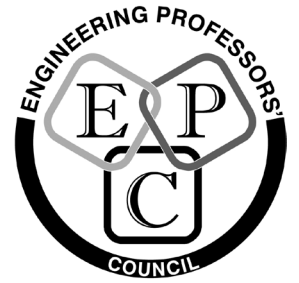




Cambridge University Science and Policy Exchange

**SPE**



# Ingenious resilience:

messages for a new Government



# Introduction

Ingenious resilience:  
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There is a need to link national policy, regional governance, city-level strategy and local action in a coherent whole so that top-down and bottom-up initiatives are mutually supportive.

Joseph Rowntree Foundation: Urban Regeneration Through Partnership Study, 2000

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## Engineering's contribution to the national economy

Engineering matters to the UK economy, on both a regional and national level, and the profession is vital to maintaining the UK's position in the world. It drives innovation, regional growth and is leading in tackling the “grand challenges” that face society more generally: food and water supply, energy and power, healthcare, transport and infrastructure.

- Engineering contributed 27% of GDP in 2014 and employed 20% of all working people<sup>1</sup>.
- The engineering sector is growing: it is estimated that more than 182,000 people with engineering skills will be recruited every year between 2012 and 2021. It is also creating jobs, with an estimate of over 250,000 new vacancies in engineering enterprises by 2022.
- But employers report difficulties in hiring qualified people. For instance, 75% of firms with higher levels of STEM occupations cited skills shortages as their main barrier to growth<sup>2</sup>. Well-qualified engineering graduates are in high demand.

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- Further, London accounted for four fifths of all net new jobs added since 2010, whilst the next nine largest cities accounted for only 10%<sup>2</sup>. Outside London, only Bristol has above national average GDP per capita.

The c.90 engineering faculties in universities across the UK are playing lead roles in educating the engineers of the future and working with businesses of all sizes: in doing so, ensuring enduring economic resilience through their regional spread and provision of talent and cutting edge research to innovative firms. This briefing provides some examples of their work and the essential contribution that supportive policy initiatives have played. We call for a long term, consistent approach to policy, particularly around early educational engagement and strong and effective university-industry collaboration.

- **Early educational engagement:** We need more engineers. To address this, engagement must begin at primary school and university engineering departments are playing their part to build from the foundations set by schools.
- **Strong university-industry collaboration:** The UK's historical record of partnerships between higher education and industry in engineering is strong, but more needs to be done to include mid-sized innovators.

## The need for a supportive and joined-up policy environment

There have been a number of supportive policy initiatives in recent years that have facilitated and catalysed strong industry-university interaction. But as the Joseph Rowntree Foundation study recommended, these need to be linked at national, regional and local levels.

### National Level

The Regional Growth Fund in England was established in 2010 to support sustainable private sector growth in areas currently dependent on the public sector. So far around £3 billion has been invested to help local small and medium-sized enterprises (SMEs) grow.

- The Higher Education Innovation Fund (HEIF), worth around £160 million per year, supports a wide range of knowledge exchange and transfer activities between businesses and universities in England (the devolved administrations have other support mechanisms). £25 million was provided in 2013 via the HEFCE-funded Postgraduate Pilot Scheme to support the development of postgraduate STEM programmes which aimed to address barriers in studying at postgraduate level and thus help to fill the specialist skills gap. A continuing commitment and clear access to financial support for postgraduate students is needed.

### Regional Level

Local Enterprise Partnerships (LEPs) were created in 2010 to partner local authorities and business in promoting local economic development. There is a broad range of scope and focus but some great examples of good practice – for instance - the Coventry and Warwickshire LEP brings together companies large and small with universities to work on low carbon and advanced transport technologies, to name but two of the grand challenges on which they've collaborated successfully.

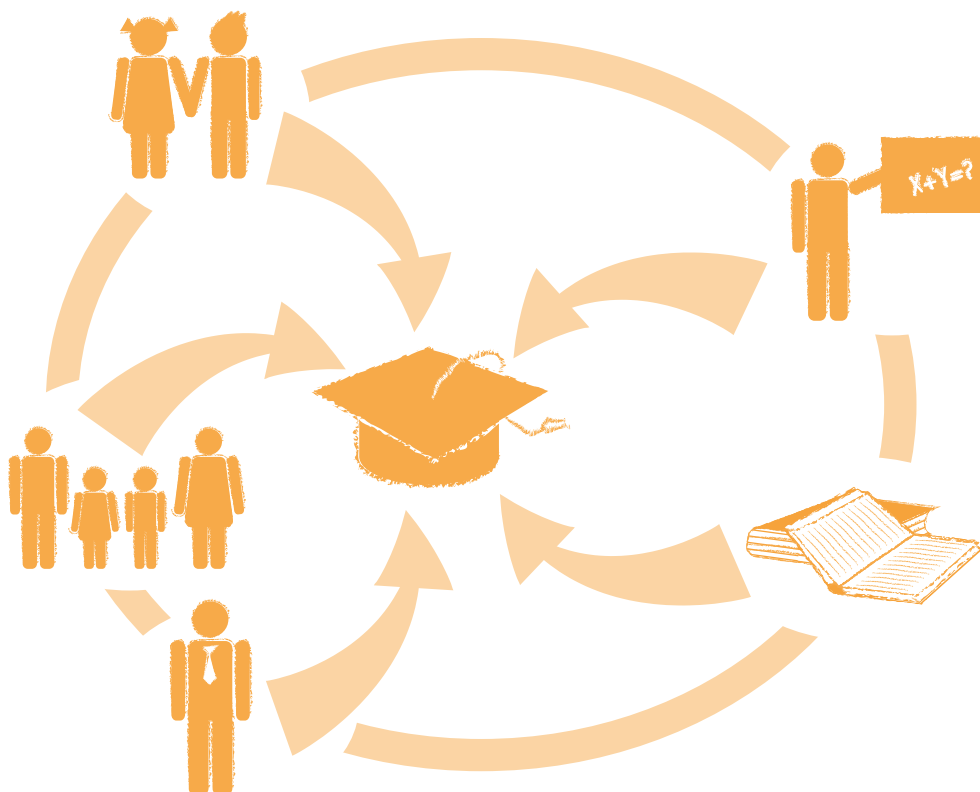
### Local Level

Local business clusters are a key source of innovative activity. There are 31 economically significant clusters spread around the UK, accounting for 20% of UK output.

Regions and cities should have the resources and frameworks to create favourable educational and entrepreneurial environments. Increasing both economic resilience and the quality of life in regions by investing in this capability infrastructure – including in our university engineering departments - will help to retain and attract the best in engineering talent.

# Engagement

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Only when society at large realises that engineer does not derive from the word engine but ingenuity will people move away from the stereotype of men with spanners to a diverse group of people using ingenuity and scientific methods to address society's greatest challenges.

Ingenious resilience briefing team,  
University of Cambridge, 2015

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## Early educational engagement

When asked to name an engineering development from the past 50 years that has had an impact on their lives, only two out of five (41%) people aged 20+ could name one, despite this being a survey carried out via the internet. How can engineering be taught or encouraged at school when such a large proportion of the population struggle to understand engineering, such that even 17% of all STEM teachers think that a career in engineering is unsuitable for their students and 82% of school teachers don't feel they have the appropriate knowledge to advise pupils on their careers?

The emphasis must therefore begin with who exactly an engineer is: someone who applies science and maths to invent new technologies and design the world around us. Early engagement at primary school stage and then continued through the secondary years is key to bringing about a marked change in perception towards engineers and the engineering profession.



## Start young



Despite the fact that more than 70% of 10-14 year olds believe that they learn interesting things in science, only 15% aspire to be scientists and 25% would consider becoming an engineer<sup>3</sup>.

There are three primary reasons for this phenomenon.

First, young people consider engineering to be difficult.

Second, there is a chasm between the study of sciences and the career prospects that it can lead to.

Third, there is a narrow perception associated with what it is to be an engineer that is particularly relevant to the gender bias in the subject: 12% of parents stated they would like their son to become an engineer, while only 2% said the same about their daughter<sup>4</sup>.

These perceptions about science are fixed at an early age (even before primary school), emphasising the need to challenge these perceptions when very young through both curricula at primary and secondary school and suitable careers guidance.

### Children as Engineers - Paired Peer Mentor Project

This project, led by the University of the West of England and funded by the Engineering Professors' Council, pairs university engineering students and trainee teachers to co-design and mentor hands-on STEM challenges for primary school children. Building on the EU ENGINEER and the US Engineering is Elementary schemes, the project aims to demonstrate the Engineering Design process - Ask, Imagine, Plan, Create and Improve - to young children, and concurrently create a sustainable model for school level engineering education by improving teachers STEM skills and engineers' public engagement skills.

## Teacher training



Teachers at both primary and secondary level must be trained suitably to ensure that they are qualified in the subject area. This can be a significant problem in schools, few teachers at primary level have any science training and at the later stages, the Institute of Physics is estimating a shortfall of 4,000 to 4,500 specialist physics teachers out of a cohort of 10,000 to 11,000. To mitigate this problem, the Adonis Review recommended the introduction of a national Teach Next recruitment and a teacher training scheme aimed at career switchers with significant work experience in STEM careers.

Teachers must also be trained to engage with pupils to help them identify the big ideas of science and how ideas may be practically developed. This may assist in the ability of teachers to advise students about their post-16 options, especially as 82% of school teachers would like better guidance on this issue<sup>5</sup>.

Programmes such as the Teacher Training Industrial Partnership (TTIP) provide opportunities for this training to be achieved through placements with local industry partners, but attempts must be made to encourage this beyond current poor uptakes. Similar initiatives with local universities may also ensure the university teaching practices in STEM are transferred to schools.

## A holistic approach



Engineering should be considered holistically, beyond the curricula of a single subject. Mathematical rigour in a range of pre-university qualifications is generally acknowledged as essential for success in the study of engineering at university level. Equally though, creativity and design skills are also required, and students pursuing these courses at school level are not often encouraged to think about science and engineering careers.

Science and maths courses must be used to emphasise the application of theory to practice by interpreting it from an engineering perspective<sup>6</sup>. This will help engage students in STEM and also help overcome the difficulty that many students find in linking regular curriculum with future career prospects<sup>7</sup>. Programmes such as the CREST Award can be used to facilitate course modifications in this direction – with a further benefit of a high proportion of CREST Award winners being female.

## Involving employers



A 2012 YouGov survey for the Education and Employers Taskforce<sup>8</sup> showed that young adults who recalled four or more employer engagement activities while at school were five times less likely to be Not in Employment, Education or Training (NEET). However, only 7% of the young adults surveyed fell into this category, and engagement with local industry would significantly alter this demographic by giving students the opportunity to see what real engineering careers are like.

A report for the Edge Foundation in 2013<sup>9</sup> has suggested that employers do not generally engage with schools because they don't see the business case or haven't been approached, while schools struggle due to financial constraints, the difficulty of finding suitable collaborators and the fact that the curriculum is too stringent.

Policies to encourage such engagement, such as the TTIP, may help a surge in excitement for the engineering profession. Some technical schools, such as Kimberley STEM College in Bedford, have been developed as part of the government's free-school initiative to maximise contacts with local industry such as



Lockheed Martin, giving their students a toe-hold into the industry that many other students are deprived of. And Aston University's Engineering Academy, formed by the University in conjunction with strong industry partners, is training 14-19 year olds for engineering careers. Other approaches include Lord Young's Enterprise Advisors<sup>10</sup> and the Adonis Review's suggestion that every secondary school should employ a full-time Director responsible for employer engagement activities<sup>11</sup>.

While the Young and Adonis recommendations might be rather resource-hungry for schools, more formal means to incentivise and recognise employer-school engagement must be considered. For instance, school league tables are heavily weighted towards examination results, and, while educational destinations are now included, they could be further adjusted to reflect employment destinations - with engineering being highlighted in as positive terms as medicine and the law.

Further, formal accreditation for schools engagement (similar to Investors in People<sup>12</sup>) for employers may give employers a business case to pursue such a relationship.

## Primary Engineer

Primary Engineer is a not-for-profit organisation established in 2005 with a vision to encourage both girls and boys to aspire to become the engineers of the future from a very early age.

Described by one teacher after attending a Primary Engineer course as "STEM by stealth", Primary Engineer's approach is to apply mathematics and science practically to "design and make" activities, leaving both children and teachers inspired. Supported by industry, education and the Institution of Mechanical Engineers, the organisation offers primary schools a way to deliver practical Mathematics and Science to Design Technology activities. The class projects are mapped to the curriculum in each year group, and designed to inspire and enthuse. Programmes include teacher training, interactive and paper-based resources, and regional and national competitions. All projects are linked to practising engineers to provide a real-world context to the project.

## Family matters



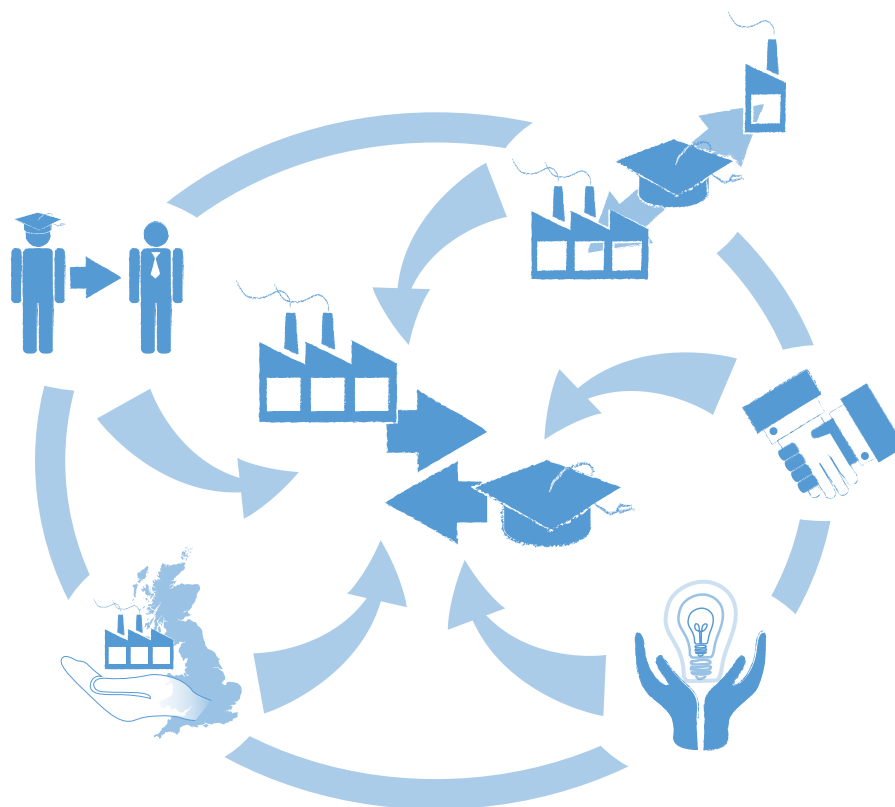
Family and friends have a significant impact on career choices, with the Institute for Public Policy Research (IPPR) indicating that they are the most important factor in deciding future careers for 15% of pupils surveyed<sup>13</sup>. To ensure pupils receive the best possible guidance for their overall development, there must be a move towards informing families about STEM prospects, beyond the traditional emphasis on educators. This is particularly important in overcoming traditional stereotypes, often bred from an early age at home.

In reality, there will be positive feedback from the other steps in this strategy. However, it can also be encouraged by a supportive media and outreach initiatives such as those run by the James Dyson Foundation which excite both parents and children about engineering.

## In summary, we need to:

- ensure that schoolchildren from primary level onwards, receive high quality careers advice and guidance underpinned by input from industry and professional organisations.
- encourage an appreciation of the application of science to the real world so as to understand the contribution of the engineering profession to society, and to provide opportunities to do so throughout primary and secondary school curricula.

A number of practical initiatives which underpin these actions are happening across the country but need consistent long-term support and joined-up governance at the national, regional and individual level if they are to develop beyond their current nascent state to make a real difference.



## Strong university-industry collaboration

The future growth of the UK economy will be driven largely by innovative mid-sized businesses<sup>14</sup>. However the UK's performance in terms of the proportion of innovative businesses is relatively weak. In fact, only 4% of expenditure on research and development (R&D) in 2011 was by SMEs that were not part of a larger enterprise group<sup>15</sup>. Further, the UK is ranked 4th out of 7 comparable countries, behind Finland, Japan and South Korea, in terms of the proportion of SMEs collaborating with higher education/public research institutions. This is in contrast with the success of larger companies in interacting with universities to bring about innovative developments, such as the highly successful Rolls-Royce University Technology Centre (UTC) scheme and that of Jaguar Land Rover.

“ There is widespread agreement that strong links between industry and academics are vital for creating and sustaining economic growth. Bringing together the best with the best and starting new conversations creates the right environment for innovation and game-changing ideas...”



Sir Alan Langlands, Chair of the N8 Board of Directors and Vice Chancellor at the University of Leeds, 2014

## Key challenges faced by growing business

- Accessing the necessary time, human and financial resources
- Accessing specialist technical knowledge (and intellectual property expertise), expert advice and relevant networks
- Accessing practical support such as incubation space
- Accessing the graduate labour market.



There are some great examples of how university engineering departments are helping businesses to overcome these challenges – supported by positive national and regional policy initiatives.

## Universities as brokers for small and large company collaboration



Successful partnerships involve collaborations between universities and large companies which include the SMEs in their supply chain as part of the research consortium. The presence of universities and larger companies in partnerships enables SMEs to access various government initiatives simultaneously to better create value (Catapult, Local Enterprise Partnerships (LEPs), Enterprise Zones). This often helps SMEs overcome the difficulties associated with initiating contact and personnel requirements. Universities are an important source of local economic advantage for LEPs and can help in driving SMEs' growth.

### Coventry and Warwickshire Local Enterprise Partnership (LEP)

University involvement at Board level in the Coventry and Warwickshire LEP has assisted in ensuring their participation in local economic developments such as:

- The Low Carbon Technology Project (LCTP) consists of a consortium of universities, large companies and SMEs including Warwick and Coventry Universities, Jaguar Land Rover, Tata Motors and the Motor Industry Research Association, together with 25 smaller local companies. It is funded by Advantage West Midlands, the European Regional Development Fund and contributions from industry partners.
- Partnering of the Warwick Manufacturing Group with the new high value Manufacturing Catapult Centre and various businesses
- Parallel partnering between Coventry University and MIRA Ltd with an Enterprise zone status, enabling the partnership to secure a £20 million Regional Growth Fund bid to develop a technology park for Advanced Transport Technologies.

## Creating an enabling environment to help develop a vibrant innovative business ecosystem



Universities and government can act as innovation intermediaries in developing the capabilities of growing businesses in the local area by providing an enabling environment which facilitates the growth of partnerships with universities. Successful university-SME interactions usually involve a managed single point of entry to make their access to the university as straightforward as possible. The environment can also encourage entrepreneurial spin-out companies from universities.

### BAE Systems Investment in Innovation Programme

BAE invests up to £5 million each year in the Innovation Programme to encourage and support innovative SMEs and academics with the development of new technology to improve security.

It establishes exploitation agreements, for the protection and exploitation of jointly owned intellectual property and plays an important role in managing its investment in the programme through close collaboration with its SME partners rather than simply giving funding to successful applicants.

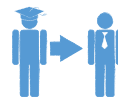
It offers its engineering and technology resources to partner SMEs, as well as the use of its test and evaluation facilities and the placement of its employees within organisations, amongst other initiatives.

For universities, it provides an understanding of end customer requirements that is critical to ensuring that the relevance of their research for industry.

One successful example of the programme is OmniPerception. This spin-off from the University of Surrey in developing ground-breaking research for improving the effectiveness of suspect identification on CCTV using face recognition technology.

Source: Business and Universities Collaborating for Manufacturing Competitiveness in the New Industrial Revolution, CIHE Engineering and Manufacturing Task Force, (2011).

## Improving access to university students and incentivising partnerships



Business-university collaboration can also be based on personal relationships built through graduate recruitment and student mobility. The examples outlined here have enabled SMEs to realise the added value that graduates can bring to their companies as well as reducing the costs and risk of their initial investment in recruitment.

### Graduate Advantage

Funded by 10 West Midlands Universities and the European Regional Development Fund, Graduate Advantage is a one stop shop based at Aston University for both undergraduate and postgraduate students seeking an internship and employers seeking to employ an intern.

The services are only available to private sector SME businesses, registered charities or social enterprises based in the West Midlands region. To ease the administrative burden on smaller employers, Graduate Advantage also offers a free payroll and HR service for 12 week internships and operates a web interface that provides advice and guidance on internship management to employers.

Source: A Review of Business University Collaboration, Wilson T. (2012).

## University of Derby: Master's degree in Innovative Engineering Solutions

At the University of Derby, students (whose course fees and travel costs are currently met by a government-funded pilot scheme) are studying on a master's level taught programme focusing on acquiring expertise in solving technical business problems in a range of engineering based businesses. As part of the programme, they undertake 24 weeks of paid work including an in-company placement. The programme has been developed to ensure that employers can test the abilities of potential employees and employers are reporting that it is particularly useful for small or medium-sized companies without a graduate programme. The work that students undertake as part of the programme can also contribute to Chartered Engineer status - an added benefit to small companies in terms of the quality accreditation needed to support their business development. Employers report that the programme is providing immediate impact in terms of reduced recruitment costs and an improved ability to fill skills gaps, as well as helping with the challenges of succession planning in, what is rapidly becoming, an ageing skilled workforce. Students report that they are learning not just specialist engineering skills but the softer skills needed by employers such as problem solving, communication, and team working, as well as an increase in career confidence. Recruitment of students from under-represented groups has been particularly successful with 25% of the first cohort being women.

### In summary:

- Universities have a key role to play in helping businesses with these challenges and there are many excellent examples of good practice (see exemplars) but more can be done at both national and regional level to enable government and universities to work together to create an enabling environment - a mutually supportive and vibrant SME ecosystem.
- Universities can act very effectively as brokers for smaller businesses in engaging with larger companies' supply chains. The Higher Education Innovation Fund (HEIF) has proved to be an effective enabler of university-SME relationships and should be reinforced and extended. LEPs also have an important role to play in directing funding to meet local and regional priorities and should be adequately resourced within a supportive government framework to do so.
- Long term partnerships between universities and businesses, which support the development of specialist skills and leading edge research through the provision of sustainable funding models should be incentivised by government. For example, through provision of tax incentives for small firms to invest in higher level skills training, particularly in areas of shortage skills, when delivered in partnership with universities.
- LEPs could improve regional potential by engaging with a broader range of businesses, making more ambitious partnerships, evaluating and acting upon outcomes and having the power to approve investment plans.

# Acknowledgements

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## Aknowledgements

**Cambridge University Science and Policy Exchange (CUSPE)** is an organisation run by and for early career researchers that aims to build stronger links between its members and government policy-makers. Founded in 2012, the society strives to support young researchers who wish either to influence policy from within the research environment of the University or to pursue directly a career with the governments of the UK or European Union. CUSPE attracts researchers from across the academic disciplines (scientists, engineers and social scientists), all of whom have a desire to understand how their own research, or science more generally, fits within a broader policy context.

**The Engineering Professors' Council (EPC)** is the representative body for engineering in higher education representing the majority of academic engineers in the UK, with 80 members comprising over 6,000 academic staff. 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 authoritative representation to funders, employers, professional bodies and policymakers. It also works with students and early career researchers to develop an awareness of the wider social impact of their work and the policy making context and to support them in their public engagement activities.

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