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Work-based HE pathways for the electrical power engineering industry.

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Abstract: *Aston University has been working closely with key companies from within the electricity industry for several years, initially in the development and delivery of an employer-led foundation degree programme in electrical power engineering, and more recently, in the development of a progression pathway for foundation degree graduates to achieve a Bachelors-level qualification.*

The Electrical Power Engineering foundation degree was developed in close consultation with the industry such that the programme is essentially owned by the sector. Programme delivery has required significant shifts away from traditional HE teaching patterns whilst maintaining the quality requirement and without compromise of the academic degree standard. Block teaching (2-week slots), partnership delivery, off-site student support and work-based learning have all presented challenges as we have sought to maximise the student learning experience and to ensure that the graduates are fit-for purpose and "hit the ground running" within a defined career structure for sponsoring companies.

This paper will outline the skills challenges facing the sector; describe programme developments and delivery challenges; before articulating some observations and conclusions around programme effectiveness, impact of foundation degree graduates in the workplace and the significance of the close working relationship with key sponsoring companies.

Introduction

Aston University has developed a series of technically-orientated electrical power engineering foundation degree programmes in collaboration with key companies from within the electricity industry in response to the growing skills shortages that the industry faces. Such close consultation with the industry has ensured that the programme is essentially owned by the sector. Indeed, the programme specification has informed the production of a Foundation Degree Framework for the sector by the National Skills Academy for Power. More recently, ongoing discussion with these companies has led to the development of a specific progression pathway for foundation degree graduates to achieve Bachelors (Honours)-level qualification.

Since initial approval of the original foundation degree in April 2006, there have been 218 graduates (up to 100 additional graduates expected in July 2012) with 30 progressing on to the BEng progression pathway that was introduced in November 2010. (Data as at April 2012). Feedback from both graduates and employers has been overwhelmingly positive, with graduates experiencing rapid career progression and employers reporting very high impact of these graduates to their operational business performance.

The original progression pathway for our foundation degree graduates was on to the final year of the BEng Electromechanical Engineering programme. However, we soon became aware that any progression route would require some form of part-time delivery, ideally with the time away from the workplace minimised (as the new graduates were now in substantive posts in their companies). Ongoing discussions with sponsoring companies also indicated that the preferred progression pathway should remain focussed on the specialist requirements for the electrical power engineering

industry. Consequently, we devised a new programme, BEng (Honours) Professional Engineering (Power Systems) delivered by blended learning, using significant additional learning resources and an innovative student mentoring system to ensure all students are fully supported throughout the typically two years they require to complete the additional 120 credits at level 6, as described below.

Skills challenges for the Power Industry

At one time some of the key university engineering programmes that have crucial roles to play in many industries were well supported and sponsored by industry. However during the last three decades many of the UK state owned industries were privatised and the emphasis shifted from building robustness in process and operation to increased profits, shareholder satisfaction and increased stock market value of company shares. This situation continued for a while with neglect in three key areas: lack of investment in the industrial base infrastructure, education and training and research. The first dimension has a long term undesirable productivity impact, the second led to lack of expertise and trained engineers and the third dimension made UK less competitive among other nations such as China and USA in terms of problem solving and in discovering new technologies and scientific knowledge and intellectual property. The lack of expertise and trained engineers was not appreciated initially and until the middle of the last decade where some major companies started to realise the market shortages in technicians and graduates; generally in many disciplines and particularly in the energy sector.

The UK Electrical power sector in particular is facing extreme skill shortages especially at Technician and Incorporated Engineer level, as shown in the UK's Shortage Occupation List for power transmission and distribution occupations that are recognised by government as being in shortage in the UK (UK Border Agency 2011). Unless redressed, the situation is likely to significantly deteriorate further as the age profile within the sector is such that up to 40% of the skilled engineers are due to retire within the next 15 years (Energy & Utility Skills 2011). It was awareness of this dilemma that led to Aston University embarking on the development of its power engineering programmes, working in collaboration with three of the leading power companies, National Grid, Scottish and Southern Energy and E.ON UK. By this time, many recruits into the UK power sector were coming from abroad. However, the international growth in power systems means that there is now increasing competition for skills, at all levels, but predominantly at levels 3, 4 and 5 as defined by the UK National Qualifications Framework (Energy & Utility Skills 2010).

Aston University is working closely with the National Skills Academy for Power (NSAP) as a founder member of its Education and Skills Provider Group. NSAP was established by the power industry to ensure future skills provisions can be delivered as fit for purpose and timely. Recent work by NSAP and their parent organisation, EU Skills, on workforce development indicates the need for massive growth in staffing with higher level skills, particularly at levels 4 and 5, up to and beyond 2020. Consequently, the employer-led foundation degree programmes we have established have a huge market potential, limited only by the availability of teaching resources (both staff and facilities)!

Electrical Power Engineering Foundation Degrees

The original concept for the foundation degree was to provide the underpinning science and engineering principles associated with power engineering in the first year (level 4) and to develop technical pathways for specific sectors in the second year (level 5). Ongoing dialogue with the sponsoring companies has resulted in production of a range of pathways to suit specific career options within the power industry, as shown in figure 1.

There is a common first year for each programme and 2 common modules in the second year, the work-based project and engineering methods. Most of the modules are worth 20 credits, with the exception of Introduction to the Electricity Industry (10) and Electrical Engineering Principles (30). The content of this latter module is fundamental to all the more specialised year 2 modules and, therefore, it was weighted accordingly. Assessment is by a mix of coursework, assignments and examinations.

Much of the proposed level 4 content was already being delivered by FE colleges within HNC programmes that our partner companies were using. Therefore, we set up collaborative delivery partnerships with key FE colleges local to the sponsoring companies. This approach was new to Aston and required that all parties (HE, FE and companies) gained a good understanding of each other's ways of working and their approaches to teaching delivery and support. QA requirements were dealt

with by implementing Partnership Agreements with each of our FE College partners and the programmes were approved and overseen by the university's Collaborative Provision Steering Group.

Two of the sponsoring companies (National Grid and Scottish and Southern Energy) used the foundation degree as the core academic component of a technical staff training programme and they recruited staff directly on to their programmes with a subsequent, initial career pathway at technician/project management level. Incorporation of the foundation degree into a company training programme clearly enhances the opportunity to incorporate work-based learning within the academic programme.

Company training programme entry requirements were based on the university's foundation degree entry requirements. In most cases, the university was able to accept the new trainees on to the foundation degree as they met these entry requirements. However, in some circumstances, company nominees were put forward without the underpinning academic qualifications, but with significant industrial experience. In such cases, we worked with the company to assess the base numeracy and literacy skills of each prospective student in order to evaluate their potential to progress through the foundation degree. Consequently, each cohort comprised of students with a very wide range of academic and industrial skills and experiences, with associated widely differing support and development needs. Additional, specialist study skills development staff were therefore recruited in order to support the needs of such a diverse student population.

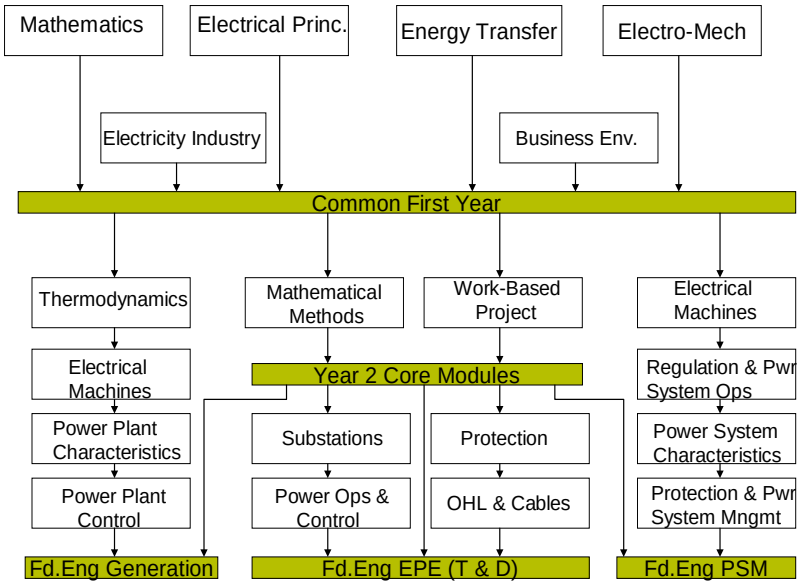

Figure 1:Electrical Power Engineering Foundation Degree Pathways

The trainees were recruited from all over the UK and, therefore, attendance at university/college necessitated the development of delivery patterns far removed from traditional term-based programmes. The preferred mode of delivery was for block teaching (2-week slots). This has created significant ongoing challenges around room allocation and timetabling within our traditional, semester-based teaching patterns.

These students spend considerable time away from the university and, therefore, they require different means of support as discussed below.

These foundation degree pathways were submitted for accreditation by IET towards Incorporated Engineer registration. The Panel was convened in December 2011 and it has recommended that all the programmes should be accredited for three years. This recommendation has been submitted to the IET Accreditation Committee that meets at the end of May 2012.

From Foundation Degree to BEng

All Foundation Degrees are required to provide a progression route to full-degree. Many organisations simply offer direct entry into the final year of an established campus-based degree either on a full-time or part-time basis. This strategy has had mixed success across a wide range of Universities. At Aston, the decision was made to further develop the work-based provision to full BEng (Honours) level. The model chosen closely followed the Engineering Council Gateways driven MSc in Professional Engineering which is offered by a number of universities throughout the UK. As such, the BEng programme offers excellent preparation for individuals who aspire to ultimately follow the MSc programme with a view to Chartered Engineer status.

Aston's strong links with the power industry and the successful power engineering programmes has provided a considerable number of FdEng graduates who have been inspired to continue their education to BEng. This situation produces a quandary for the university: the company has recruited their staff onto the foundation degree within a defined career pathway at level 5, but the student has aspirations to progress beyond this endpoint. However, sponsoring companies have recognised that some of their FdEng graduates have potential for further development and they have sought ways to support these students' ongoing study. Consequently the university has experienced a growing market for progression to a specialist level 6 power engineering qualification.

The BEng Professional Engineering (Power Systems) programme in Aston University, was developed in consultation with key power companies to be delivered by distance/blended learning where specialist learning materials and associated support facilities (e.g. on-line tutorials) are located on the VLE (BlackBoard9) with additional support (timetabled and requested workshops/tutorials) and predefined dates for module examination taken on Saturdays.

The programme specification, shown in Table 1, consists of five modules and a work-based project. The first module, a 10 credit professional development audit module, is effectively a position audit of the candidate's existing skills and competences mapped against the requirements for Incorporated Engineer Status. Deficiencies can be identified from this exercise, which allows an individual learning contract to be developed. The work-based project is worth 30 credits and there are a further four 20 credit technical modules. Each technical module comprises 40% of academically challenging topics, 10% reflective log book, 20% assignments and a mini work-based module project (30%) relating the module academic topics to a real application in the workplace. This programme affords many advantages over a conventional engineering programme. The programme is delivered typically over two years and offers flexibility to account for the participant's personal and employment circumstances, so that a student may extend their period of study if appropriate.

Module Title	Credits	Level
Professional Development Audit	10	6
Sustainable & Renewable Technologies	20	6
Elements of Power Systems I	20	6
Elements of Power Systems II	20	6
Power Electronics & Machines for Power Systems	20	6
Work Based Project	30	6
Total	**120**	

Table 1: B Eng Professional Engineering (Power Systems) - Programme Content

Whilst not necessarily funding progression students, the company does ensure the student can access resources and provides local support to ensure the work-based learning can be achieved effectively.

The above description of the BEng progression programme shows that it is different to conventional university programmes; the structure and delivery of the programme and the kind of participants dictate a new way of tutoring**.** The participants spend most of their time away from the university, at

their workplace. In addition, more than 60% of the programme materials and activities are work-based. Consequently, the university is unable to maintain close management of learning in the traditional sense, requiring the development of different coaching methods to support the participants in order to achieve the targeted learning outcomes.

The programme has adopted an innovative approach to mentoring, so that each participant is appointed a competent academic mentor and a professional mentor from industry and academia. The academic mentor is an experienced, practicing power engineer, generally with a higher degree (MSc, PhD) and their role is to support the participant's understanding of the 40% component of academic topics in each of the four technical modules as well as reinforcing the correlation between theory and practice. The role of the professional mentor is to help develop the participant's competencies to meet the requirement of professional institutions for the IEng class of membership as well as supporting their development as a balanced, confident engineer. Academic and professional mentors work closely and communicate regularly with the programme director and module leaders. They have their own section within the programme VLE site to discuss and share good practice. They also have representation in the programme committee, but they are not directly involved in any formal academic assessments.

Lessons learned and experiences gained

In conventional engineering programmes one can see that there are two rings in the learning chain: a ring based on knowledge delivered in lecture rooms and the other based on laboratory sessions. For many UK universities, with year on year budget cuts, the affordability of establishing engineering laboratories that provide adequate engineering learning with hands-on experience is restrictive. Many university engineering laboratories are nowadays built around software facilities which provide a thorough insight to theories but none on practical aspects. The analogy one may borrow here is taken from the medical profession - you cannot train a surgeon without an operating theatre and a patient, just to rely on theoretical explanations and a DVD recording of a surgical procedure definitely wouldn't produce a confident and competent surgeon! Work-based learning bridges this divide between theory and practice. The authors have adopted this pragmatic concept in the development of the foundation degree and B Eng progression programmes. The engineering application in the FdEng and BEng programmes is achieved by access to state-of-the-art equipment found in industry where a lot of investigative learning and case studies can be found to link theories with practice and provide the necessary skill and competency.

Naturally all universities try their utmost to ensure that vocational provision meets the needs of the industry it serves, with strong technical content, good currency and generally a good fit for purpose. Moving into the work-based arena requires the university to move rather further along that same ideal. To be successful and supported by the industry, work-based programmes need to be absolutely based on employer need, such that the employers can expect the graduates to make an immediate and significant impact on their business performance, to reclaim the very considerable investment in that individual. Whilst remarkably straightforward in principle, actually achieving such fitness for purpose is incredibly difficult to achieve in practice. Some of the complicating factors are detailed below:-

1. For any programme to succeed, it needs to be supported by a number of employers. Even for employers operating in the same business sector, it is remarkable how different the aspirations are between individual companies. Business culture may be very different, as may corporate priorities, and of course in-house corporate training will vary.

2. The scope of delivery by the university needs to be clearly defined. In general, employers are not good at distinguishing between education and training. In safety critical industries, such as power engineering, there is a preference for a tick-box type competences approach. Universities are not in a position to determine these competences and should not be drawn into any commitment to do so. Rather, there needs to be a clear understanding from the outset, that the university provides underpinning technical knowledge and understanding which will ultimately support the student's job function, whereas on-the-job competence itself needs to be determined independently. Understandably, Employers consider that such areas as Health and Safety, Corporate Ethics etc should be delivered within their own corporate training. This is both sensible and pragmatic, particularly as each employer will have their own aspirations and priorities, but universities should be aware that this may cause problems in terms of professional accreditation of these programmes, as professional institutions may deem these aspects to be critical omissions.

3. The long-term sustainability of the programme needs to be carefully considered. University staff often work in environments where financial costing and accountability are unclear. The costing of work-based programmes does tend to be more transparent, but detailed financial business planning will need to be undertaken. During the euphoria of closing the deal, it is very easy for promises to be made in terms of provision, which may ultimately prove unsustainable. In particular, care should be taken to match the delivery commitment as closely as possible to the skill-base of the existing university staff, as bought-in expertise comes at a high price for these specialist, industrially-focused areas. On occasions, the required expertise may be available within the employing organisation and staff may be released through the partnership agreement to deliver material to their own and indeed students from other employers. Concerns relating to commercial sensitivity are often raised, but such perceived risks rarely stand up to close scrutiny.

4. It is essential that the constitution of the working arrangements are absolutely clearly understood by all parties from the outset. Those working in the university may be familiar with collaborative partnerships, whilst those working in commercial business are used to working with contractors. The business / contractor relationship is very straightforward, the business defines their requirements, the contractor meets those requirements, and when the business is satisfied it pays the contractor. Any employer entering a work-based delivery agreement with a university, and maintaining a contractor mindset is following a path that will inevitably lead to disappointment. Universities cannot operate as a contractor, as they simply do not have the freedom of operation to do so. Universities have to maintain academic standards, meet the requirements of HEFCE and the QAA, and of course protect their own brand. Equally, the university sector has to work in a far more dynamic and responsive way, offering the level of service that would normally be expected in a commercial environment.

The importance of getting the constitution of the arrangement correct at the outset cannot be overstated. The process of re-negotiating an inappropriate constitution further down the line is guaranteed to be a painful process for all concerned!

5. Once the curriculum has been approved in the first instance, it will need to remain under virtual continuous review, as employers attempt to respond to dynamic changes in the market-place. For example, the generation sector is presently going through a very significant shift from traditional thermo-plant to large-scale renewables within very short timescales. The curriculum needs to reflect such transition.

The Aston Power Engineering programmes are intensive and very technically demanding. Delivery mode is by six, two week blocks per annum. Each block is a 20 credit, 200hr module, which will require in excess of 100hrs of individual study by the students when off-campus. Given that individual modules may be 4-5 weeks apart and factoring in the demands of student employment and family commitments, there can be no doubt as to the intensity of the programme. Aston staff have been required to be very flexible and imaginative in the way that remote student support is facilitated, including the extensive use of Blackboard VLE and on-line Webinars. Offering effective support to remote students is very demanding on staff time, particularly for research-active staff with high teaching loads. Relatively straightforward problems which could be easily solved in a brief meeting become very long email trails. Various conferencing technologies, including Skype, have been tried with mixed success.

The Aston mode of foundation degree programme delivery does not fit well with the traditional university calendar. Other than August, the work-based programmes are effectively a continuous operation. Timetabling is not an issue outside of normal undergraduate teaching periods, but gaining access to the locked rooms is another matter entirely! Maintenance tends to be carried out during these periods and standard university facilities such as catering, IT, student support and library facilities are at best severely reduced.

During undergraduate term-time, block booking large rooms for two weeks at a time has a massive impact on the wider undergraduate timetable. The obvious answer of assigning a number of rooms purely for work-based activity, is effectively ruled out as it causes major complications with the HEFCE room utilisation statistics. The experience at Aston has been that staff need to focus on either work-based or undergraduate delivery, as combining the two has proven to be very problematic.

Similarly, traditional university procedures are often too inflexible and lack the dynamic response required by employers. Universities are largely regulated by committee, which inevitably introduces a lack of responsiveness to the process. Employers understand that work-based programmes are complex to manage and deliver and will be generally supportive when problems occur from time-to-time. However, these same employers will expect any such problem to be swiftly resolved (circa 2-3

days). The standard university response of referring student complaints to a Staff-Student Liaison or Programme Committee three months in the future would clearly not be deemed as being acceptable.

Delivery of these work-based modules is very challenging to the staff involved. When delivering to work-based students, an individual member of staff may well teach continuously for several days, which of course requires the lecturer to be very imaginative in delivery style to maintain student engagement. Students on these programmes have a wide variety of backgrounds, both in terms of academic attainment and industrial experience. For 2011 entry, the age profile ran from 19-55, with an average age of 27. Some candidates gained entry by means of their practical experience and may not have undertaken formal study for some years, while approximately 15% of the students had completed a science or engineering first or post-graduate degree in the previous five years. Delivering in a manner which engages with all groupings within the cohort can be very challenging.

Interestingly, analysis of student results shows little correlation in relation to their academic qualifications on entry - the strongest correlations are to motivation, effective time management and the amount of support they seek from staff. There also seems to be a strong correlation between success at university and success in the workplace, which seems to give further anecdotal evidence that the programme is fit for purpose.

Given the challenges in delivering this programme, the Aston team are very proud of the student success rate. The very intensive nature of the programme inevitably results in a small number of students that withdraw from the programme (typically 2-3 per year, often because they have left the employ of the supporting company). Throughout the history of the programme, 5 students have elected not to proceed from a successfully completed year1 to year 2 and have accepted a Certificate of Higher Education as a level 4 qualification. Of those who complete the programme, typically in the order of 5-10% will have their graduation delayed because of year 2 referred assessments, but ultimately the programme enjoys virtually 100% success rate of completers.

Any university considering a movement into work-based learning must be prepared to accept a change in culture. Probably the most controversial issue is that of staffing. Academic appointments in the university sector are normally made on the basis of academic credibility i.e. PhD, research record, grant income etc. To be successful in delivering work-based programmes to experienced practitioners in industry, the emphasis needs to change to that of industrial credibility. The ideal candidate for such a role, would possess a good first degree / MSc, Chartered Engineer status, with 10 or more years of industrial experience. Unfortunately, such a candidate is unlikely to meet traditional university selection criteria, and would be unlikely to even be selected for interview.

Both final year Foundation Degree and BEng Progression students are eligible to enter the National Student Survey. Many practitioners in the work-based arena are of the view that the standard NSS questions infer a negative bias towards work-based programmes (e.g. “I have been able to contact staff when I needed to”). Many work-based programmes have not scored well on the NSS (although the Aston programmes have scored on a par or better than many campus-based programmes in the same school). Any university which makes a transition into the work-based arena has to accept a potential risk of NSS scores suffering a negative impact. Student perceptions are inevitably coloured by their experience in the work-place as well as the university. Clearly, the circumstances of the workplace are completely beyond the control of the university, but for example, a change in conditions in the work-place regarding for example time-off to study, may well seriously affect the student’s response to the question, “I have received sufficient advice and support with my studies”.

A key benefit of developing and delivering successful employer-led HE programmes is the additional opportunities for partnership that evolve from the initial relationship. At Aston, we have been able to re-build a Power Engineering Group, not only from recruiting new lecturing staff to deliver the taught programmes, but also as a result of developing new research projects in collaboration with staff from our sponsoring companies. The group has achieved over £1M in research funding within the first two years of setting up its research base. The growing network of mentors within the BEng progression programme is a further source of both additional research ideas and specialist teaching inputs to all our taught programmes.

Conclusions

Aston University has developed a range of successful work-based foundation degree and BEng progression programmes in close collaboration with the power industry. Such programmes have been acknowledged as strategic for the skills development needs of sponsoring companies and there is

significant potential for growth in student numbers. There are many ongoing challenges associated with work-based HE programmes, although the rewards for students and the benefits for their employers are significant when the programme is delivered successfully.

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