THE ROLE OF HIGHER EDUCATION PROVIDERS IN PROMOTING MANUFACTURING GROWTH WITHIN THE UK

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Abstract: Manufacturing is crucial in the UK, contributing some £150bn ($231bn) pa to the economy. Since 2009, there has been something of a post-recession recovery in both the UK and the EU, but this has been relatively insignificant, such that manufacturing output in the UK remains below that of 10-15 years ago. This is what needs to be addressed and the role that HE institutions can play in resolving the issue is considered here.

The continued growth of manufacturing output in the UK relies on the sector overcoming a wide variety of challenges. Some of these, such as global competition and global resource pressures are external factors, but there are also internal challenges such as skills gaps, graduate supply, perception of engineering as a career and demographic issues. HE providers can play a critical role in overcoming many of these internal challenges, thereby helping to ensure the continuing success of the manufacturing sector. The nature of the challenges faced by manufacturing industry is considered here. Beyond this, the experiences gained by one academic institution in responding to these challenges are recounted. The University of Sunderland engineering provision covers all levels, ranging from Foundation degrees through to Doctoral degrees. For maximum impact, innovative collaboration programmes have been initiated at all of these levels.

Case studies are presented detailing how collaboration with industry, government bodies, professional institutions and quality assurance bodies have enhanced the engineering education process and, in turn, promoted skills, knowledge, employability and graduate supply to aid the success and longevity of manufacturing industry within the UK.

Key Words (Manufacturing, Skills-gap, Training, Consultancy, Higher Education)

1. INTRODUCTION:

Manufacturing in the UK: Challenges and Opportunities

The turnover of UK-based engineering companies currently exceeds £1 trillion pa. This figure approaches 24% of the turnover of all UK businesses. The recently published *Engineering UK 2013* report [1] notes that the sector employs 5.4 million people across over 540,000 engineering companies. Within the engineering sector, manufacturing contributes £150 billion pa to the UK economy, employs 2.5 million people, contributes 46% of all UK exports and makes up 72% of UK business R&D [2]. As such, manufacturing is clearly of critical importance to the UK economy. This begs the question as to how UK manufacturing sector is performing and what are its future prospects? Recent trends (2005 to 2013) in UK manufacturing output are illustrated in Figure 1. Output dropped after the turn of the century and it wasn't until 2006/2007 that these levels were reached again. 2008/2009 saw a steep recession with major reductions in manufacturing output. This was followed by a post-recession recovery between 2009 and 2011. However, a "double-dip" recession resulted in outputs dropping off again during 2012 and early 2013. The end result is that manufacturing output in the UK remains below that of 10-15 years ago.

Future trends and expectations are, however, much more optimistic. Latest figures from the UK Office for National Statistics (ONS) [2] show a 2.1% increase in manufacturing output during June and July 2013. This has already caused much speculation about the "green shoots of recovery" in the UK. In the longer term, engineering companies are projected to have 2.74 million job openings between 2010 and 2020, across a diverse range of disciplines [3]. This represents 19.8% of all job openings across all industries. Two thirds of these job openings, 1.86 million jobs, will be for workers needing engineering skills of varying levels. Just less than half of these openings (865,100) will be for people with level 4+ engineering qualifications (level 4 is first year undergraduate level). These figures predict a demand for around 86,500 recruits pa with level 4+ engineering skills. Unfortunately, only around 46,000 people qualify at this level each year [3].

Hence, with a rough doubling of candidates qualified to level 4+ required, a skills gap is likely to occur and this is where UK universities can make a difference.

Here are some of the recommendations arising from the Engineering UK 2013 study [1, 3]:-

- *A two-fold increase in the number of engineering graduates. This is vital to meet the demand for future engineering graduates and to meet the shortfall in physics teachers and engineering lecturers needed to inspire future generations of talented engineers.*
- *A doubling of the numbers of young people studying GCSE physics as part of triple sciences and a growth in the numbers of students studying physics A level to match those studying maths.*
- *The provision of (face-to-face) robust and consistent careers information advice and guidance for all 11- to 14-year-olds that promotes the diversity of engineering careers available and the variety of routes to those careers, and includes opportunities to experience the workplace.*
- *Support for teachers and careers advisors in delivering careers information so that they understand the range of career paths, including vocational/ technician, and have the opportunity to experience a 21st century engineering workplace for themselves.*

- *This programme is best achieved if Government works in partnership across the engineering industry, professional bodies and third sector.*

The first key hurdle here is practical implementation. Discussions are ongoing about how long would it take for university departments to build the capacity to be able to accommodate a doubling of student numbers [4]. This will inevitably involve working in partnership with government, since government allocates student number quotas, provides opportunity for student loans and contributes to tuition fees in general.

The second key to this is that a suitably large pool of qualified and motivated candidates must exist for entry into HE engineering education. Over the last 10 years, accepted applicants from UK engineering and technology students have grown by 21.5%. While this is creditable, it lags some way behind the required doubling of numbers. Success will require some creative thinking. Two critical issues relate to demographics and perception of engineering as a career.

In terms of UK demographics, by 2035, the most economically-active sector of the population, namely the 20- to 64-year olds is likely to decline and the proportion of those over 65 years old will increase. Vince Cable, the UK government Secretary of State for Business, Innovation and Skills has commented on this, "*...the age profile in the industry is high and that currently not enough young people are coming forward with the right skills and aspirations to meet the anticipated demand from industry.*" Hence, growth in capacity presents some interesting challenges. Nevertheless, the talent is there. For example, women are generally very badly under-represented within engineering. In 2010/2011 only 10.8% of engineering applications came from women. Given this figure, it is clear that if the number of applications from women was raised to the same level as currently exists for men, this would almost achieve the target of doubling the number of engineering students in one stroke. So, why aren't women coming into university to study engineering?

The UK has the lowest proportion of female engineers in the EU. Within the UK, research shows that 91% of women effectively rule themselves out of a job in engineering by not choosing the appropriate science subjects at school at age 14 [5].

This is a perception issue, but those perceptions are showing signs of changing. The proportion of **12- to 16-year-olds** who understand what people working in engineering actually do has almost doubled in the last year, from **11%** to **19%.** The likelihood of **12- to 16-year-olds** seeing a career in engineering as being **desirable** has also increased year-on-year, from **29% to 38% [**6**].** The student tuition fees increase (from around £3300 to £9000), caused by shifting the burden of tuition fees from government to student, has had the side-effect of making students much more focussed on post-graduation employability than previously. This has worked in the favour of recruitment into engineering disciplines. Across the UK, more than 85% of engineering graduates gain employment or go into further study within 6 months of graduating. This compares very favourably with competing disciplines (72% is the all-subject mean). Further, the starting salaries for engineering graduates entering the profession (at £27,415 pa) are the third highest, ranking behind only medicine and dentistry. In essence, public understanding about the professional nature and status of engineering as a career is improving. Given this, how can this changing perception be exploited to increase recruitment?

For degrees in engineering, the primary pool of potential students comprises those with A levels in physics and mathematics. The Engineering UK report [1] has singled out a study of A level Physics as a key goal. Indeed, it has been shown that almost everyone who passes, goes onto a STEM-related course at university. Within the STEM subjects, **the principal destination of students with A level physics is engineering**. Since the pool of students taking physics is two and a half times smaller than that taking maths: the emphasis must be on increasing the pool of students taking A levels in physics if we are to grow the degree numbers. This needs to be addressed as early as possible in a student's studies at school. Currently, students who study triple science (individual physics, chemistry and biology) at GCSE are **three times** more likely to study **physics A level** than those who studied core and additional science. However, o**nly 18% of pupils were entered for triple science GCSEs.** This is where major growth in STEM-related course recruitment can be achieved and it is a job for government, universities, industry and professional bodies must engage in to continue and accelerate the ongoing perception change.

2. THE ANATOMY OF A UK ENGINEERING DEGREE

Of course, filling skills gaps and providing industry with suitably qualified engineers can't happen unless those degrees are fit for purpose. There are numerous ways in which this is ensured.

While every university in the UK has its own degree awarding powers, each operates within a national quality framework with a variety of components. Firstly, there are common skills required of graduates of any discipline and these requirements are spelled out by the Quality Assurance Agency for Higher Education (QAA) in its document, Framework for Higher Education Qualifications (FHEQ), [7]. The current FHEQ dates from August 2008.

The fundamental premise of FHEQ is that HE qualifications should be awarded on the basis of "*achievement of outcomes and attainment rather than years of study*". Such outcomes are usually expressed as learning "outcomes" or "descriptors" and they differ depending on the level of study undertaken. The levels associated with university teaching are levels 4 to 8 and the mapping between levels and associated qualifications is shown in Table 1.

The QAA FHEQ learning descriptors are, necessarily, generic since they cover all disciplines at a given level. The first two of these are reproduced below as examples:

Bachelor's degrees with honours are awarded to students who have demonstrated:

- *a systematic understanding of key aspects of their field of study, including acquisition of coherent and detailed knowledge, at least some of which is at, or informed by, the forefront of defined aspects of a discipline.*

- *an ability to deploy accurately established techniques of analysis and enquiry within a discipline.*

At a finer level of resolution, the UK Engineering Council defines learning outcomes specifically for engineering degrees in its publication, *UK Standard for Professional Engineering Competence*, usually abbreviated to UK-SPEC [8].

This publication specifies the engineering competences required for various levels of ***professional*** qualification awarded to practising engineers. For graduate engineers, these are currently:

- Incorporated Engineer (IEng)
- Chartered Engineer (CEng)

The relationship between the Engineering Council and UK universities is that engineering degree programmes may be accredited to IEng or CEng standards, as defined by UK-SPEC. This accreditation is undertaken by a member institution licensed by the Engineering Council. Examples of such institutions are the Institution of Mechanical Engineers (IMechE), Institute of Electrical and Electronics Engineers (IEEE) and the Institution of Engineering & Technology (IET)

Qualifications deemed appropriate for Chartered Engineer status tend to be at Master's level minimum and include [9]:

- **either** an accredited Bachelor's degree with honours in engineering or technology, plus either
  - An appropriate Master's degree or Engineering Doctorate (EngD) accredited by a Licensed Member
  - Or appropriate further learning to Masters level
- **or** an accredited integrated MEng degree.

Similarly, for Incorporated Engineers:

- **either** an accredited Bachelor's or honours degree in engineering or technology
- **or** an accredited HNC or HND in engineering or technology (for programmes started before September 1999)

Because the higher qualification (CEng) requires a minimum of Master's level (L7) qualification, Bachelor's degrees may be accredited either to IEng standard or "partial CEng" standard.

UK-SPEC lists 5 major engineering "competences" (A to E) required of Chartered Engineers (CEng). Each competence is split into sub-sections, each with its own integral components. Guidance is provided as to how each may be achieved. An extract is provided in Table 2.

At the finest level of detail, all engineering degree programmes will have their own specific learning outcomes. Each module within the programme also has its own learning outcomes. These programme and module learning outcomes are defined in terms of "knowledge" and "skills" where the definition of each outcome is appropriate for that level (e.g. L4/5/6 for undergraduate Bachelor's degrees) and guided by systems such as Bloom's taxonomy [10] or some more recent derivative [11].

The programme and module learning outcomes are hugely important in the education process because they are the prime reference point for all learning, teaching and assessment. Changing a programme or module learning outcome is regarded internally as a major revision and requires significant administrative effort to achieve. Hence it's important to get them right in the first instance. How is this done?

Firstly, it is imperative that the programme as a whole meets the requirements of FHEQ and UK-SPEC. Beyond that, it is important to meet the needs of industry (to keep the degrees relevant) and the accrediting body (such as IET, IMechE or IEEE: to meet FHEQ, UK-SPEC and engineering discipline-specific requirements). University of Sunderland engineering degrees are accredited by the Institution of Engineering & Technology (IET). The relevance to industry is ensured by the appointment and involvement of an “Industrial Advisory Board” (IAB). Our IAB comprises 25 members in total. Of these, 17 industry members are drawn from local and national companies including, British Airways, Sage, Nissan, IBM, Gestamp Tallent, British Telecom and CISCO. A further 8 academic members make up the forum.

Within the Terms of Reference of the IAB, the need to inform curricula, enhance the student learning experience and advise on employer needs with respect to output skills and overall employability is made explicit. Collaboration is not limited to undergraduate programmes. IAB also commit to collaborate in research and reach-out matters.

It is worth noting at this point that the University of Sunderland has a significant presence in Trans-National Education (TNE). Our engineering degrees are not limited to our Sunderland Campus. We have a campus in the heart of London’s docklands at Canary Wharf. It is also possible to study for our degrees at a wide variety of centres around the globe, including Malaysia, Hong Kong, Singapore, Sri Lanka and Vietnam. The models of collaboration vary from centre to centre but the need to map and cross-reference learning requirements and ultimately satisfy the needs of both UK (e.g. FHEQ and UK-SPEC) and local awarding bodies (e.g. BEM and MQA in Malaysia) remains a constant.

In summary, therefore, we have tried to ensure that adherence to the FHEQ and UK-SPEC frameworks, allied to academic staff expertise and input from industry specialists all contribute to make our degrees relevant and thereby enhance the employability of our graduates. Our engineering provision covers all levels from 4 to 8 (i.e. 1st year Bachelor’s degree study, through Foundation degree study, Master’s degrees to Doctoral research. Engineering disciplines taught cover mechanical, electronic & electrical, automotive, manufacturing and maintenance engineering together with engineering management. They are tabulated in Table 3.

Other engineering discipline skills and expertise (e.g. materials engineering) exist within the university and may be called upon for training, consultancy or research purposes - but there are no unique subject-specific degrees offered in these disciplines at the moment. Such skills and expertise find an outlet as core themes within many of the above-named degrees.

The following discussions concern the experiences of the University of Sunderland in addressing the issues of interacting with and improving the efficiency of manufacturing industry. This has been done by breaking down case studies by function (consultancy, teaching, training, research) rather than by engineering discipline or FHEQ target attainment level – though there is undoubtedly some overlap between these functions.

3. CASE STUDIES

3.1 CONSULTANCY for SMEs

A critical area of focus in respect of UK manufacturing is the SME ("Small to Medium Enterprises") sector. 99.6% of UK engineering enterprises are SMEs, where an SME is an enterprise employing less than 250 people) [12]. In the UK, SMEs account for 42% of all engineers employed within the sector. Research [13, 14] shows that about 6% of innovative, high-growth companies created 40% of new private sector jobs. Many such companies are SMEs. Hence, it is important that they are not overlooked.

The challenge in the context of economic growth is the identification of those companies that have the capability, the capacity and the motivation to grow. This issue has been the subject of a number of reports (e.g. by the National Endowment for Science, Technology and the Arts, NESTA and the Confederation of British Industry, CBI) [14, 15] and various funding avenues are available to help secure the continued growth of these companies. One such route is the UK Government's, Department for Business, Innovation & Skills (BIS) so-called innovation "vouchers" [16]. Universities will play a major role in this. The current BIS objectives here are to:

- encourage first contact between SMEs and the knowledge base
- introduce innovation processes into businesses
- raise awareness and recognition within SMEs of the services the knowledge base can provide
- encourage on-going collaboration with the knowledge base beyond the expiry of the voucher, generated by satisfaction with project outcomes and services provided by the knowledge base

Working in partnership with business, the Technology Strategy Board and Local Enterprise Partnerships, the innovation voucher programme has been introduced during 2012-13 to support SMEs in working with external knowledge providers (i.e. universities). The programme is regionally focussed (those with relatively low levels of private sector innovation and growth) and the NE of England is one such region. A number of similar schemes designed to meet the needs of SMEs (e.g. skills & technology transfer) by bridging the gaps between SMEs and universities have been operated in the past.

One such scheme in which the University of Sunderland took part was funded by the European Regional Development Agency (ERDF) and its aims essentially mirrored the current BIS aims listed above. During the 1980's and 1990's we provided materials and manufacturing engineering consultancy services for industry. Customers were predominantly large companies. SME customers were very rare – presumably either not being aware of what was available or believing commercial consultancy rates were too expensive. The ERDF grant funding provided was aimed at breaking down these barriers such that SMEs were aware of, and could access, skills and technology previously denied them. An ERDF-funded service was set up entitled UMT, or Universal Materials Testing. UMT was a materials and manufacturing consultancy unit which operated for 10 years (1997 to 2007) within the University of Sunderland, representing the "reach-out" function of the university ("reach-out" covers those activities which are not teaching and not research, but simply being useful to industry). The services offered were wide-ranging and include those shown below.

- Product development/development of materials for specific applications (e.g. adhesives, friction materials).
- Mechanical evaluation of materials and components covering a wide range of applications, namely:
    - Tensile, compressive and torsional testing.
    - Fracture toughness determination.
    - Low cycle fatigue.
    - Fatigue crack growth.
    - Fatigue life.
    - High strain rate behaviour.
    - Static and dynamic testing of full-scale components as well as standard test pieces.
- Failure analysis (also involving optical and scanning electron microscopy)
- Thermal analysis
- Quality control.
- Troubleshooting / problem solving.
- Litigation / expert witness services.
- Organic and inorganic analysis of materials.
- Rheological evaluation of polymer melts, adhesives, gels and clay pastes.
- Process / manufacturing advice and optimisation.
- Materials selection and design.
- Short courses for industry.

There is an important philosophical point about this work. We did not set this up to compete with commercial test houses whose core function is to provide raw data, usually via standard test methods. It was the added value function we were pursuing in which expert interpretation of data became the primary function rather than the data per se. The business was set up initially with the aid of EU regional development funding (ERDF) with a total value approaching £1.5m. The aim of this ERDF funding was to aid regional SMEs and this was where aid was targeted to the extent of a 50% subsidy in consultancy costs. However, it did not make financial sense to ignore larger industrial concerns. UMT performed much work for larger companies - except they paid full economic costs.

Commercial income to the university averaged around £150,000 pa over and above ERDF grant income. The project was extremely useful in (i) raising awareness among SMEs of what university resources and expertise could add to their business, (ii) allowing SMEs access to services they otherwise could not have afforded (iii) developing relationships with local governmental and regional development organisations, (iii) allowing a larger staff complement which in turn allowed greater market penetration, (iv) allowing purchase of new equipment and (v) drawing in grant income which helped offset the salary bills for existing university staff. Importantly, at the end of the project, UMT satisfied all of ERDF's stringent output metrics regarding increases in both turnover and workforce resulting for UMT's collaboration with SMEs.

3.2 TRAINING by AMAP

The Institute of Automotive & Manufacturing Advanced Practice (AMAP) [17] is a commercial research, reach-out and training centre operating within the Faculty of Applied Sciences within the University of Sunderland. It is housed in our custom-built Industry Centre in a local riverside enterprise park approximately one mile from each of the university's 2 main campuses. AMAP expertise spans automotive engineering, maintenance engineering and manufacturing engineering with particular focuses on digital and low carbon vehicle technologies.

Over the past 15 years, AMAP has made a major contribution to productivity of local manufacturing industry through all of its activities, but the main activity considered here will be its industrial training function. Such activities have made an unprecedented impact on bridging skills gaps within the local manufacturing sector. Two such training projects will be reported here. The first of these was our *Digital Factory* project.

3.2.1 Digital Factory (2003 – 2011)

The Digital Factory project was jointly funded by ERDF and the regional development agency, One North East (ONE).

The Digital Factory Project was essentially a ***training*** project covering any aspect of digital technologies which could be employed to improve the productivity of local manufacturing industry. It assisted regional manufacturing firms helping them to improve competitiveness and productivity by delivering:

- high level **skills** in relation to the use of Digital Engineering technologies and their application across the whole product lifecycle to improve product quality, cost and time to market as well as supporting skills and academic short-courses. The sorts of technologies offered included 3D Printing and Rapid Prototyping, 3D Scanning, Inspection and Reverse Engineering, CNC Machining and software applications applicable to each.

- consultancy and practical assistance to improve **innovation** (product, process & strategic).

- practical support to remove barriers and risk associated with **investment** in technologies for both established firms and start-ups (**e**nterprise), i.e. three, if not four of the drivers of productivity.

Over 6500 training opportunities were delivered during the lifetime of the project and hundreds of manufacturing companies were assisted in the process. It was awarded 3rd place in the 2006 Best of British Industry Awards in the Supporter of Industry Category and recognised as an exemplar in the process.

In practice, the skills training element of Digital Factory made the largest impact. Within the skills training envelope, training in 3D CAD and associated technologies was perhaps most valuable, with access available to most or all industry-standard software packages. This proved to be the case for both large and small companies. Here are some quotes from Nissan Manufacturing UK:

"The University is helping us deliver in a fiercely competitive global market. We knew that we needed a step-change in the use of digital technology in the manufacturing operation to keep ahead of our competitors. Our partnership with the University was critical in raising the skills levels of our employees. We have seen real bottom-line benefits as a result."

"Our collaboration with AMAP has allowed us to expand our use of DELMIA Digital Factory tools within our Body Engineering Group quickly. When modifying our process this powerful study tool allows us to find and fix problems earlier, saving cost and time"

For further testimonials and information, see AMAP's *Case Studies and References* [17].

3.2.2 ANPQP: the Alliance New Product Quality Procedure (Sept 2011 to Date)

Digital Factory was an example of a very successful project from the past. However, training needs are perennial and we need to respond to those needs. Another way in which this has been done is the ANPQP project.

ANPQP is Renault/Nissan's procedure for communicating with suppliers during new product development. Similar in structure to the AIAG APQP process, it covers all aspects of new product development from initial response to enquiry, through to ramp-up and mass production. It provides a framework within which suppliers are able to understand when and which tools to apply at particular times and when and what paperwork is required to be submitted in order to demonstrate that all necessary activities have been completed satisfactorily. From Sept 2011 to Sept 2013, over 250 employees have been trained in this procedure.

3.3 LEARNING & TEACHING

Teaching is the core business of the university. The engineering degree provision and the quality framework under which it operates have been considered earlier. Here, we will consider specific examples of some of our less conventional degree routes. The first of these concerns our Foundation degree programmes.

3.3.1 Foundation Degrees

Foundation degrees are examples of part-time degrees designed to meet the specific training needs of local industry. Liaison with bodies such as our Industrial Advisory Board, provides the opportunity for HE providers to understand industry's training needs and to respond in kind. One such response is the foundation degree. A Foundation Degree is a degree developed in collaboration with experienced industry practitioners and bridges the gap between vocational and academic qualifications. Employees study part-time for 2 years and graduate with industrially-relevant qualifications. At Sunderland, we work primarily here with Nissan Manufacturing UK and its supply chain, but entry to the degree is not restricted to these companies. In the past we have offered a foundation degree in Operations Improvement, but currently the foundation degree on our books is in Maintenance Engineering. Briefly, this degree includes study in the following areas.

- Maintenance Strategies
- Engineering Science
- Analytical Methods
- Electrical and electronic principles
- Fluid Systems
- Mechatronics
- Instrumentation and control systems
- Electrical Power

Such work-based learning and teaching is an efficient means of increasing the skills levels of employees working in the local manufacturing sector.

3.3.2 Level 0 Entry Degrees

The need for a doubling of undergraduate engineer numbers has been discussed earlier. One barrier is the lack of suitably qualified school-leavers with A levels in maths and/or physics. To help overcome this problem and increase the pool of potential engineering graduates, we have initiated a programme with a "Year 0" entry point. The purpose of this is to take on candidates who lack the required maths/physics qualifications into Year 1 of our Bachelor degrees. An additional advantage for the students is that Year 0 carries lower tuition fees than subsequent years.

During Year 0, we can deliver the skills and knowledge required for these students to progress into Year 1 of our degrees. Recruitment onto Year 0 in 2013 has been very successful. If the Year 0 students successfully progress into Year 1 and this pattern repeats itself in the future, this should make a good contribution toward increasing the pool of well-qualified graduates destined to become professional engineers.

3.4 RESEARCH

Engineering research at the University of Sunderland is healthy and, along with every university department in the UK, is currently undergoing a periodic government review known as the "Research Excellence Framework" (REF). The REF evaluates research based on publications, environment and esteem factors. The REF review is critically important and affects future research funding and the ability to attract international students. This discussion will not attempt to reproduce or even distil our REF submission. Rather, a selection of noteworthy research-based involvements and interactions with manufacturing industry will be presented. Two of these involve work-based research.

3.4.1 Engineering Fellows Project

It was the opinion of well-informed regional economic development bodies such as One North East (ONE) and the North East Productivity Alliance (NEPA) that, in contrast to manufacturing industry elsewhere, there was a lack of research culture embedded within NE England's manufacturing companies. To help overcome this, the *Engineering Fellows* project was conceived and funded to the level of £2.7m over the 2003 to 2008 period. This project was conducted and managed by AMAP within the University of Sunderland, with some additional supervisory input from all the NE regional universities.

The project was designed with the clear aim of helping to develop and embed a research culture within regional industry, by engaging senior industrialists in PhD research programmes within their own parent companies. Its stated concept and objectives were as follows:

Concept:
To develop a body of knowledge for the region in key areas of engineering expertise to support the automotive industry, its supply chain and the general manufacturing sector, in line with the Regional Economic Strategy.

Objectives
- research into real and specific areas of industrial concern happening now
- implement the research findings within their own company
- disseminate the knowledge throughout their supply chain
- disseminate the knowledge throughout the general manufacturing sector of the North East.

The project was implemented by taking senior engineers from within NE England manufacturing companies and formulating a PhD research programme of direct relevance to their employers and appropriate to their skills and job function. Like many NEPA projects, it proved to be a great success, bringing benefits to companies in terms of a more highly skilled, research-active workforce together with sustained links to partner university research and technological resources.

3.4.2 GRASP Project

The NE England automotive sector largely comprises Nissan Manufacturing UK in Sunderland and its supply chain. This sector is hugely important to the local economy. A major problem became apparent in that the best qualified local graduates tended to move outside of the region, to the detriment of the local manufacturing sector and economy. The purpose of the GRASP project was therefore to ensure that the best engineering graduates took up positions within the local automotive sector and stayed in those positions.

GRASP stands for ***Graduate Retention in the Automotive Sector Pilot (GRASP)***. This project, managed by the University of Sunderland through AMAP, was the largest project of its kind ever undertaken in the UK. GRASP was a regional suite of Knowledge Transfer Partnership (KTP) model projects [18] and had a total project value of **£6m**, with some **£4.4m** being contributed by One North East (ONE).

The project involved placing over 40 highly qualified engineering graduates into local automotive sector companies. For the 2 years of their programme, the graduates were officially university employees, though by any other operational measure they were full employees of their parent company. Their roles and research programmes were carefully negotiated between university and employer. These programmes involved the student contributing a minimum of 1800 hours to their research programme. This required that the programme met both employer needs and the academic needs associated with the award of a Master's degree at the end of the programme. In this way, a research culture was embedded in the company, its workforce became more highly qualified and the student benefitted from being awarded a higher degree and, in almost all instances, the offer of permanent employment within their organisation.

Ultimately, the project was a major success, generating over £20m in audited benefits to regional industry.

3.4.3 Maintenance in the Manufacturing Sector

Advanced maintenance research at the University of Sunderland has helped incorporate a more formal maintenance culture into NE industry.

Maintenance has been demonstrated to be a critical activity within the manufacturing sector. Economic pressures have meant many organisations are keen to optimise the availability and uptime of the production systems and increasing their life span, thereby reducing the need for costly overhauls and replacement. Frameworks such as Total Productive Maintenance (TPM) have been shown to be highly effective in ensuring maintenance activities support the strategic goals of manufacturing organisations [19]. Furthermore, the application of techniques such as condition based maintenance (CBM) can lead to demonstrable benefits in many organisations [20].

The costs associated with an organisation's maintenance activities are not easy to estimate but some studies give typical figures of between 8% and 10% of turnover and in certain industries are as high as 16%. The total maintenance costs in the UK are thought to amount to around £16–£18 billion per year [21]. The significance of improved maintenance activities can therefore have a dramatic effect on the direct costs of maintenance. According to the UK DTI (1991), a modest 8% reduction in direct maintenance costs can increase bottom line profit by 30%.

Despite this, maintenance has long been viewed as a cost to manufacturing with limited perceived value. For this reason there is often a lack of development within organisations with respect to employee knowledge and skills development. Worrying trends in NE England include

- The majority of companies (52%) have only "poor to fair" levels of maintenance practice.
- Maintenance is one of the worst performing areas of manufacturing practice.

Recent years have seen substantial focus on maintenance and reliability-related research in higher education institutions worldwide. Areas of interest range include:

- Technological measures such as condition monitoring technologies which use sensors to monitor the condition of equipment to optimise the scheduling of maintenance
- Mathematical approaches which utilise data to provide estimates of parameters such as remaining useful life, leading to a recent focus on prognostic algorithms
- Strategic concerns in terms of relating maintenance objectives to the strategic objectives of an organisation and ensuring they align
- Business processes allowing the performance of maintenance regimes to be monitored, assessed and improved.
- ICTs application supporting all of the above.

Translating this research locally into transferable skills has proved problematic in the past. Two such areas of difficulty are:

- Use and understanding of instrumentation, measurement and condition monitoring technologies which bridge traditional engineering subject disciplines.
- Understanding of established strategic approaches to maintenance and reliability.

Research and training are helping to change the maintenance culture in general and in NE England in particular. Private training bodies offer a range of certifications appropriate to carrying out maintenance-related activities at a technician level, including PCN (Personnel Certification in Non-Destructive Testing). Such competing bodies, while providing relevant and valuable skills at the level they are pitched, offer limited progression opportunities, unlike those offered by HE providers. This is the area in which the university has been very successful. By exploiting the excellent relationships developed over many years with many industrial partners, the opportunities for discussion and dissemination of maintenance philosophies and practices within these organisations have been many and varied. Research and training projects in this area have flourished and they continue to grow, to the benefit of both the university and the local manufacturing sector.

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FIGURES & TABLES

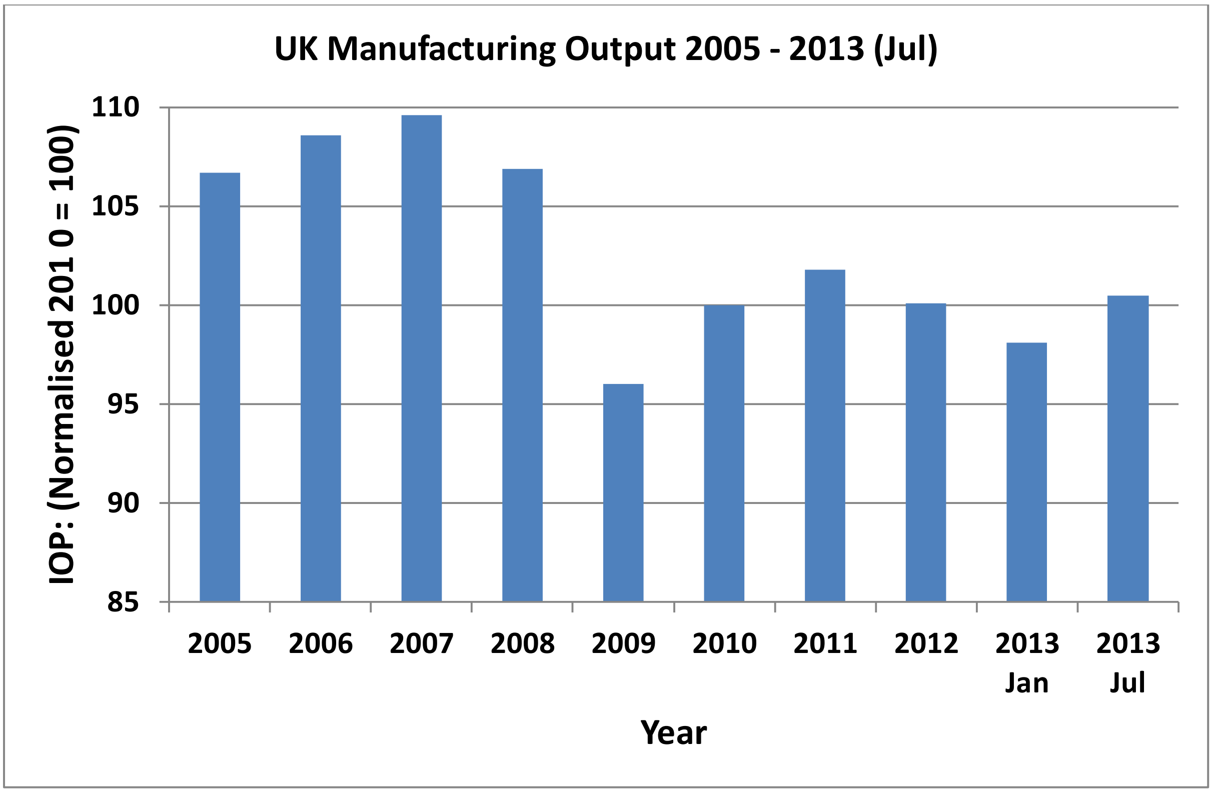

Figure 1. UK Manufacturing Output from 2005 to July 2013. Data is seasonally adjusted and normalised to 2010 = 100. Index of Production (IOP) data courtesy of UK Office for National Statistics (ONS) [2].

Level	Typical HE Qualifications at this Level
8	Doctoral Degrees (e.g. PhD, DPhil, Prof Doc)
7	Master's Degrees (e.g. MPhil, MSc, MA, MEng) Postgraduate Diplomas (PgDip) Postgraduate Certificates (PgCert, PGCE)
6	Bachelor's Degrees (e.g. BSc, BA, BEng)
5	Foundation Degrees (e.g. FdA, FdSc, FdEng) Higher National Diplomas (HND) Diplomas of Higher Education (DipHE) 2nd Year Bachelor's courses
4	Higher National Certificates (HNC) Certificates of Higher Education (CertHE)

Table 1. Examples of HE qualifications at each level of the QAA FHEQ.

Competence and Commitment Standard for Chartered Engineers **Chartered Engineers** must be competent throughout their working life, by virtue of their education, training and experience, to:	**Guidance**
A Use a combination of general and specialist engineering knowledge and understanding to optimise the application of existing and emerging technology.	
A1 Maintain and extend a sound theoretical approach in enabling the introduction and exploitation of new and advancing technology and other relevant developments. This could include an ability to: • Identify the limits of own personal knowledge and skills • Strive to extend own technological capability • Broaden and deepen own knowledge base through research and experimentation.	Engage in formal post-graduate academic study. Learn and develop new engineering theories and techniques in the workplace. Broaden your knowledge of engineering codes, standards and specifications.
A2 Engage in the creative and innovative development of engineering technology and continuous improvement systems. This could include an ability to: • Establish users' needs • Assess marketing needs and contribute to marketing strategies • Identify constraints and exploit opportunities for the development and transfer of technology within own chosen field • Promote new applications when appropriate • Secure the necessary intellectual property rights • Develop and evaluate continuous improvement systems.	Lead/manage market research, and product and process research and development. Cross-disciplinary working involving complex projects. Conduct statistically sound appraisal of data. Use evidence from best practice to improve effectiveness.

Table 2. Extract from UK-SPEC [8] citing required competences of Chartered Engineers.

Engineering Discipline	Degrees Offered / Level
Automotive Engineering	BEng Automotive Engineering / L4/5/6 MSc Professional Practice / L7 PhD / L8
Mechanical Engineering	BEng Mechanical Engineering / L4/5/6 MSc Professional Practice / L7 MSc Mechanical Engineering / L7 PhD / L8
Electronic & Electrical Engineering	BEng Electronic & Electrical Engineering / L4/5/6 PhD / L8
Manufacturing Engineering	BEng Manufacturing Engineering / L6 MSc Professional Practice / L7 PhD / L8
Engineering Management	MSc Engineering Management / L7 PhD / L8
Maintenance Engineering	FdEng Foundation Degree / L5

Table 3. Engineering degree provision at the University of Sunderland