

Engineering and Science Education Today

The challenges of educating engineers and scientists for the future are well known. In the latest CBI Education and Skills Survey (2014), nearly two in five firms in the UK needing STEM employees say they are struggling to recruit staff. Businesses state concerns about the quality of STEM graduates and their lack of workplace experience. The core of this problem starts in schools, where there is an inconsistency in the appropriate skills and qualifications of science teachers. Perhaps more concerning are the perceptions of engineering and science among the next generation. A recent BIS report notes that science is widely seen as geeky, boring, male, uncreative and – perhaps surprisingly – offering limited career options.

There is clearly a gap between what universities are providing and what employers need, a gap that a new university in Hereford can fill.

The world is changing

Already, a number of institutions across the world are starting to change. In countries with strong and growing knowledge economies – the United States, Germany, Singapore, Canada and Denmark – new models of education are emerging. These models share a number of key features, all of which will be central to the new university in Hereford:

- All have put problem solving at the heart of the curriculum, creating opportunities for students to tackle real-world problems
- All have taken innovative approaches to education, creating new pathways and new modes of learning
- All expect their students to learn by doing, making experiential learning a central part of the education program
- All facilitate inter- and multi-disciplinary study, recognizing that 21st problems cannot be solved within the boundaries of a single discipline
- All promote student-led learning, enabling students to decide for themselves what their priorities are and how they will reach their potential.

The case studies below illustrate the specific ways each of the institutions delivers these new models of science and technology education.

Exemplars for the future

Established in 2002, **Olin College of Engineering** (USA) was founded to radically change engineering education with the goal of fuelling the technical innovation needed to solve the world's complex future challenges. Recognising that their graduates will drive the knowledge economy around the world, the focus at Olin College is on preparing their

students to become exemplary engineering innovators who recognise needs, design solutions and engage in creative enterprises for the good of the world.

The entire student curriculum is structured around the premise that engineering starts with people, with opportunities for interdisciplinary study and hands-on project work from the very start of the programme. Classes are organised in three interconnected themes – Design and Entrepreneurship; Modelling and Analysis; and Systems and Control – and are complemented by interdisciplinary classes that connect engineering, maths, and science to arts, humanities, and entrepreneurship.

This approach is already having results. 95% of Olin students graduating in the class of 2013 are employed or in graduate school, with an average wage for those employed of over \$80,000. Half of all Olin students are women, and 30% are non-Caucasian. Major employers include Microsoft, Boeing, Google and Twitter.

In contrast to the 900 students at Olin are the 20,000 people studying across Humanities, Social Sciences, Medicine and Engineering & Science at **Aalborg University** in Denmark. Since its founding in 1974, Aalborg has designed all of its courses around the principles of problem-based learning, synthesised into the *Aalborg Model of Problem Based Learning* and applied across all subjects. In May 2014, the university opened a global Centre for Problem Based Learning in Engineering Science and Sustainability, under the auspices of UNESCO.

A central purpose of the Aalborg model is for students to develop social and academic skills simultaneously, and to develop the kind of collaboration skills that are seen as central to any kind of work in Denmark's knowledge economy. The model has extended across a global network of partner institutions, corporations and professional organisations.

All programmes at Aalborg incorporate an introduction to the model followed by study courses and project courses, where students work in groups to complete a large assignment or project. Projects are often in collaboration with Aalborg's business partners, which include Siemens, Nokia, Samsung and Texas Instruments, among many others.

A much newer European institution, **Zeppelin University** in Germany, was founded in 2003 with the motto – 'the problems within our society are ill-disciplined, and so are we!' Zeppelin's mission is to prepare their graduates for a changing world – one that requires a 'new, reflective, capably complex, interdisciplinary, specialized generation of decision makers for the current as well as future challenges of a globalizing knowledge society.'

All programmes at Zeppelin are multi- or interdisciplinary and centre on students conducting research or engaging in other kinds of projects with faculty. Approaches to teaching and learning include the Zeppelin *Project* (inquiry-led projects around a central theme, in the first year), the *Humboldt year* (an individual research project in the third year) and

StudentStudies (students form groups of 10 around a topic of interest, to design their own course and then invite lecturers to provide it). Additionally, students typically spend a final fourth year abroad at a partner university. Projects with Zeppelin's range of over 600 business partnerships form a core part of the student learning process.

Like Olin, results are tangible. Zeppelin graduates have founded 120 companies in the last decade.

Another example of a new institution – established in 2007 – is **QUEST** in Canada, which offers an innovative Bachelor of Arts and Sciences degree, again multi- and interdisciplinary, where small groups of students study one thing at a time in short blocks. This block plan allows courses to be designed as intensive projects and seminars and to be interspersed with off-campus activity. The approach is based on the recognition that traditional education is no longer sufficient to handle the complex and shifting challenges of the knowledge economy.

Students design their own programmes, centred on a *Question Project*, which involves developing and then answering a question of their choosing. Students are also encouraged to undertake internships, service learning, studying abroad, or research projects, with at least one experiential learning opportunity a mandatory part of the programme.

Despite 2011 being the first graduating class, former students are already going into successful positions in business and academia.

Similarly, the newly created **Amsterdam University College** is a three-year undergraduate institution where all students

pursue a Bachelor in Liberal Arts and Sciences. The University College was founded with an aim to promote Science education within a Liberal Arts context.

All students pursue learning in one of six *Themes*, each rooted in science – Social Systems; Life, Evolution, Universe; Health and Wellbeing; Energy Climate and Sustainability; Cities and Cultures; and Information, Communication, Cognition. The themes incorporate students from different majors, facilitating peer learning and interdisciplinary approaches.

The University College also offers a range of *Big Question* courses for students in their first year, which draw together traditional and contemporary issues in science, society, and history. The courses feature debate of seminal works or examples, and in the case of Big Questions in Science, site visits to state-of-the-art science labs and institutions to meet researchers working on the questions.

At the end of their third year, all students complete a capstone experience that involves writing a thesis based on a research project or internship. All capstones must involve hands-on experience. This contributes to the University's aim to prepare students to be successful at cooperating and competing in the global knowledge economy.

Building on these patterns, **Singapore University of Technology and Design** was created in collaboration with MIT, with faculty and students working jointly to design an undergraduate curriculum with a focus on design and cutting-edge opportunities. The aim of the University is to 'create a new type

of technically-grounded leader and inventor, one fully equipped to address the challenges and issues of today and tomorrow' and able to contribute to and capitalise on the fast-growing Asian economy.

The curriculum centres on the idea of the *Big-D* (for Design), which permeates the student experience through an emphasis on experiential learning. Courses are offered in four *Pillars*: Architecture and Sustainable Design, Engineering Product Design, Engineering Systems and Design, and Information Systems Technology and Design. Alongside these majors, all undergraduates have to take at least seven Humanities, Arts and Social Sciences courses, to balance depth and breadth in the curriculum.

Students complete a capstone group project, often working in mixed groups from different pillars. Groups work with businesses or design their own products. All students also have the opportunity to engage in internships during their studies, with major companies including Google, Microsoft, IBM, Nestle and Rolls-Royce.

These innovations are not just taking place at institution level. **EPICS and EPICS HIGH**, created within the engineering department at Purdue University, USA, provide opportunities for undergraduate and high school students to earn academic credits by working on project teams with partner organisations. Each project must be focused on an engineering or technology-based problem for a non-profit organisation in the local community.

Each EPICS team is matched with a not-for-profit organisation, the 'project partner'. The team and its project partner work closely

together to identify and solve the project partner's technology-based problems. Common products include environmental adaptations, apps, databases, or learning materials that improve how the partner serves the community.

Established in 1995 with 40 students, over 3000 undergraduate and 2000 high school students have now worked on EPICS projects, benefitting an estimated 250,000 people. The approach has spread across 20 partner universities and 60 schools. Sponsors include major companies like Intel, Rolls Royce, Google, GM and Boeing.

Most notably, perhaps, is the impact on girls and young women. In the 2014 programme, 44% of high school participants and over half of undergraduate students were female, signalling a very positive trend for the future of STEM.