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University-led innovative and inspirational engineering education

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Abstract: *The UK Government and large employers have recognised the skills gap between learners leaving the education system and the requirements of employers. The current system is seen to be failing significant numbers of learners and has been accused of schooling but not educating our young people. University-led technical colleges are one part of the solution being developed to provide outstanding engineering education.*

This paper focusses on the learning experience that the Aston University Engineering Academy, the first University-led University Technical College (UTC), has created for entrants to the Engineering Academy in September 2012, when it opens in brand new buildings next to the University. The overall aim is to produce technically literate young people that have business and enterprise skills as well as insight into the diverse range of opportunities in Engineering and Technical disciplines. The project has brought University staff and students together with employers and Academy staff to optimise the engineering education that they will receive.

The innovative model presented has drawn on research from across the world in the implementation of this new type of school, as well as educational practices from the USA and the Scandinavian countries. The resulting curriculum is authentic and exciting and expands the University model of problem-based learning and placements into the secondary school environment. The benefits of this close partnership for University staff and students, the employers and the Academy staff are expanded on and the paper concludes with a prediction of progression routes from the Academy.

Background

There has been world-wide recognition that there is a declining interest in young people's motivation to study Science, Technology, Engineering and Mathematics. A study undertaken by the Organisation for Economic Co-operation and Development (OECD, 2006) showed that far greater numbers of people are going to University than ever before but not to study physics, mathematics and engineering. This declining engagement with disciplines that are key to the economic success of countries has become a major cause for concern. The reasons for lack of interest in the science and engineering disciplines are complex, however, there is firm evidence that a major factor is the way in which Science and Mathematics are taught and the expertise with which they are taught from early years. The report on the evolution of student interest in science and technology studies recommended that teaching should concentrate more on scientific concepts and methods and less on retaining information and that much stronger support should be given to teacher training in science and engineering. The report from the High Level Group on Science Education chaired by Rocard (2007) also concluded that science subjects are often taught in a much too abstract way, which leads to young people viewing science as irrelevant and difficult. It was concluded that school science is often detached from everyday life and work experience. Better links are needed with the real world of science. More hands-on experience is necessary, especially in primary and secondary level courses, which should be designed to meet the needs and interests of young people. The Science and Engineering educator communities would agree that pedagogical practice based on inquiry and problem-based methods is more effective and there are many excellent examples of such practices at all educational levels. However, the reality of much classroom and lecture theatre practice means that

a traditional didactic approach is still prevalent. A report on Technicians and Progression, from the Skills Commission chaired by Halstead (2011) confirmed this trend and also highlighted the huge skills gap between young people leaving school and university and the skills, knowledge and competences that employers want. Many Universities engage with outreach activity but in general this is not focused on inputting to the taught curriculum. Engagement with UTCs (Richardson et al, 2010) enables University staff and students to directly benefit learners who are interested in science and engineering, whilst providing exciting current examples of industry, research and development along with advice and guidance about progression routes and careers. The development of UTCs specifically addresses this declining interest and skills gap, at the same time as maximizing the time and effort expended by employers and university staff and students. The next section provides an introduction to the development of a UTC in Birmingham and the reasons why Aston University has provided the leadership.

Introduction

The creation of the Aston University Engineering Academy (AUEA) started in December 2007 after a visit to Aston University by Lord Kenneth Baker and the late Sir Ron Dearing. They shared a vision for a new type of School for 14-19 year olds that would inspire and motivate young people to develop high quality technical and practical skills alongside academic attainment. At Aston University they met the Vice Chancellor and Pro Vice Chancellor for Learning and Teaching Innovation, both of whom are materials engineers. They understood the concept and how it resonated with the University's widening participation and learning and teaching strategies. In addition it reflected the commitment the University has to the West Midlands as well as the work that staff and students engage in with local schools and partners. The University has a well-developed internal peer mentoring scheme (Gill, 2008) and also trains mentors to work in local primary and secondary schools. Academic staff run master classes, taster days and summer schools. In addition engineering students and staff worked closely with the local schools involved in the Engineering Diploma and significant numbers of staff from across the University provide talks on their research and discipline interests. The opportunity to develop a UTC provided a focus and alignment for the work that was already being done; to specifically raise local aspirations to study science and engineering and motivate young learners by sharing the research and industrial application of the work. UTCs offer an environment in which highly motivated young apprentices can be expected to benefit from an ethos of hands-on learning, with clear progression, either within a school already strongly attuned to their interests and capabilities or in work or higher education (Richardson et al, 2010).

Aston University has one of the highest graduate employability ratings in the UK. The two main reasons for this are the fact that degree programmes provide students with a year in industry and most of the research is applied and industrially focused. This provides the University with an extensive group of employers. The benefits of these close employer relationships have previously been evidenced by the joint creation of degrees in Power Engineering with E-ON, Scottish and Southern and National Grid have enabled the development of authentic and interesting curricula. There has also been a recent introduction and development of the Create, Design, Innovate and Operate (CDIO) approach in the BEng Mechanical Engineering. This innovative educational framework, conceived by Massachusetts Institute of Technology about ten years ago, has been captured by Crawley in 2002. It is based on the development of the Kolb learning cycle and application of thinking styles to problem-based learning (Kolb et al, 2000). The scheme has been adopted worldwide and collaborators maintain a dialogue about what works and what does not, as well as continually refining the programmes. Much of the activity within these schemes draws on the pioneering work of Aalborg University. Established in 1974 all of the programmes at Aalborg have always been based on a problem-based learning (PBL) model (Kolmos et al, 2004). This approach gives students the possibility for independent learning to achieve knowledge and skills at a high academic level. Students also have the possibility of working with the industrial and business community to solve real-life problems. This type of approach has been very successful in helping students to learn how to analyse problems, how to focus on outcomes as well as to work successfully within a team. The final aspect of influence was the previous engagement in curriculum development and delivery that staff and students from Aston had in the design and implementation of the Engineering Diploma for 14-19 year olds (Halstead et al, 2008). This employer-enabled and teacher-led shared design and delivery produced both outstanding results for Birmingham learners and also a high quality learning experience for the staff and students. The unique learning experience designed for the 14-19 year olds within the Aston University Engineering Academy has very much evolved from these approaches. The next

section looks in detail at the qualifications and learning experience that has been created for the students.

Developing a unique learning experience

The Academy has been designed to offer leading-edge opportunities for students with a strong interest in a technical oriented programme and to respond to the distinctive needs of employers in the City and the Region. Against the background of the Government's commitment to create more professionals with high level technical skills, the Engineering Academy will take 240 students at 14 (key stage 4) and 360 learners at post 16. The Academy will offer students apprenticeships, BTEC National Diploma as well as GCSE and A Level engineering, science and language options alongside English and Maths. The Engineering Academy opens in September 2012. On leaving the Aston University Engineering Academy at 19, all learners will have GCSE English and Maths and Level 3 qualifications as well as being extremely employable. The expectation is that most of these learners will have registered with a professional body at 16 and by 19 will be recognised as Eng Tech – which is the first step on the professional route to becoming a Chartered Engineering (Halstead et al 2012). The unique focus on Engineering, Physics, Maths and Chemistry with a strong emphasis on business enterprise will be delivered in a problem-based and highly motivating way; the learning will be contextualised through strong links with local and national industrial and commercial partners. These partnerships will enable the Engineering Academy to realise its ambition to become a local centre of excellence and to act as a hub for other secondary schools in Birmingham engaged in delivering high quality technical education. In September 2012 this will be initiated through the Academy acting as the regional lead for Formula 1 in Schools and Jaguar Land Rovers 4x4 challenge supporting the participation across the secondary schools. For the primary schools in Birmingham AUEA will lead Jaguar Land Rover's primary challenge and primary engineer. This educational and employer type of curriculum partnership which is at the heart of the development of University Technical Colleges is exactly what is needed to inspire learners to develop technical skills and consider careers in science and engineering.

The Curriculum Model for 14-19 year olds in AUEA

AUEA has two specialisms, science and engineering, and all students will complete the City and Guilds Level 2 Certificate of Engineering in Year 10. The science and engineering curriculum is based around a series of real industrial scenarios facilitated by industrial partners working with staff in the Academy. The four-year experience will enable all students leaving the UTC to have English and Maths GCSE and be qualified at Level 3. Employers see this as the minimum entry level. The specific curriculum on offer with the Aston University Engineering Academy is set out in the next two sections.

Curriculum offer 14-16

AUEA has an open admissions policy and has places for 120 learners in Year 10. Marketing and recruitment is ensuring that all applicants are aware of the experience that they will receive in the UTC. Depending on the individual's entry level, the curriculum offer will be personalised from the following:

- English, Maths and Science (Physics, Chemistry, Biology and Dual Science) GCSEs
- NVQ Language programme
- GCSEs in Engineering, Systems Control and Electronics
- C & G Level 2 Certificate in Engineering
- Personal, professional development and leadership skills
- Sports and languages in partnership with the University
- Range of enrichment activities

Curriculum offer 16-19

There are places for 180 in Year 12. In most cases it is expected that year 11 students will remain at the Academy with additional students being attracted by the curriculum offer and innovative approach to learning. There are three pathways of study at 16:

- Physics, Maths, Further Maths, English and Chemistry A level

- Range of Engineering and Business BTEC options
- Apprenticeships

The curriculum will be personalised for the students who take options from the A Level and BTEC pathways. In addition all students will have a work placement and complete the extended project in their industrial company.

The apprentices spend increasingly longer periods with their employer over the three years of the programme. National Grid and E-ON, who have designed foundation and degree programmes with Aston University, see direct progression at 19 into work and then on to study foundation degrees and degrees. With the current fee situation this is expected to have considerable appeal to the most talented young people.

Contextualisation and design of the curriculum

Employers work with the AUEA partnership manager and teaching staff to establish the outcomes required from individual modules. The companies involved have allocated a variety of staff from apprentices, new graduates and team leaders to engage in this development. For example; engineering maintenance with National Grid, energy futures with E-ON, computer and control with Jaguar Land Rover, electronics with Amey, mathematics with Cundalls, quality manufacturing with Johnson Controls, automation and manufacturing with Cadbury, and CAD through F1 in Schools.

Detailed discussions take place between the employer teams and the academic staff to agree which aspects of the curriculum they can illustrate in their working environment and what elements of physics, chemistry, mathematics, engineering or general business they can relate the work to. The culmination of these discussions is the production of a detailed learning plan. The plan details everything from the staff involved, the dates, time and content of the teaching, the learning resources that need to be developed, where the learning will take place, whether this is at the Academy, the employers site or an alternative location, any transport arrangement and finally the details of the assessment. An outline plan is provided in Table 1. Details would be inserted for each week of activity across a range of modules for the year and is produced with every employer partner. This is accompanied by a general memorandum of understanding and ensures that the model and the learning experience that is being created is sustainable. Partnership learning plans run to several pages and represent an overview of the employer-led learning experience that will take place within the modules.

Partnership Learning Plan 2012/13

Academy Contact		E-mail		Telephone		Alternative contact	
Company Contact		E-mail		Telephone		Alternative contact	
Curriculum Area		Year Group		Unit		Numbers of students	
Overall outcome for partnership							
Week No	Course	Activity	Learning Resources	Location	Outcome	Assessment	Staff
Summary of Partner Commitment	Staff	Time	Learning materials	Transport	Travel and subsistence	Equipment	Web links

Table 1: Outline of a basic Partnership Learning Plan

The Partnership Learning Plan is the key document that outlines the work that will be undertaken by the students, partners and supported by staff. The plan acts as the bridge between the Academy's schemes of work and the company's planning documents. There is a separate partnership learning plan for each area of the curriculum into which the company is inputting. Figure 1 provides an indication of the variety of curriculum aspects and levels that National Grid is contributing to.

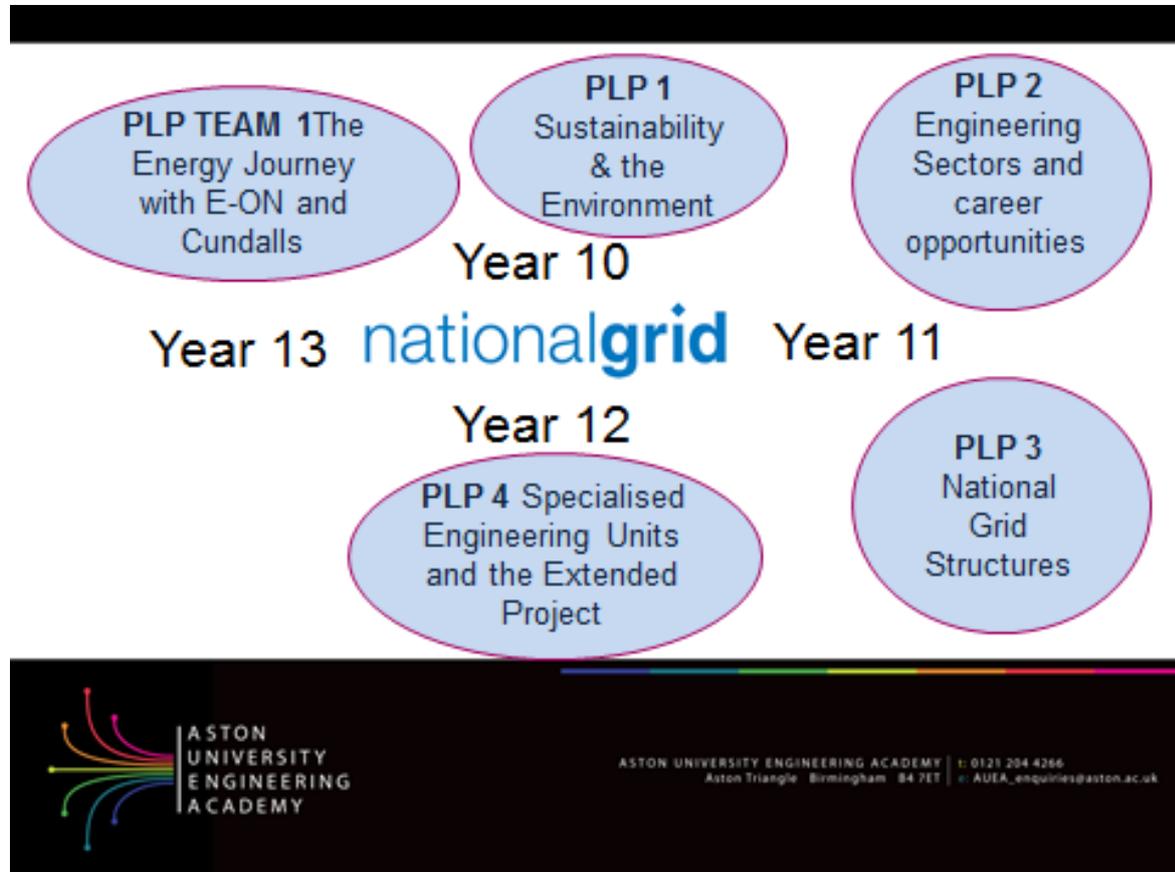


Figure 1: An example of National Grid input through partnership learning plans.

These collaborative partnerships have been established between a range of employers and University and Academy staff. Employers are attracted to the opportunity to input directly to the education of the young people and are inputting staff time to design the curriculum, the assessment, co-ordinate site visits and set problems as well as advising on equipment. An example of a typical plan is the work that Year 10 students will do to understand the energy journey as seen in Figure 1. The team partnership learning plan has been developed to enable students to learn about the generation, transmission and distribution of electricity from source to consumer. There are three partners contributing to this - National Grid, E-ON and Cundalls, with each working on separate outcomes within the unit. Cundalls is leading on the energy losses within buildings using the software developed to model the Engineering Academy. E-ON is leading on generation of electricity from fossil fuels to renewables and National Grid on the transmission of electricity. There will be visits to a power station, opportunities to use power modelling kits and computer models. The learning experience provided through this partnership will contribute to the physics, mathematics and engineering curriculum. Learners in the Engineering Academy will receive this highly contextualised curriculum which will enable them to apply science and technological opportunities that are available in industry. This approach which is based on the best international practice, is expected to produce significantly greater numbers of learners that progress on to study science, technology, engineering and mathematical subjects and who enter the professions.

Summary

This paper has presented a new and innovative approach to the design and delivery of the post 14 year old curriculum in a new engineering academy for 14-19 year olds. Drawing on national and international research and practice, the delivery model has enabled high levels of employer input. At the centre of the new model is a partnership learning agreement that is developed with each partner and ensures clarity and sustainability of the provision. The authentic learning experience that learners in the Engineering Academy will receive, alongside the exposure to industrial based staff and the placement experience is expected to produce students who are highly motivated to pursue studies in science, technology, engineering and mathematical subjects as well as young people who have outstanding employability skills. In addition, there are major benefits to both the industrialists who are able to input current industrial practice and an insight into opportunities directly to learners who are interested, and to the teachers in the University and the Engineering Academy who are able to acquire direct experience of the relevant industry.

In this dynamic, creative and innovative technologically-rich environment, it is expected that most progression from the Aston University Engineering Academy will be into industry, on to a higher level apprenticeship, on to a sponsor physical science or engineering degree, or directly into the workplace with options to continue on to a foundation degree or other higher level qualification.

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