduction of face-paced technological change in the industry. Nevertheless, our exploratory research has evidenced approaches to pedagogy designed to address and overcome these challenges. These strategies are not only sector-specific, but also reflect the specific company location in the competitive aviation landscape. In terms of outputs, we have shown that regardless of a respective country's domestic certification of apprenticeship completion, the progression routes in the industry are universal. This is a specific output of the international regulatory framework and technical standardisation.

Our findings challenge the widespread and outdated assumption that all apprenticeship training in Germany and England (and the UK more broadly) continues to be markedly different. In terms of input, we have shown how the training content is influenced by the technical standardisation and regulatory requirements. The companies operate their apprenticeship programmes within the national and European regulatory requirements of the industry, as well as the requirements of their national education and training systems. Additionally, the standardisation of input factors is, in some cases, an indirect response to strict regulatory requirements at the output level; for example, the achievement of the CAT-A licence. In particular, the EASA regulations, which require technical and regulatory standardisation both within a company and between the cooperating companies around the world, influence the convergence of training curricula.

Much of the research on the shift towards or away from international convergence in vocational training is located within a political economy or comparative education perspective that examines the phenomenon at a system level (Lauder, 2011; Brockmann *et al.*, 2011). It is a common assumption that convergence is mainly driven by the ways in which individual countries respond to worldwide shifts such as the adoption of competence-based training; the use of tax credits to incentivise employers/individuals to invest in training; or the advocacy for cross-national recognition of qualifications to promote labour market mobility for the benefit of individuals as well as a production resource (Gibb and Wallace, 2014). However, the system-led approach can render change at the level of sectors invisible or tangential. Our approach has therefore been to apply the economic concept of productive systems (Felstead *et al.,* 2009) and the manufacturing model of input, process and output dimensions to our research analysis. In so doing, we have been able to identify *how* the external pressures of international regulations and standardisation alongside technological change within the aviation industry influence the structure of production and work process. These are both interlinked and key drivers for the social organisation of skill formation.

7. Conclusion

Given the globalised context of the aerospace and aeronautical industry and the safety critical nature of the work, it is perhaps unsurprising that each company was investing in the sustainability and continued enhancement of high-quality apprenticeship programmes. In an industry where parts of aircraft are being built by different companies in different countries and where production lines can vary between the companies, there has to be a shared level of trust based on the recognition that all involved are working within the same regulatory framework and technical standardisation. This is mirrored in training programmes for apprentices. As one of our company participants suggested: "*aerospace is different […] we're a family; we're special*" (G4).

Our research indicates that industry-led analyses are capable of shedding new light on the extent to which convergence in the conceptualisation, organisation and delivery of training programmes is happening at an international level. It has revealed that apprenticeship programmes located within a global sector in two countries with very different national education and training systems show high levels of convergence in relation to training design, process and outputs. As such, the findings have implications for apprenticeship policy at the

national and international level. We highlight four. First, our research indicates that, in some sectors, the level of technical knowledge and the capacity to apply that knowledge may be rapidly diverging from the prescribed curriculum of national apprenticeship frameworks. Second, they indicate that some apprentices are engaged in work processes and using learning technologies that overturn traditional notions of the apprentice as a 'novice'. Third, they raise questions about how much priority is being given to the pedagogical and technical expertise of vocational teachers and trainers. Fourth, as evidence in this paper has shown, aircraft maintenance apprentices are expected to learn and apply complex technical knowledge in dynamic team-based settings and, as such, are expected to continue learning. This adds weight to the development within national systems of hybrid approaches that connect academic and vocational/technical pathways to facilitate both horizontal and vertical progression (see Deissinger *et al.*, 2013).

Finally, the research design employed in this study could be developed and replicated in other sectors to stimulate a more grounded approach to the comparative study of apprenticeship and vocational training more generally.

7. References

Aarkrog, V. and Jørgensen, C.H. (2008) (Eds.), *Divergence and Convergence in Education and Work*, Peter Lang, Bern.

Beckett, D. and Hager, P. (2002), *Life, Work and Learning: Practice in Postmodernity*, Routledge, London.

Berger, S. (2005), *How We Compete: What Companies around the World Are Doing to Make It in Today's Global Economy*, Doubleday, London.

Berger, S.; Canning, R.; Dolan, M.; Kurek, S.; Pilz, M. and Rachwal, T. (2012), "Curriculum making in pre-vocational education in the lower secondary school: A regional comparative analysis within Europe". *Journal of Curriculum Studies*, Vol.44 No.5, pp.679–701.

Billett, S. (Ed.) (2010), *Learning Through Practice. Models, Traditions, Orientations and Approaches*, Springer, Heidelberg.

Billett, S. (2002), "Workplace Pedagogic Practices: Co-Participation and Learning", *British Journal of Educational Studies*, Vol.50 No.4, pp.457-481.

Boreham, N., Samurcay, R. and Fischer, M. (2002) (Eds.), *Work Process Knowledge*, Routledge, London.

Bohlinger, S., Haake, U., Jorgensen, C.H., Toiviainen, H. and Wall, A. (2015) (Eds.), *Working and Learning in Times of Uncertainty*, Sense Publishers, Rotterdam.

Bremer, R. (2008), "VET in the European aircraft and space industry", *Journal of European Industrial Training*, Vol. 32 No. 2/3, pp.187-200.

Brockmann, M., Clarke, L., and Winch, C. (2011) (Eds.), *Knowledge, Skills and Competence in the European Labour Market. What's in a vocational qualification?,* Routledge, London.

Brown, P., Green, A. and Lauder H. (2001), *High Skills*, Oxford University Press, Oxford.

Busemeyer, M. R. and Trampusch, C. (2012), "The Comparative Political Economic of Collective Skill Formation", in Busemeyer, M. R. and Trampusch, C. (Eds.), *The Political Economy of Collective Skill Formation*, Oxford University Press, Oxford.

Cavaglia, C., McNally, S. and Ventura, G. (2017), "Apprenticeship for Young People in England: Is there a Payoff?", CVER Research Discussion Paper 010, London School of Economics, London.

Deissenger, T., AFF, J., Fuller, A. and Jørgensen, C.H. (2013) (Eds.) *Hybrid qualifications: structures and problems in the context of European VET policy*, Peter Lang, London.

Felstead, A., Fuller, A., Jewson, N. and Unwin, L. (2009), *Improving Working as Learning*, Routledge, London.

Fenwick, T. and Nerland, M. (2014) (Eds.), *Reconceptualising Professional Learning*, Routledge, London.

Fuller, A and Unwin, L. (2013) (Eds.), *Contemporary Apprenticeship: International Perspectives on an Evolving Model of Learning,* Routledge, London.

Fuller, A. and Unwin, L. (2004), "Young people as teachers and learners in the workplace: challenging the novice-expert dichotomy", *International Journal of Training and Development*, Vol.8 No.1, pp. 32-42.

Fuller, A., Unwin, L., Felstead, A., Jewson, N. and Kakavelakis, K. (2007), "Creating and Using knowledge: An analysis of the differentiated nature of workplace learning Environments*", British Educational Research Journal*, Vol.33 No.5, pp. 743-759.

Fürstenau, B., Pilz, M. and Gonon, P. (2014), "The Dual System of Vocational Education and Training in Germany – What Can Be Learnt About Education for (Other) Professions", in Billett, S., Harteis, C. and Gruber, H. (Eds.), *International Handbook of Research in Professional and Practice-based Learning*, Springer, Dordrecht, pp. 427-460.

Gibb, S. and Wallace, M. (2014), "Soul mates or odd couples? Alignment theory and HRD", *European Journal of Training and Development*, Vol.38 No.4, pp. 286-301.

Green, A. D. (2013). *Education and State Formation: Europe, East Asia and the USA. Education, Economy and Society* (2nd Edition ed.), Palgrave, Basingstoke.

Green, A. (1999), "Education and globalization in Europe and East Asia. Convergent and divergent trends", *Journal of Education Policy*, Vol.14 No.1, pp. 55-71.

Guile, D. and Unwin, L. (2019) "VET, Expertise and Work: Situating the Challenge for the 21st Century", in Guile, D. and Unwin, L. (Eds.), *The Wiley International Handbook on Vocational Education and Training*, Wiley, Boston, pp.19-40.

Guile, D. (2011), "Apprenticeship as a model of vocational 'formation' and 'reformation': the use of Foundation Degrees in the aircraft engineering industry", *Journal of Vocational Education and Training*, Vol.63 No3, pp. 451-464.

Hall, P. A. and Soskice, D. (2001) (Eds.), *Varieties of Capitalism: The Institutional Foundations of Comparative Advantage*, Oxford University Press, Oxford.

Hampson, I. and Fraser, D. (2016), "Licencing and training reform in the Australian aircraft maintenance industry", *Journal of Vocational Education and Training*, Vol. 68 No.3, pp. 342-358.

Jakobi, A.P. and Teltemann, J. (2011), "Convergence in education policy? A quantitative analysis of policy change and stability in OECD countries", *Compare: A Journal of Comparative and International Education*, Vol.41 No.5, pp. 579-595.

Lave, J. and Wenger, E. (1991), *Situated Learning. Legitimate Peripheral Participation,* University Press, Cambridge.

Lauder, H. (2011), "Education, economic globalisation and national qualifications frameworks", *Journal of Education and Work*, Vol. 24, No.3-4, pp. 213-221.

LBA (2013) LBA supports dual education reform. LBA Press Release, July 15th. Available at: https://www.lba.de/DE/Presse/Pressemitteilungen/Presseinfo2013/Presseinfo03Ausbildung.

Malloch, M., Cairns, L., Evans, K. and O'Connor, B. (2011) (Eds.), *The SAGE Handbook of Workplace Learning,* SAGE, London.

Pilz, M. (2009), "Initial Vocational Training from a Company Perspective. A Comparison of British and German In-House Training Cultures", *Vocations and Learning*, Vol.2 No.1, pp. 57-74.

Pilz, M. (2012), "International Comparative Research into Vocational Training: Methods and Approaches", in Pilz, M. (Ed.), *The Future of Vocational Education and Training in a Changing World*, Springer, Wiesbaden.

Pilz, M. (2016), "Typologies in Comparative Vocational Education. Existing Models and a New Approach", *Vocations and Learning*, Vol.9 No.3, pp.295-314.

Pilz, M. and Li, J. (2014), "Tracing Teutonic Footprint in VET around the world?", *European Journal of Training and Development*, Vol.38 No.8, pp. 745-763.

Price, M. (2018) *Current and emerging trends in the aerospace sector*. Atkins, London. Available at: https://www.atkinsglobal.com/~/media/Files/A/Atkins-Corporate/aviation-trends-white-paper-digital.pdf

Robson, C. (2002), *Real World Research (2nd edition)*, Blackwell, Oxford.

Ryan, P. (2012), "Apprenticeships: Between Theory and Practice, School and Workplace", in Pilz, M. (Ed.), *The Future of Vocational Education and Training in a Changing World*, Springer, Wiesbaden.

Ryan, P. and Unwin, L. (2001), "Apprenticeship in the British 'Training Market'", *National Institute Economic Review*, Vol.178 No.1, pp. 99-114.

Schwab, K. (2017), *The Fourth Industrial Revolution*, Penguin Books, London.

Short, T. and Harris, R. (2017), "Harmonising training and development across an industry: the case of Australian rail", *European Journal of Training and Development*, Vol.4 No.4, pp. 373-387.

Steedman, H. (2012), *Overview of Apprenticeship Systems and Issues: ILO contribution to the G20 Task Force on Employment*, International Labour Organization, Geneva.

Thelen, K. (2004), *How Institutions Evolve: The Political Economy of Skills in Germany, Britain, the United States, and Japan*, Cambridge University Press, Cambridge.

Yin, R., K. (2014), *Case Study Research: Design and Methods*, Sage, Los Angeles.

Unwin, L. (2017), "Employer-led In-Work Training and Skill Formation: The Challenges of Multi-Varied and Contingent Phenomena", in Warhurst, C., Mayhew, K., Finegold, D. and Buchanan, J. (Eds.), *The Oxford Handbook of Skills and Training,* Oxford University Press, Oxford.