

New approaches to engineering higher education

Case studies of six UK
universities leading the way
for change in the sector.



Introduction



It is well known throughout industry that we are currently experiencing a severe skills shortage, with supply of work-ready engineers lagging far behind demand and concerns growing about the existing skills gaps.

For a number of years the annual Skills and Demand in Industry survey from the Institution of Engineering and Technology (IET) has highlighted a discrepancy between the numbers of engineering graduates coming through the system and what industry actually expects and needs from those graduates. In addition, it is increasingly being recognised that the career paths and aspirations of current and future students are significantly different from those of just ten years ago.

Through the New Approaches to Engineering Higher Education steering group, we at the IET and the Engineering Professors Council (EPC) have been examining how a sector-wide shake-up of the ways in which engineering is taught at higher education level could help address these problems. Following on from the successful international conference jointly

organised by the two organisations in 2017, we recently published our 'Platform for Change' (see opposite), which detailed the six key areas where action needs to be taken across engineering higher education in order to create an effective engineering skills pipeline between universities and industry, which is lacking at present.

However, there is plenty of good work already being done – universities that are rightly placing a greater emphasis on creativity, working extra closely with industry partners to ensure their graduates are as well prepared as possible for the world of work, or taking their efforts to increase diversity to the next level.

With this publication we're offering up some case study examples for each of the six new approaches that we are calling for. We believe this proves that the required changes can be achieved – are already being achieved – and that by taking their lead, other institutions can be inspired to come up with new approaches of their own.

We then conclude by introducing three challenges that should be considered by all stakeholders involved – educators, industry and policymakers – because ultimately, it will require a truly collaborative effort for the higher education system to fully evolve in the way that's needed.

A platform for change

The IET and the EPC are calling together those leading or in a position to lead an evolution in engineering education. We believe engineering higher education should be developed in these six ways:

Incorporating creativity into engineering – To reflect developing industrial needs and to attract a broad range of applicants, engineering programmes should enhance and emphasise the creative and innovative nature of the work of engineers; although acknowledging maths and science are important, they are a necessary but not sufficient part of the skill set required.

Broaden the diversity of students – The image of engineering means that women and ethnic minorities are far less likely to apply to study it. The emphasis (and the perception in schools of an emphasis on maths and physics as a requirement to study engineering at top engineering schools also restricts access to the subject. This is especially true in physics where the proportion of female students at A-level is particularly low. Opportunities to increase the diversity of engineering students should be explored.

A strong emphasis on project work – Students engage and are enthused by authentic and relevant engineering experiences. In engineering, a primary vehicle for this is the design project. However, it is not sufficient that these are only in the latter years once sufficient grounding in theory is achieved. They should be from day one and spread throughout the degree programme to develop skills and encourage active learning.

Industry engagement in design and delivery – Working with industry in framing the skills graduates need is vital to engage and highlight to students their relevance and importance. This is particularly important to encourage students to enhance their transferable and employability skills.

Experience of the workplace for students – The formation of the professional engineer is a process; one that involves education, training and experience. In an ideal world these are not separated. It is beholden on academics and industry to work together to develop programmes that bridge the separation between university and work in a way that provides equal opportunities for all students, regardless of background and career aspirations.

Greater interdisciplinarity – Modern engineering challenges and the global issues that most enthuse our current cohort of students will not be solved by any one discipline, but instead by teams of engineers from across the disciplines and non-engineers, bringing together their skills and expertise to create innovative solutions. We must prepare our students for this with appropriate experiences, such as undertaking complex projects in interdisciplinary teams.

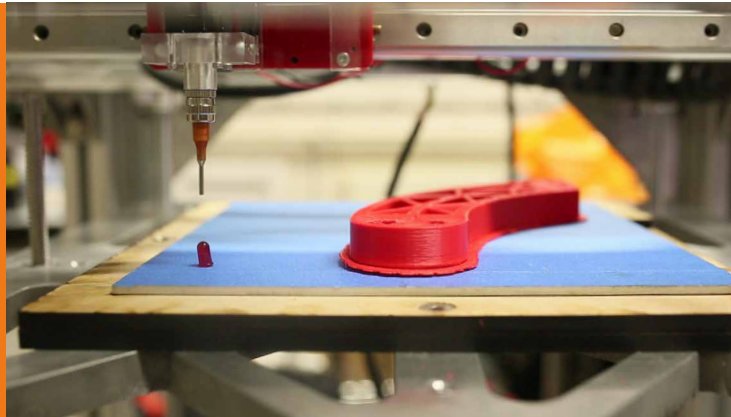
Over the following pages, we've identified six UK universities that are able to demonstrate how they've managed to successfully implement new approaches in each of these areas, backed up by comments from some of the students themselves.



Creativity

Case Study: University of Bristol – Engineering Design

The innovative EngX manufacturing device - capable of combining 3D printing, assembly and wiring - which was developed through a final-year Engineering Design project.



This unique course aims to develop high-calibre engineers who can lead complex engineering projects vital to modern society. After a broad common first year, students can choose to specialise in Mechanical, Aerospace or Civil Engineering, studying technical units alongside students from these discipline-focused degree programmes.

What makes the course unique is that it also gives opportunities to study bespoke design units, undertake industrial placements and work on real-world design projects in partnership with industry. Inspired by the Royal Academy of Engineering, it is accredited by all the main professional engineering institutions and is supported by leading companies from a wide range of engineering sectors.

Why is this a great example of a new approach to creativity?

The combination of design teaching, industrial experience and challenging open-ended projects enables students to develop strong skills in creativity, problem solving and entrepreneurship. The flexibility of the course, giving students the chance to take units from different engineering departments, as well as units outside engineering, also helps to nurture strong interdisciplinary design skills. The course places a strong focus on ensuring students understand how technical issues interlink with a wider set of social, economic and

environmental constraints in most real-life design projects. Using skills and experience gained from the course, a large proportion of its students have developed their own innovative startup companies and gained recognition through schemes such as the Royal Academy of Engineering (RAEng) Leaders Scholarship programme.

A student's perspective

"The Engineering Design programme has been a large factor in the success of me and three fellow students from the course developing our manufacturing start-up company, EngX, giving us a broad set of skills to cope with the tough transition from education to enterprise. The course ensures that graduates have a strong technical background suitable for developing innovative technologies, alongside fundamental leadership skills and group-focused project experience. The course's projects help develop the transferable skills necessary to successfully launch an enterprise, from project management to effective communication, and in our own case, the final year design project formed the basis of our company."

Jack Pearson
(MEng 2016 and RAEng Enterprise Fellow)



Jack Pearson pitching the EngX manufacturing device in the final of the RAEng's Launchpad competition.

On accreditation

"The accreditation process was very smooth with clear guidance on the documentation required, an efficient visit schedule and comprehensive feedback following the visit."

About the course

- No of students: 25-30 students in each year of course
- Location: Clifton Campus, Bristol
- Gender balance: Approx. 65% Male, 35% Female
- Course duration: 5 years full-time

Industry engagement

Case Study: Coventry University – Manufacturing Engineering

Two current AME BEng Manufacturing Engineering students working in the AME workshop.



The BEng/MEng Manufacturing Engineering degree at Coventry University addresses the domestic skills shortage and the need for more graduate engineers that can enter industry, having an immediate impact.

All students are required to work on 'real' factory floor projects throughout the degree at The Institute for Advanced Manufacturing and Engineering (AME), a partnership between the university and Unipart Manufacturing Group. Part-funded by the Higher Education Funding Council for England, Coventry University, through the AME, has established the UK's first 'Faculty on the Factory Floor', bringing together the best in academia, industry and R&D in a 'live' manufacturing environment.

Why is this a great example of a new approach to industry engagement?

Coventry University have located the AME onto the Unipart Powertrain Applications manufacturing factory site, ensuring that staff (both university and Unipart) and students (for much of their degree) are co-located in a unique environment providing invaluable industrial experience to the students. In addition to the taught content, students are required to work on 'real' factory floor projects throughout the degree with a view to presenting ideas and solutions to the various levels of the Unipart Manufacturing Group - from

machine operators to middle management, all the way up to senior management and managing directors.

A student's perspective

"I have got a friend doing electrical engineering and the first time he will go into a factory setting is in his third year - if he does a placement. But I am here twice a week."

Nick Hugill
Manufacturing Engineering Graduate

"There are also lots of life skills you pick up, one of which is the ability to work in a team with contrasting characters – this is often overlooked and shouldn't be. This is something that AME teaches you day in day out, as your team changes every term to approach a new challenge. The ability evolves each time so it challenges you to deal with scenarios you wouldn't otherwise be presented with until you are in work."

Daniel Davey
Manufacturing Engineering Graduate

On accreditation

"We are currently going through the accreditation process for BEng/MEng Manufacturing Engineering at Coventry University but we are finding the IET to be extremely helpful and supportive as we navigate through the process for accreditation."

About the course

- No of students: 102
- Location: The Institute for Advanced Manufacturing and Engineering, Beresford Avenue, Coventry
- Gender balance: 91% Male, 9% Female
- Course duration: 3 years full-time (BEng) or 4 years full-time (MEng)



A UNIPART & COVENTRY UNIVERSITY COLLABORATION

Workplace experience

Case Study: University of Lincoln – Engineering



Engineering degrees at Lincoln aim to produce graduates that are highly skilled, creative engineers who can adapt to new challenges and deliver sustainable solutions for modern society.

Founded in collaboration with Siemens, the University of Lincoln's School of Engineering has a core philosophy of research-led teaching and shares its facilities with Siemens Training and Competency Institute to provide a working industrial environment for students to carry out their studies. Strong links exist between its Mechanical and Electrical programmes, ensuring all graduates have a strong cross-disciplinary focus and an excellent understanding of industry perspectives.

Why is this a great example of a new approach to industry engagement?

Through a series of industry 'touch-point' opportunities, where students are provided with opportunities to engage directly with industrial partners on project work, teaching by industry experts etc., students are exposed to real-life engineering problems and work practices. Furthermore, students are engaged in active research during their higher-level studies. This not only exposes students to cutting-edge technologies to help develop relevant academic skills, but also supports the development of their soft skills and behavioural characteristics. This

approach has led to a significantly reduced integration period and increased retention rates for its graduates.

A student's perspective

"I love it at Lincoln. It's a peaceful place and the partnership with Siemens was something that really made the University stand out to me. We cover so many aspects on the course and I really enjoy it."

Ming Liu
(BEng(Hons) Mechanical Engineering Student)

"I would highly recommend Lincoln. Studying a course like this will really give you an edge in the jobs market."

Jarek Grebenik
(BEng(Hons) Mechanical Engineering Graduate)

On accreditation

"We are currently going through the accreditation process with the IET for our electrical engineering programmes. So far, we have found the process very clear and well structured, and the support from the institution has been excellent."

About the course

- No of students: 192
- Location: Brayford Campus, Lincoln
- Gender balance: 91% Male, 9% Female
- Course duration: 3 years full-time or 6 years part-time

* Figures for BEng(Hons) Mechanical Engineering programme.



UNIVERSITY OF
LINCOLN

Diversity

Case Study: University of Sheffield – Pathway to Engineering

Mo-Anna Tucker (left) on the first Pathway to Engineering programme.



Women are under-represented in the field of engineering, with only 11% of the UK engineering workforce being female, according to the IET's 2017 Skills Survey. The Women in Engineering programme involves staff across Engineering at Sheffield working together to become the number one choice for women to work in and study engineering.

Historically, its approach promoted engineering to pre-A level female students to encourage an uptake of engineering degrees and the required pre-requisite subjects. The University also offered scholarships and support for women as an under-represented group. However, national uptake of pre-requisites has remained weak, acting as a barrier to entry, and whilst improving, its percentage of female students has not done so at any real pace.

Why is this a great example of a new approach to diversity?

The University of Sheffield sought an independent psychological assessment which suggested its approach could invoke stereotype threat - by treating prospective female students as a special case, it reminds them of, and reinforces, a societal stereotype that engineering may not be for women.

It therefore developed a new approach, one focused on inclusivity. It still promotes engineering to under-represented

groups, but without continually referring to individual characteristics such as gender. For example, the new Pathway to Engineering offers students with A-Level Maths but not Physics a free pre-essional Physics programme to help them successfully undertake degrees that require it as a prerequisite.



The approach strikes a balance between honestly addressing under-representation and not targeting an individual by characteristic. Similarly, while the University has a Women in Engineering Students Society, participation is gender mixed, and their activity is simply about promoting engineering as a fun and exciting discipline, accessible to all.

A student's perspective

"I can't stress how good this pathway is. We don't have a lot of time to decide what we want to do at school and I think engineering is really interesting and exciting at the moment. I am more excited now to start my course because of doing the pathway."

Mo-Anna Tucker
Aerospace Engineering Student

About the course

- No of students: 7
- Location: Department of Mechanical Engineering, University of Sheffield
- Gender balance: 71% Male, 29% Female
- Course duration: Four weeks before start of degree course



The
University
Of
Sheffield.

Project work

Case Study: Swansea University – SEM4ID



The Sustainable Engineering Management for International Development (SEM4ID) programme is based around multidisciplinary, participative and action-based learning through real in-country engineering development projects, defined in collaboration with in-country and University stakeholders.

Early stage taught elements run alongside the projects to develop leadership, teamwork, creativity and design-thinking, alongside knowledge of management and development tools; the aim is to develop practitioners who can think rapidly, flexibly and creatively to support sustainable engineering solutions.

Why is this a great example of a new approach to project work?

Students are engaged on real team based projects from very early on in the programme, with most of the taught modules building towards the final project through learning outcomes and assessments. For example, the "Risk" module involves developing a high-level risk assessment for the team's deployment in-country as the assessment, and the Project Management module involves development of a Project Plan for the project. Other modules involve engagement with stakeholders and further project development through both remote and in-country activity and build upon modules on Community Engagement, Tools for

International Development and Monitoring and Impact Assessment. The final project results in a dissertation based around an in-country project, which may or may not have physical deliverables, but will in any case have impact.

A student's perspective

"A great opportunity to develop both personally and professionally, this course has shaped my aspirations and enhanced my career prospects significantly. Taught models tailored towards a real project deliverable have proven hugely valuable in deepening my understanding of engineering practices in the context of development. Few courses offer the opportunity to spend such a substantial amount of time in the field working on a real-life project. Such an opportunity led to the high highs and low lows that go hand-in-hand with development work, which have prepared me for the road ahead. The course has offered me the opportunity to learn from serious practitioners who are making the world a better place."

Arron Goodfellow
Mechanical Engineer

On accreditation

The programme is yet to undergo accreditation, but early stage discussions with the IET have been very supportive of approach and what needs to be done to achieve full accreditation for the engineers on the programme.

About the course

- No. of students: 8
- Location: Swansea, with field work in Sierra Leone and Zambia
- Gender balance: 50% Male, 50% Female
- No. of people employed after 6 months: First cohort just finishing, but two already have jobs in the International Development sector



Swansea University
Prifysgol Abertawe
College of Engineering
Coleg Peirianeg

Greater inter-disciplinarity

Case Study: University College London – Integrated Engineering



The Integrated Engineering Programme (IEP) is a teaching framework that covers all the engineering disciplines and computer science at University College London (UCL).

All 800 students that enter the faculty on the courses take part in the programme, which looks to build on the solid technical foundation provided by the degree programmes offered by the disciplines. The IEP has introduced a renewed emphasis on the practical application of engineering through problem-solving activities coupled with the development and practice of professional skills.

Why is this a great example of a new approach to greater inter-disciplinarity?

Engineering problems do not respect the divisions of the disciplines. To create a multi-disciplinary teaching framework that enables students to engage in authentic projects UCL needed to build a new curriculum structure that allows students to bring their disciplinary knowledge and outlook to collaborations with other student groups. It does this through inter-disciplinary projects, the first as part of a project-based module in the first term of the first year, and again in a two-week intensive project at the end of the second year. In between these two experiences students build their skills in one-week intensive projects within their discipline.

UCL has also introduced the concept of IEP Minors, a block of three intermediate and advanced level modules that draw students from across the disciplines to study a cross-disciplinary or out-of-discipline topic.

A student's perspective

"A lot of satisfaction came from noticing the strong points of each team member relative to their degree. We approached our final project by splitting the roles relative to what we studied. It was a challenging yet eye-opening experience when my team mates from other disciplines presented their progress on their aspect of the project and I had to explain the negative effects on mine. Repeatedly, we had to brainstorm new ideas to accommodate for this, and this really made me understand and appreciate working in a multidisciplinary team."

Ayobami

MEng Chemical Engineering, 3rd year student taking the Environmental Engineering IEP Minor.

On accreditation

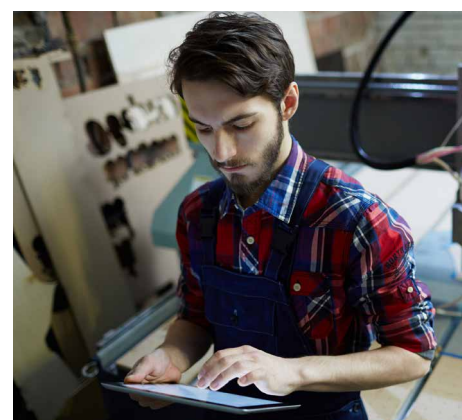
"Accrediting bodies consulted during the development process were exceptionally supportive of the changes. Some accreditation panels needed convincing that the technical content remained as strong, but all programmes have now been reaccredited. The largest challenge was documenting learning outcomes in the taught elements of the IEP via existing data systems that do not cater for interdisciplinary and skills based learning."

About the course

- No of students: ~2500
- Location: Bloomsbury, London
- Gender balance: 73% Male, 27% Female
- Course duration: 3 years

— The three key challenges

As well as identifying the six ways that the higher education sector can implement much-needed New Approaches, we have also identified three key challenges that need to be addressed by all relevant stakeholders in order to create a successful engineering skills pipeline between universities and industry that suits the needs of businesses, educators, students and the UK as a whole.



Challenge one

How can universities work differently with industry to ensure that the present and future requirements of engineering are met?

We need an education system that not only encourages learners to pursue pathways that create a healthy industrial economy, but also courses that equip students with the skills needed by industry now and in the future.

The IET's 2017 Skills Survey showed that the majority of businesses (61%) currently see the recruiting of engineering and technical staff with the right skills as a barrier to meeting their objectives. Work needs to be done to restore confidence in the skills supply.

Challenge two

How do we reinvent our academic approaches to engineering education to remould the diversity, inclusivity and flexibility of future engineers?

By focusing more on inclusivity and diversity we can pull in not just more students, but a broader spread of students.

Traditional engineering education has focused on teaching hard skills, despite the labour market shifting to position engineering sit between science and the creative industries. We need courses that not only teach students technical skills but also develop their creativity and soft skills; producing a supply of school leavers, apprentices and graduates with transferable skills, better equipping them for the constant developments in industry.

Of those businesses that are looking to introduce new digital technologies in the near future, 79% say they will need to develop their skills force to meet these new challenges (2017 Skills Survey).

Challenge three

How do we better embed work-related learning into engineering education?

Industry and businesses should be threaded throughout the education journey to support career pathways and recruitment.

We need to help broker more opportunities for work experience and implement them at earlier stages of the journey as it better prepares learners for the workplace, improving learning on an individual, systematic basis.

84% of businesses questioned for the 2017 Skills Survey also accepted that they should be doing more to provide work experience opportunities.

About us



The IET

The IET is one of the world's largest engineering institutions with over 168,000 members in 150 countries. It is also the most interdisciplinary – to reflect the increasingly diverse nature of engineering in the 21st century. Energy, transport, manufacturing, information and communications, and the built environment: the IET covers them all.

One of its aims is to build the profile of engineering and change outdated perceptions about engineering in order to tackle the skills gap. This includes encouraging more women to become engineers and growing the number of engineering apprentices.

The EPC

The Engineering Professors' Council (EPC) is the representative body for engineering in higher education. Its primary purpose is to provide a forum at which engineers working in UK higher education can exchange ideas about engineering education, research and other matters of common interest and to come together to provide an influential voice and authoritative conduit through which engineering departments' interests can be represented to key audiences such as funders, influencers, employers, professional bodies and Government.

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