Engineering: integrated, not differentiated

How does engineering contribute to the UK economy and how can that contribution be increased? Is there a role for UK engineering in higher education in making this happen?

Engineering has been the backbone of the UK economy for centuries. Since the industrial revolution, engineers in the UK have been pioneering ways to make people's lives easier and have been the facilitators in enabling the UK's economy to burgeon. From James Watt and George Stephenson, to Frank Whittle and Tim Berners-Lee, the UK has been graced by some of the best engineering minds in history. This is no coincidence; it is the result, rather, of an education system that was ahead of its time, and a national ambition that has in the past motivated engineering innovation. Can these two systems still be relied on to inspire world-class engineering in the UK?

Currently the UK's engineering sector accounts for around a quarter of the country's turnover in all sectors, and the government hopes to bolster the UK economy by increasing this figure (Kumar et al., 2013). It has suggested that a substantial increase in the supply of engineers will benefit the economy. According to Vince Cable's Industrial Strategy the UK needs around 87000 graduate engineers per year for the next decade to sustain its predicted engineering output (cited in Kumar et al., 2013). But herein lies a problem. In 2013 the number of engineers that graduated from UK universities was 36000 short of this. Given the UK's historically strong engineering background, why are young people not choosing a career in engineering?

Growing up I was never very sure about what it was that an engineer did. At school I was aware that engineering was some form of science, but one that had a more hands-on approach. When I thought of an engineer I envisioned someone in an oil-blackened boiler suit holding a spanner. I embarked on an engineering degree without *really* knowing what a career in the subject would entail. The more I learned at university about what engineers actually do, the more I was astonished at what an excellent decision I had made! It seems to be the case that I was not alone in my ignorance of the world of engineering. I generally found that my course mates were not at all sure about the exact role of an engineer either; they had chosen engineering because they had good grades, and they knew that it involved some science. Perhaps, then, the lack of understanding about what is involved in engineering is the cause for the low number of school pupils choosing it as a career.

This deficiency stems from a lack of emphasis on engineering in UK schools. The core science subjects of biology, chemistry, and physics have been in the secondary school curriculum for decades, but engineering is rarely more than an afterthought to the occasional physics lesson. Considering the depth of engineering heritage in the UK, and the state of the engineering industry, this seems odd. There should be no problem in encouraging school pupils' interest in engineering. Engineering is the epitome of applied science: the bridge between scientific theories and the everyday world. It takes abstract ideas that are unintelligible to all but a few people, and transforms them into practical products that can improve the quality of life for everyone. It is what enables a continuous food supply for billions of people; it allows friends to talk face to face from opposite sides of the planet; and it is what makes it possible for humans to leave Earth in search of new worlds. Surely there must be many pupils who would be inspired by such a subject.

It has been recognised by the UK and Scottish governments that more emphasis must be put on Science, Technology, Engineering, and Mathematical (STEM) subjects to encourage young people into engineering. This sounds logical, but reading through the Scottish government's *Action Plan for Education for the 21st* Century (Scottish Government, 2010) it quickly becomes apparent that Engineering is little more than an addendum to the broadly classed "Science" subjects. Of course a basis in theoretical subjects is essential for an engineer, but they often do little to inspire the minds of the more practically orientated. Some would argue that engineering has been available as an A level or Higher subject, and that GCSEs are available in subjects like *Applications of Mathematics*, however uptake of these subjects is very low - just 2.4% of pupils signed up for the latter in 2012 (Tim Gill, 2013).

What is needed is a far more comprehensive approach. It is critical to convey the importance of engineering as a standalone subject, while allowing the relation to theoretical sciences to be appreciated. In order to inspire pupils' interest in engineering it needs to be introduced early in the school curriculum. As the recently published Perkins' review suggested, 16 year olds have already made their subject choices, and closed off options (Perkins, 2013), and so engineering must be introduced before GCSE and National 4 /5 level to allow young people the opportunity to formulate an idea of what it involves. This could be done as a more regular part of core science subjects, and perhaps even as a subject in its own right - with as much emphasis as is currently given to biology, chemistry, and physics. There also needs to be a more concerted effort from industry to help inspire school pupils. The willingness of professional and voluntary organisations to provide engineering initiatives to schools has been admirable - but with such a large number being delivered it is difficult for teachers to coordinate and convey the material to pupils coherently (Perkins 2013).

Even if sufficient numbers of young people decide on a career in engineering, problems exist in the current setup that will prevent the desired economic growth. One of the most prominent issues is the worrying decline in investment in research and development (R&D) in the UK, which has traditionally been the engine driving engineering innovation.

In the late seventies the UK had one of the most R&D intensive economies in the world. Today, compared to other advanced economies, it has one of the least (Jones, 2013). Historically, there has been an even balance between government funded R&D and that conducted by the private sector. However, over the last decade, private sector investments have dropped substantially, leaving the UK in the unusual position of having the majority of R&D funded by the public sector (*Ibid.*). This decline can be attributed to a highly market-centred economy, in which mid-sized businesses are unwilling to invest in projects that will not produce rapid financial returns. This can be sustained in the short run, while novel ways are found to use existing technologies, but ultimately it is unsustainable, as it fails to provide support for larger innovations that require bigger investments over substantially longer periods of time. Previously, these investments would have been made by large conglomerates, but recently even their research budgets have been tightened, leaving no-one to pick up the slack.

The capacity for this R&D may no longer lie in the hands of the private sector, but that is not to say that the R&D can no longer be done. The UK has some of the longest-standing and best academic institutions in the world that, with the right private sector funding, could continue to drive forward engineering innovation in the UK. R&D is always a risky investment in financial terms, as there is no guarantee of finding something. To not invest, however, is a guarantee of finding nothing, and would, in this case, stunt engineering development and economic growth in the UK. The problem is linking up academic institutions with businesses.

One of the outcomes of 2013's National Manufacturing Debate held at Cranfield University, was that a bridge was needed over the so-called "valley of death" that lies between innovative conceptual ideas, and reality (Cranfield University, 2013). If theoretical scientists stand at one side of this valley, and industry stands on the other, then engineers should be the ones bridging the gap. Engineers in industry and engineers in academia may have their feet on opposing sides, but their hands should certainly be linked in the middle. Both sides have assets that are deemed valuable by the other. Universities have unique resources that would be uneconomical for industry to invest in, such as vast libraries and supercomputers. Industry has the capital, both financial and in terms of workforce, to build things on a scale universities simply could not. Both sides need to make changes in order to bridge the gap between them.

Vaclav Smil, Professor Emeritus at the University of Manitoba and one of Bill

Gates' favourite authors, argues that academics have too narrow a field of vision. He accuses them of sitting at the bottom of a deep well of knowledge in one niche field (Thompson, 2013). This may be a stereotype, but few would argue that it is entirely false, and often makes academic ideas seem inaccessible to industry. There is obviously a delicate balance to be reached between acquiring a level of knowledge that allows world-class research to be undertaken, and maintaining enough peripheral vision to see where it fits into the puzzle. However, for academia's sake it is essential that this balance is reached if investments are to be made by industry.

Similarly, industry is often too short-sighted to see the value in these investments. In 2004 Physicists in Manchester published a paper detailing the discovery of graphene - a wonder-material that had been the subject of scientific legend for decades. As well as being the thinnest material in the world, it is tougher than diamond, stretchier than rubber, and an extremely good conductor of electricity. Its practical applications would therefore seem endless. In 2010 its two discoverers were awarded the Nobel Prize for Physics. However, after spending a few hours learning about the material from researchers at the place of its discovery, large multinational companies turned down the opportunity to invest in it, claiming it wasn't close enough to market (Chakrabortty, 2013). To say this is short sighted is an understatement. What farmer would inspect his crops and decide he wasn't going to water them because they were too short? Some foresight is needed by industry leaders to see that short term investments are unsustainable in the long run, and that the sooner long-term investments are made, the sooner they will bear fruit.

A much more integrated approach to engineering between industry and academia is needed. In the current financial climate it is simply not feasible for mid-sized businesses to conduct their own extensive R&D, as it might have been in the past. This shouldn't be an issue, particularly in the UK where such a well established academic sector exists. Industry needs to recognise that there are long-term opportunities available by exploiting this sector, while academics need to make it easier for them to do so.

A strengthened pairing between academia and industry would have the potential to produce more world-leading engineering innovations in the UK. This, in turn, could motivate more school pupils to pursue a career in engineering, helping to sustain the predicted economic output from the sector.

One of the most satisfying things about engineering is the possibility of taking an existing creation and improving it. It is having the ability to see a rusty engine, dismantle it, remodel it, grease it, and see it working better than it ever did before. Historically the UK has had an enviable engineering sector, but without continued growth, that might not be the case for much longer. It is time to remodel, and grease the current systems in the UK to ensure that it maintains its prestigious engineering position for decades to come.

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