Development and Delivery of Innovative Engineering Degree Apprenticeship Programmes in Collaboration with Industry

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Abstract: Work Based Learning (WBL) programmes such as Degree Apprenticeships (DAs) have the potential to widen participation in Higher Education and transform lives, while also supplying the engineering industry with high calibre workforce that are committed, knowledgeable, skilled, and professional. In 2019, Aston University's Professional Engineering Centre (APEC) developed a suite of level 6 BEng Professional Engineering DA programmes in line with three existing DA standards and in collaboration with major UK manufacturing companies. The curriculum was designed to be flexible and responsive to employers' needs while ensuring academic and professional development of apprentices aligned with the Knowledge, Skills, and Behaviour (KSB) requirements of the DA standards. This work details our approach in working with employers to develop effective, efficient, and flexible curricula for three DA Programmes launched in January 2020. The case study also outlines the student support measures put in place as part of the successful delivery of this programme to ensure simultaneous academic and professional growth of the apprentices while ensuring compliance with the KSB and the End Point Assessment (EPA) requirements of the DA standards. The success of the programmes in meeting the needs of over 70 apprentices and 15 employers since January 2020 while meeting the rigorous academic and regulatory requirements of such programmes is appraised using feedback from the University validation panel, employer feedback, and apprentices' feedback from Module Evaluation Questionnaires (MEQs) scores and comments, tripartite review meetings, and programme committee meetings.

Keywords; Work Based Learning, Degree Apprenticeship, Widening Participation, Engineering Education, Professional Competence.

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1. INTRODUCTION

Since 2015, and with the introduction of apprenticeship levy funding, both learning providers and employers have gradually moved to change traditional WBL courses to levy funded DA programmes, especially in the engineering sector where companies have been facing a major skills shortfall (Doss et al., 2020 and Neave et al., 2018). DA programmes have the potential to widen participation in HE, provide opportunities of social mobility, and address the needs of employers to recruit workforce that has both professional and academic qualifications suited to the needs of industry and/or develop their existing workforce (Smith et al., 2021).

1.1 WBL at Aston University

Aston graduated its first Apprenticeships in 2017 and introduced the UK's first Healthcare Science Audiology DA in 2018. The University has over 13,000 students, of which 10% are on apprenticeships across 23 level 4-7 programmes that are referenced against 14 apprenticeship standards. Provision is managed across our three Colleges: Business and Social Sciences (BSS); Engineering and Physical Sciences (EPS) and Health and Life Sciences (HLS). Apprentices come from over 400 primarily private sector employers, and over 53% from the West Midlands Combined Authority and neighbouring regions.

Engineering WBL Degrees at Aston University Professional Engineering Centre (APEC) dates back to 2004 starting with the Foundation Degree Engineering (FdEng) courses developed in collaboration with National Grid (Doss et al., 2021). Over the past 18 years, the WBL programmes at APEC developed further to include other FdEng programmes, with top-up BEng Professional Engineering progression routes, as well as an MSc Professional Engineering Degree provision as part of the Engineering Council's Gateway project (EC, 2012). Since 2017, the new programme development efforts at APEC have focused on the development of new engineering DA programmes which allow employers to upskill their workforce by drawing from the apprenticeship levy funding (Office for Students, 2019). Figure 1 demonstrates the development timeline of the WBL programmes at APEC from 2004-2020.

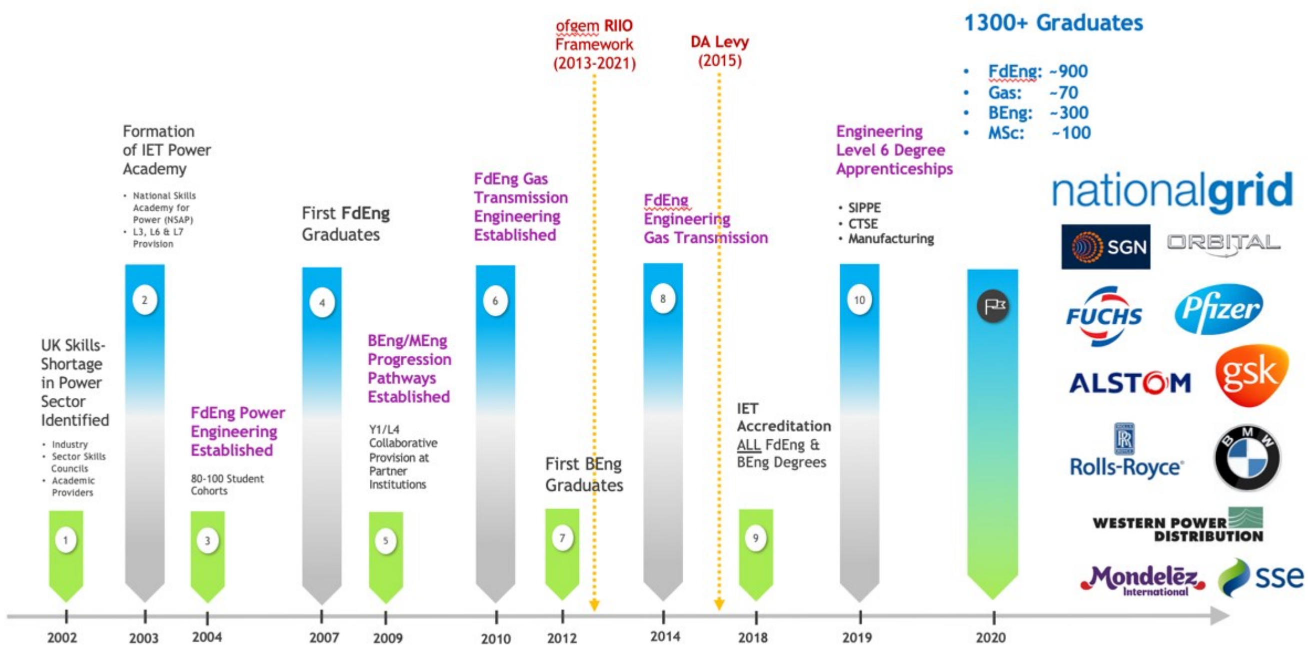

Figure 1 WBL Programmes at APEC (2004-2020) (Doss et al., 2021)

In January 2020, in line with the Aston University strategy, three level 6 Engineering DA Programmes were approved by the EPS College. The three programmes were developed in close partnership with industry and were aligned to the following DA standards (Institute of

Apprenticeship, 2021):

- Control/Technical Support Engineer (ST0023)
- Science Industry Process/Plant Engineer (ST0473)
- Manufacturing Engineer (ST0025)

Since their implementation in January 2020, the programmes have successfully recruited more than 70 apprentices from more than 15 major companies in the UK engineering sector, such as BMW UK, Alstom Transport, Fuchs PLC., National Grid Gas Transmission, Babcock, 3M, Ibstock, amongst others. The programmes are still growing, and APEC is now in the process of adding another DA programme to this suite based on the *"Product Design and Development"* apprenticeship standard (ST0027) (Institute of Apprenticeship, 2021). The success and appeal of these programmes is due to the careful and collaborative way in which the overall learner journey and support mechanisms were designed. The programmes have also featured in the Engineering Professors' Council (EPC) Crucible Toolkit (EPC, 2022). The following sections highlight some of the measures that led to the success of these BEng Professional Engineering DA programmes.

2. PROGRAMME DESIGN AND DELIVERY

2.1 Curriculum Design Process

Degree Apprenticeship Programmes are employer-led programmes which should meet the needs of industrial stakeholders (Fabian et al., 2021). Therefore, a proactive consultative approach was adopted in engaging with the already existing pool of engineering companies collaborating with APEC in 2019 to initially determine which level 6 engineering DA standards were to be prioritised for development by the programme design team. Having established three DA standards to develop, an iterative and participatory curriculum design (Couso, 2019) process was carried out between the programme team and three major manufacturing companies in the UK from March to October 2019. The dialogue between the training managers and the programme team resulted in an understanding of how the broad KSBs of the DA standards need to be interpreted to suitable content and Learning Outcomes (LOs) to ensure the learning journey of the apprentices follow the foundational and developmental KSB targets of each standard while also ensuring that the content, the Programme Learning Outcomes (PLOs) and Module Learning Outcomes (MLOs), and the assessment methods are constructively aligned (Biggs, 2014) and harmonized with the needs of the employers, the scope of the apprentices' roles, and the assessment methods and requirement of the EPA. The programmes were also mapped to the QAA subject benchmark and the Engineering Council's Accreditation of Higher Education Programmes (AHEP) version 3.0 requirements for Incorporated Engineer (IEng) and partial Chartered Engineer (CEng). After finalising the details of the programmes, letters of interest were obtained from the Engineering Directors of these companies. Additionally, from the point of view of resourcing, the programmes needed to be efficiently designed to allow for shared modules where possible, to utilise already existing WBL content and modules, and to allow for future growth of similar programmes. The latter also reflected the fact that based on the DA standard KSBs, there are many commonalities amongst most level 6 Engineering DA standards with regards to the foundational Engineering Science and Mathematics and the transferrable KSBs.

2.2 Programme Structure and Delivery

The three DA programmes were designed as 4-year part-time programmes. The programmes are front loaded with levels 4 and 5 completed in the first two years, followed by a two-year level 6 or Stage Final. The model was influenced by the needs of employers to close the skills gap in their workforce as quickly as possible by working with apprentices that obtain the foundational engineering knowledge in the first two years of their apprenticeship. Additionally, the model fitted the already widely established (2+2) WBL model that had presence at Aston University as well. Given the commonalities of the KSBs of the three DA standards, the programmes were designed to have 30, 45, and 60 credits difference, covering the specialist modules in levels 4, 5, and 6 of the programmes, respectively. Figure 2 demonstrates the overall structure of the three DA programmes.

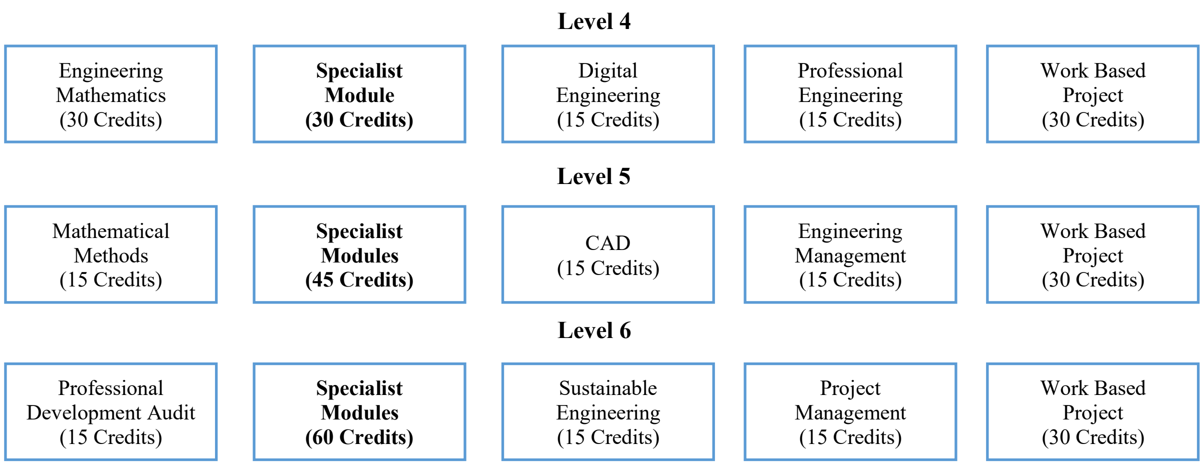

Figure 2 The overall structure of the DA programmes

Traditionally, WBL programmes are usually delivered in block release or day release formats (Doss et al., 2021).The block release format usually suits larger size employers who can afford to release learners for week-long blocks, while the day release mode is more suited to the needs of SMEs who cannot afford to release their staff for more than one day a week. APEC WBL programmes were traditionally designed in collaboration with large employers, so they were mainly based on the block release format with learners attending on campus sessions for 24 weeks spread out over two years for Foundation Degrees in Engineering (level 4 and 5). The BEng Professional Engineering top-up programmes (level 6 top-up programmes) were designed to be delivered as blended distance learning programmes (Booth et al., 2012). These established methods were utilised in the delivery methods of these new 4-year DA programmes with further emphasis on a scaffolding approach in learning (De Grave et al., 2002). Therefore, the programmes included direct on-campus delivery of eight weeks in Stage 1 (level 4), six weeks in Stage 2 (level 5), followed by two years of blended distance learning delivery for Stage Final (level 6). The on-campus sessions, which were delivered online in 2021 due to COVID-19 implications, were designed based on flipped classroom principles (Strayer, 2012) to allow for the overall reduction of 10-week blocks compared to the traditional Foundation Degree models at Aston University. Since the main aim of DA programmes is to widen participation in HE, the programmes were also made available in an online blended distance learning format. While the latter format was preferred by some employers, the former model has been the more popular model with the engineering companies.

2.3 Assessment Methods

A variety of assessment methods were incorporated into the design of these programmes. When designing the assessment methods, the requirements of the EPA were also considered. The EPA for these DA standards comprise two elements of assessment: a portfolio presentation and a professional discussion, underpinned with work-based evidence, tasks, and projects during the course of the DA programme. Therefore, the assessment methods for the on-programme modules were designed based on Situated Learning Theory (Cobb and Bower, 1999) and Problem Based Learning (PBL) to allow apprentices to contextualise their learning to their role and produce naturally occurring evidence and artefacts for meeting the KSBs which could form the apprentices' portfolio as they progress on the programme. The inclusion of work-based projects, case studies, and assignments which are successfully employed in various APEC programmes, allowed the programmes to achieve this while also demonstrating the added value of the programmes to the employers (Booth et al., 2012). Overall, a range of different assessment methods were implemented as part of these programmes, depending on the subject, the requirements of the EPA, and the need for overall growth of apprentices in different aspects. The range of assessments include tests, exams, case studies, coursework assignments, lab reports, reports, video presentations, poster presentations, technical interview, and reflective log books.

2.4 Student Support Mechanisms

Apprentices on these courses are provided with a number of academic, professional, and work based support mechanisms. Initially, each apprentice was allocated an academic supervisor, a professional supervisor, and they were also supported by the module tutors and the Programme Director throughout the course. While the professional supervisors are tasked with supporting the apprentices on their way toward achieving professional registration status (IEng), the academic supervisors are tasked with helping the students in meeting the academic requirements of the course as well as identifying appropriate work based project/case studies. The role of the academic supervisors is further complemented by allocation from workplace mentors to each apprentices by their employers. Additionally, the successful model of embedding targeted sessions on Maths and Academic skills delivered by the University's Learning Development Centre were timetabled in the curriculum to support the diverse needs of the apprentices (Doss et al., 2021).

From a regulatory point of view, quarterly tripartite meetings between the University, the employer, and the apprentice are required to take place to ensure that the apprentices are supported in terms of being provided with the minimum 20% Off The Job (OTJ) training and are also developing in line with the KSB requirements of the DA standard. Within the first year of the programme, based on the feedback from employers and apprentices, and other successful DA models at Aston University, the role of academic supervisors at levels 4 and 5 were replaced by professional skills coaches who would be able to monitor the development of the apprentices in line with the KSB requirements of DA standards and the assessment requirements of the EPA and record those during the tripartite review meetings. Additionally, the coaches would meet with the apprentices regularly one-to-one to address the transferrable skills development of the apprentices, as well as embedding a growth mindset in them. A scaffolding approach was also adopted for the one-to-one coaching sessions with six sessions in the 1st year, four sessions in the 2nd year, and two sessions per year scheduled in the 3rd and 4th year.

3. EVALUATION

This section presents the evaluative feedback from internal and external stakeholders of the programmes both as part of the validation of the programmes (pre-implementation) and the delivery of the programmes (post-implementation). As this was naturally occurring feedback that was obtained anonymously as part of the continuous monitoring and enhancement processes of the programmes and shared anonymously, no separate ethics approval application was required for this work. Please note that company names have also been anonymised.

3.1 Pre-implementation

These programmes were approved by the University's Programme Specific Approval Panel (PSAP) with high commendations and have been used as some of the best examples of programme design by the EPS College Quality Team. This was mainly due to the background participatory curriculum design process that had taken place over a nine-month period prior to the programme being submitted for validation, as well as the student support mechanisms embedded in the programmes. The comments below outline the success of this approach by the programme team:

"Not only were the programmes well designed, cohesive programmes and should be shared widely, but the approval process highlighted the level of understanding the programme team have regarding the needs of work-based learners." PSAP Chair

"The concept allows us to support the development of our existing workforce across a number of sites to Bachelors level through levy funded remote working." Training Manager, Company 1

"I can confirm that the Professional Engineering Degree Apprenticeship programmes you are developing are going to be suitable for our engineers and meets our needs." HR Manager, Company 2

3.2 Post-implementation

Since implementation of the programmes and despite the challenges presented due to COVID-19, the modules have received excellent MEQ scores from various cohort apprentices taking the modules. Table 1 shows a summary of received MEQ scores.

Module Title	**Overall Module Satisfaction Scores**	**Response Rate**
Engineering Mathematics	4.2/5	92.5%
Mathematical Methods	4.7/5	15%
Work Based Project	4/5	35%
Digital Engineering	5/5	25%
Introduction to Control Systems Engineering	4/5	50%
Introduction to Process Engineering	5/5	50%

Professional Engineering Practice	4/5	65%

Table 1 The overall module satisfaction scores

Below are example of apprentices' comments on the quality of the 1st year Engineering Mathematics module:

"The online lectures are very informative. Support from both lecturers has been outstanding and I understand that if I need any more help, I am more than welcome to email either of them." 1st year apprentice

"I have understood everything so far and the support from class and lecturers is very good" 1st year apprentice

"I like self-study with the online slides, working in the class with peers having a readiness to help answer questions when needed." 1st year apprentice

Since the implementation of the programme, many examples of positive feedback from apprentices and employers have also been recorded at tripartite review meetings, service review meetings with employers, and programme committee meetings which illustrate the success of the provisions. The employers and apprentices have particularly commended the applied nature of the assessment elements and the added value of the work-based projects which has allowed apprentices to solve real life problems that are of high priority nature to the employers.

4. CONCLUSIONS

Engineering DA programmes that are aligned with employer-led DA standards have the potential to widen participation in Higher Education (HE) and also help close the growing engineering skills gap that the industry is experiencing. However, these programmes ought to be designed in meaningful consultation with the internal and external stakeholders and appropriately aligned to the KSBs of the respective DA standards. Our experience has shown that a participatory and iterative curriculum design process in collaboration with industry allows us to create programmes that are fit for purpose and meet the needs of industry, ensuring that the content, delivery models, assessment methods, and student support mechanisms are appropriately designed into the curriculum. Moreover, this approach also afforded the flexibility to allow for gradual adjustment over time based on feedback and reflection, so that the programmes are adaptive in nature, responding quickly and efficiently to changes in the needs and focus of the employers and the diversity of learners.

Stakeholder feedback received on pre-implementation and post-implementation of the new DA programmes at Aston University demonstrated the accomplishment of the curriculum design and delivery methodologies followed here, highlighting the provision of impactful work-based learning opportunities to the apprentices that significantly advance their professional development, and, in turn, verification of added value of these programmes to employers. Based on this appraisal from stakeholder engagement, our established approaches, in essence, the development of strong partnerships with employers as an HE institution, can serve as practical models for other HE providers in the delivery of tailored, impactful and successful degree apprenticeship programmes that are in-step with the current and future needs of industry.

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