WHAT DOES BRITISH INDUSTRY WANT FROM OUR SCIENTISTS AND ENGINEERS?

NATIONAL SCIENCE AND ENGINEERING WEEK SEMINAR ON THURSDAY 13TH MARCH

During National Science and Engineering Week the Parliamentary and Scientific Committee joined with the Department for Innovation, Universities and Skills to host a Seminar in Parliament on British Industry's requirements from Scientists and Engineers. The Seminar, entitled What Does British Industry Want from our Scientists and Engineers?, was jointly chaired by Mr Ian Pearson MP, Minister of State for Science and Innovation, and Dr Douglas Naysmith MP, Chairman of the Parliamentary and Scientific, and was held in the Attlee Suite in Portcullis House on Thursday, 13th March.

Report by Robert Freer

Introductory Remarks

Ian Pearson MP

Minister of State for Science and Innovation

In opening the meeting Mr Ian Pearson MP, Minister of State for Science and Innovation, said he was very pleased to be attending this event as part of Science and Engineering week. He expected the total attendance this year at all events during the week would exceed that of last year when nearly 800,000 people took part in 3,000 events across the country.

He said the Government's commitment to promoting British science has steadily improved the supply of Scientists, Technicians, Engineers and Mathematicians (STEM) over a number of years. Attainments at GCSE, A-Level, first degree and postgraduate results are all on an upward curve. But despite this encouraging progress challenges remain to ensure supply fully matches demand.

In schools we now have more science graduates teaching science than at any time in the past and we have 18,000 volunteer science and engineering ambassadors going into schools. These ambassadors come from a variety of different backgrounds, many are undergraduates, and can show school children not only what a subject is but what it is used for.

We need all the positive PR we can get for engineering; three quarters of young people don't know what engineers do. The Government has plans to improve the profile of engineering including the Technology and Engineering in Schools Strategy (TESS) and the National Engineering Programme (NEP), both of which are being delivered through the Royal Academy of Engineering. And the new Engineering Diploma will be available from September 2008 to help pupils with the skills to enable them to go into engineering degrees or into employment.

Mr Pearson said he wanted to see an improvement in the number of those studying science and engineering at all levels and to break down the stereotypes that surround some science subjects. For example, in subjects allied to medicine there are five times more women than men and in the biological sciences there are over 40% more women than men. Meanwhile, there are about 11,000 more men than women studying the physical sciences, and with the NVQ in construction there are over 50 times more awards going to men than to women.

NVQs are part of the programme of the Further Education and Skills sector designed to enable our workforce to adapt to the needs of the increasingly technology driven 21st century workplace. We are on course to meet our commitment to have 12 National Skills Academies by the end of the year which takes us closer to our goal of making skills more relevant to particular sectors.

Success with Government initiatives such as Train to Gain, Apprenticeships and the Skills Pledge depend on close partnership between business and providers. The focus on apprenticeships has been particularly successful and completions have risen from 40,000 in 2001/02 to over 100,000 now. In addition, the Qualifications and Curriculum Authority (QCA) is working with some 75 employers to explore ways of crediting their own industrial training programmes.

Our skills programme is overseen by the various Sector Skills Councils (SSC). SEMTA is the SSC for Science, Engineering and Manufacturing Technologies sector and is one of the largest SSCs covering 100,000 companies employing 2.5 million people, which provides up to 10% of our GDP – £74 billion every year – and contributes 33% of total UK exports. SEMTA is taking forward several key Government initiatives. They have published the Sector Skills agreement for the Automotive, Aerospace, Electronics, Marine and Bioscience sectors. SEMTA is also working with other SSCs to develop the 14-19 Diploma in Engineering and the Diploma in Manufacturing which will be available in 2009.

In Higher Education the outlook is promising, the long-standing decline in the numbers of university entrants in almost all the sciences has been reversed. The Government and the professional associations are working hard on this agenda, for example the 300 bursaries for physics undergraduates that the Institute of Physics offers have had a real impact.

Employers complain that we need more home-grown graduates in science and engineering but the problem is complex because up to three-quarters of the science graduates we do produce end up working outside science. This implies specialist skills are going to waste so we need to do more to promote careers in science and engineering and to ensure that science graduates have the skills they need to work in the scientific industries.

In my view there needs to be much closer collaboration between those who teach skills and those who turn them into products and profits. From school to post-doctoral level we are seeing the beneficial results for the UK science base that flows from dialogue and joint working between education and training providers, employers and professional associations. The Government will continue to promote more and better links of this kind.

Finally, the science challenge isn't just about training scientists, there is a job to be done with the general public. Public dialogue on science issues is crucial when it impacts so heavily on our lives. The recent survey of Public Attitudes to Science found that people are becoming more interested in science. Four-fifths of those surveyed said they were amazed by advances in science and technology. DIUS will shortly be setting out its plans for a new strategy on the role of science in society.

Business engagement with university scientists and engineers

Dr Alison Hodge MBE

QinetiQ University Partnerships Director

Dr Hodge said QinetiQ is a creative business which seeks to generate greater value from technology throughout the world through technology solutions, services, products, consulting and patents and licensing. New technologies offer both enabling opportunities and threats.

QinetiQ has a strategic interest in establishing links with scientists, technologists, engineers and mathematicians (STEM) in universities as part of the business supply chain and to improve its positioning with stakeholders and the wider public. Working with universities allows access to scientific techniques and facilities so that we can spot and access both existing and new developments worldwide. These contacts not only demonstrate the benefits gained from the significant national investment in universities but also encourage recruitment and recognition. Apprentices, graduates and PhDs are strongly motivated, willing and able to learn and have the opportunity to become world leaders in their subjects.

The universities gain considerable benefit from working with business. For the research staff business raises relevant challenges and provides valuable market knowledge. Students gain not only the opportunity to work on real projects but also an insight to teamwork and are introduced to wider employment opportunities. The market pull encourages universities to innovate and apply new scientific and technological discoveries. Universities also benefit from the publication of their work which helps improve their visibility with funders and the public. But there are special problems when working with universities. The role of universities is to use existing knowledge and where necessary to pursue new frontiers. Their product is not usually delivered in a package which can be immediately applied in business. Transferring the knowledge relies on human interaction and we need to ensure the right people are available.

There are a number of significant differences between the culture of a university and the issues which affect business decisions. A business has a corporate strategy developed by management to meet customer needs and financial targets, whereas university researchers enjoy academic freedom in pursuit of new ideas but rely on funding organisations.

Businesses respond to commercial sensitivities and usually require rapid action to produce a product or service of sufficient quality for its purpose at a cost determined by the market. On the other hand, universities usually work with a more protracted time scale with a different attitude to costs, and quality is judged by peer review in open publication in the technical literature.

For a business, necessity is the mother of invention and can lead to innovation by the universities to tackle a specific challenging problem rather than a generic challenging problem. Another practical difference is that in universities the student and staff turnover is higher than in business which has more managed staff profiles and successions.

To produce a mature product or service from an idea the completed project requires people with the relevant experience, sufficient time and financial investment and an integration of a number of separate systems. Technical considerations are just part of the solution; full performance includes training, data records, analysis, and maintainability among other criteria. As an example of technology transformation a laboratory experiment at Southampton University was developed by QinetiQ into a swimmer detection system.

EPSRC and QinetiQ together have jointly sponsored a new Professorial Chair of Technology Transfer in the Physical Sciences. This appointment is based at Imperial College and the first occupant of this chair is Prof Erkko Autio in the Tanaka Business School. The purpose of this appointment is to promote wealth creation in the physical sciences and engineering through an academically rigorous understanding of the needs of industry and the capacity of the universities.

In summary, business needs the science and engineering skills developed in universities to ensure that both existing knowledge is re-used and that new knowledge is created and applied. We need to promote the understanding by industry, by the public and by those advising the young that science and engineering are recognised as exciting and creative disciplines. To support this linkage we need more people with sound training and with practical skills who are willing to learn and gain experience and apply the knowledge gained. There are cultural gaps which exist and we need both business and the universities to understand, recognise and exploit these gaps.

What does British Industry want from our Scientists & Engineers? – ARM as an illustrative example

Sir Robin Saxby FREng

Past President, Institution of Engineering and Technology

Past Chairman and co-founder of ARM Holdings plc.

With the assistance of *Prof Ian Phillips Principal Staff Engineer at ARM Ltd*

Sir Robin Saxby said ARM is a listed public company registered and based in Cambridge but operates globally with almost all its revenue coming from outside the UK. It is a good example of an industry working with scientists and engineers. More than half its shareholders are based overseas and each site throughout the world is a centre of excellence, often developed out of a university connection.

ARM's engineers and scientists are global leaders in what they do. They are customer-driven and sensitive to the need to deliver on time to specification at the highest quality. To do this they need to be not only technically strong but also broadly aware of other business disciplines such as finance, sales, marketing, legal, production and human resources. They are also culturally aware of the need to work as a team with people across different regions and countries. Nowadays everyone is connected electronically and communication is rapid.

ARM is now the silicon IP supplier to the world. In 1990 ARM was a joint venture spin out from Acorn UK with cash from Apple and VSLI in USA. It had 12 good engineers and a hired experienced CEO in Robin Saxby, it had no revenue and no patents but did have a vision to become the global standard for embedded CPUs. By 2008 they had become the world leader with 2.5 billion chips supplied in 2007 and more than 10 billion to date. Today ARM employs 1800 people in 19 offices throughout the world. Revenue is €500 million, profit before tax is about 25% and R&D is about 25% of sales,

ARM recognised that although computers were not a new concept the need for powerful embedded computation was only just emerging. ARM's innovation was to offer the 32 bit RISC CPU as a cell-library element for use in Application-Specific Integrated Circuit (ASIC) designs and to make it equally available to everyone, to make it available from all major silicon foundries and to make it available for use in all major design tools. The focus is on improving MIPS per watt, MIPS per dollar and the time to market. The necessary integration and interworking was achieved by partnering and by sharing the risk and success through a licence and royalty revenue model. ARM is a business based on Partnership from the beginning.

ARM is active in Europe and since 1990 ARM has been, and still is, involved in 28 projects under the EU Future Framework Programme. ARM's contacts with Plessey, Nokia and others helped to promote ARM activity and concepts within Europe, and also gained support for ARM's methods and development of the embedded CPU concept when the rest of industry did not believe it was necessary. Parallel business developments in the USA and Japan are even more important, because they are bigger markets and are the locations of the headquarters of the leading semi-conductor companies.

ARM has partnered with world wide companies and has become more international with the development of skill centres outside Europe. High growth opportunities are frequently in those markets which are low value today. The USA is a major market but the fastest growing emerging markets are India and China, and none of them can be ignored. Today ARM has a connected community of over 300 world-wide partners and their activities include processors, system level IP, physical IP, development tools and software.

From our experience the lesson is to do only those projects which align with Corporate Interest, and to corporately believe in what you are trying to achieve. ARM made sure that collaborative R&D activity fitted with strategy and not the other way round, in other words don't just go for the money. The profile for successful product development is to employ only the best employees, chose the right strategic partners, use world-class universities for research and acquire viable companies which align with the corporate plans.

Hi-tech projects and businesses have become more global with teams working in different countries around the world. Out-sourcing occurs in all aspects of the work with overseas teams working together. It is important to pick those areas where UK operations have global leadership and then support and develop them. Good advice for a new company would be to do only what you are world best at.

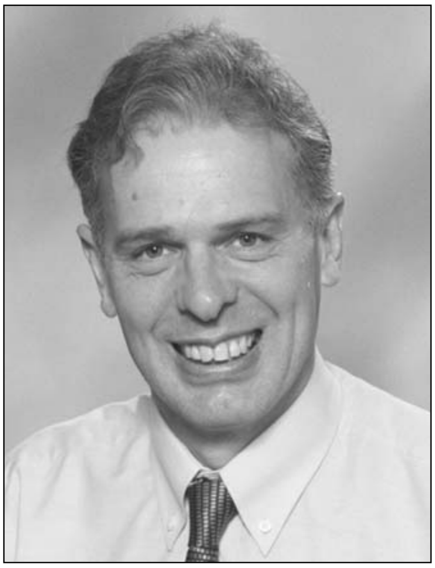
The Government also needs to provide leadership and support, and not just money. It has the opportunity to be both a catalyst for innovation as well as a customer. The opportunities are in such departments as the NHS, defence, energy and security.

The contribution that business makes to the national economy is important for our economic prosperity. The UK is just 1% of the world population but produces 5% of its economy. To maintain our position it is not enough to be world-class, we have to be world-beating.

A Marine Scientist and Engineer's view

Professor Ralph Rayner

Vice President, Institute of Marine Engineering Science and Technology



The Institute of Marine Engineering, Science and Technology (IMarEST) is an international professional membership body and learned society for all marine professionals. It is the first professional institute to recognise the need to bring together marine engineers, scientists and technologists to encourage a multidisciplinary approach to issues related to maritime safety, commerce and environmental protection.

The Institute is active in promoting the role of marine professionals in helping to address pressing societal challenges such as energy security and climate change.

The human population of planet Earth has grown from some 500 million in 1492 to over 6.6 billion in 2008, with a projected growth to 9.1 billion by 2050. This transition from an empty to a full world has created many challenges. Amongst the most critical is finding ways to meet ever growing demands for energy (without which adequate agricultural production, sufficient water supply and growing industrial economies cannot be maintained) at the same time as protecting the environment and especially mitigating the impact of human induced climate change.

The oceans play a crucial role in both aspects of this challenge. On the one hand a large proportion of the world's conventional energy in the form of oil and gas lies beneath them. They also hold an enormous potential as a source of renewable energy from winds, waves and tides. On the other side of the equation they are the critical driver of future climate, are a major natural sink for atmospheric carbon dioxide and present opportunities for enhanced sequestration of greenhouse gases.

Despite reductions in energy intensity in much of the developed world global demand for energy continues to grow. Projected rates of growth are of the order of 1.6% per annum with the fastest growth occurring in non OECD nations. Assuming no further increase in the rate of growth this translates into a global increase in energy demand of more than 30% in the coming two decades.

Despite the developing potential of renewable energy sources much of this growth will probably be satisfied by conventional hydrocarbons, a large proportion of which (more than 50%) are expected to be recovered from beneath deep ocean waters.

This presents huge engineering challenges. The biggest constraint on meeting these challenges is an acute shortage of suitably qualified and experienced engineers and scientists. This is already proving to be a major constraint on offshore developments. Order backlogs for many of the critical components in the supply chain for new developments are now measured in years with much of the constraint in supply being driven by a lack of suitably qualified and experienced engineers and physical scientists.

Similar skill shortages are impacting the rapidly growing marine renewables sector as this demands many of the same skills as are required for conventional offshore developments.

If you add to the demands on this already insufficient skill base the need for researching, developing and implementing means of separation and sequestration of greenhouse gas emissions from the burning of fossil fuels it is clear that we face a skill shortage which demands immediate attention.

On the other side of the energy and climate challenge there is a pressing need to reduce the very large uncertainties in projections of future climate if governments and businesses are to make informed decisions about the future.

Given the dominant role of the oceans in controlling climate, achieving the best possible projections of what will happen in the future demands a very good understanding of how the oceans work and how they are changing through time. Yet commitment to systematic and sustained observation of the oceans remains woefully inadequate and poorly co-ordinated.

Here the critical need is for greater political recognition of the implications of this lack of commitment.

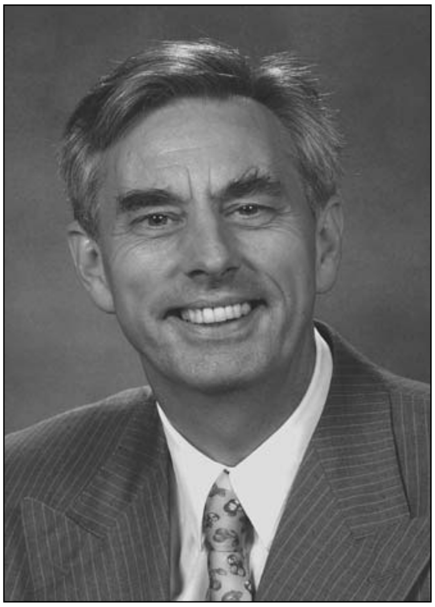
The need to commit additional resources and implement improved organisational structures to permit better understanding of the oceans was recognised in the recently issued House of Commons Select Committee report 'Investigating the Oceans'. Regrettably, the Government response failed to endorse the key recommendations of this well formulated and important report.

It is only by addressing the need for sufficient engineers and scientists that the challenge of meeting a growing demand for energy at the same time as ensuring environmental security can be satisfied. Their efforts must be guided by sound policy informed by an appropriately organised and resourced science base.

An Engineering and Technologist's View

Dr John Morton

The Engineering and Technology Board



Dr Morton said the Engineering and Technology Board (ETB) was created to promote engineers, engineering and technology. And to do this in partnership with industry, who are the customers for skilled engineers and technicians, and with the universities and colleges who are the suppliers. The ETB publishes an annual digest of engineering statistics called Engineering UK (2007) which includes information on the supply of, and demand for, engineers. The full report can be downloaded from www.etechb.co.uk/_db/_documents/EngUK07.pdf

On the supply side the number of engineers in Higher Education in the UK has remained almost constant for the last 10 years but since the total number of students in all subjects has increased by about 33% the proportion of engineers in the student population has decreased, giving the impression that engineering is becoming less popular.

India and China are often cited as producing large numbers of graduate engineers but until 2003 we produced more engineers per head of population than China, and we still produce far more than India does. In post-graduate education we have a large number of engineering PhDs per capita compared with India, China and even the USA, but more than half these PhD students are from overseas. We have world class universities and we make contributions to the science and technology base far beyond our size.

At the intermediate skill level in the Colleges of Further Education the picture is not so good. The number of students has fallen by 25% in the last 3 years and our performance does not compare well with, for example, Germany, Japan and the USA. To try to remedy this the Chancellor in the Budget yesterday announced a grant of £60 million over the next 3 years to provide new opportunities for people to gain skills, including apprenticeships.

There is a further problem that over the next 10 years there will be a 16% drop in the number of 16 year olds so it may become harder to recruit the young into engineering. One solution would be to encourage more women into engineering and encourage more returners back into the profession. At present 85% of engineering students are male and only 3% of professional engineers are female. Excellent work on encouraging women to take up a career in science and engineering is being done by the UK Resource Centre for Women in SET, WES and WISE (Dr Morton said he is the chairman of WISE). But there is much more to do.

On the demand side it is difficult to get a clear picture of what companies want. Data provided by our Sector Skills Council indicates that over the next 10 years we need to replace over 1 million skilled workers at all levels to replace those who will be leaving the workforce.

The ETB has carried out an informal poll of their Corporate Members. Many said that they had vacancies which were hard to fill because there were too few applicants and the applicants were of poor quality. Another comment was that starters lacked skills and work experience and some lacked motivation.

It was also pointed out that there are considerable differences between large companies and small companies. Small companies (who may be key parts of the supply chain) find it much more difficult than large companies do to afford the training needed in the workplace.

One example was of a high-tech company that hired only one or two graduates per year out of a workforce of 60. It takes two years to get full productivity from the new graduates and this is a huge overhead for a small company to carry.

The skills which companies say they want from tomorrow's engineers are the fundamentals of mathematics and physics and the ability to apply them to solve problems. They want engineers who are comfortable working in a group and who can communicate well, which is more than just being literate. They want engineers who have an entrepreneurial flair and who are aware of the roles of finance and marketing in a company's success.

Fortunately these challenges are recognised by the Government, by employers and by education providers. There are examples of good practice and we need to recognise them and build upon them.

Educating Engineers for the 21st Century

Professor Julia King CBE FREng

Vice Chancellor, Aston University

Professor King said that in a changing world with unprecedented global challenges there is a growing demand for engineers and scientists and a recognition that the nature of their jobs is changing, partly due to the greater complexity in the technical, management and financial systems which contribute to modern projects. The number of engineers in the UK is static at 24,000 but represents a low and falling percentage of the UK undergraduate population; in Japan and Germany the percentage of engineers is nearly twice as high. There are greater financial pressures on the universities and students and a shortage of good maths and physics teachers, which lower student motivation to start engineering courses and to stay in engineering after they graduate.

The Royal Academy of Engineering has conducted a survey on engineering training by sending questionnaires to industry and to academia. They received 444 replies from industry and 88 replies from academia. Industries reported a worsening shortage of high calibre UK engineering graduates, although the best were as good as their peers in Europe. This shortage is having an impact on productivity, creativity and growth, and industry is looking for changes in engineering education. With new graduates industry is looking mainly for practical application followed by theoretical understanding and innovation. Team working and technical breadth are also important.

The academic questionnaire went to all university engineering departments and the replies showed a strong agreement with industry's concerns and enthusiasm for change. They wanted more multi-disciplinary teaching, more project and practical activities and more industrial involvement. Many universities supported the introduction of new engineering courses such as bioengineering and nanotechnology.

Universities are critical of their present system of funding, especially the decline in funding per student for teaching. They consider the Research Assessment Exercise is highly detrimental to teaching. They recommend that Government should recognise teaching excellence alongside research excellence for funding purposes, and they should increase funding for teaching to cover its true cost, including such initiatives as visiting professors and lecturers and for industrial placements, especially in small companies.

The universities are seriously concerned about the underfunding of engineering degrees. A review by the Engineering Professors Council and the ETB showed that engineering departments needed an increase of 14% just to stand still, and significantly more to move forward for the 21st Century. Without this investment we face the possibility of losing the quality and reputation of our courses which attract students both from home and overseas. 11% of our students are from overseas and they make a net contribution to the UK economy estimated at £3.8 billion per year and, together with academic visitors, are estimated to generate 24,000 additional jobs.

Professor King concluded by putting forward recommendations to the universities, industry and the institutions. Universities need to strengthen their links with industry and enhance the design of their courses so that they can deliver the engineering knowledge, skills and competencies, new world-class engineering degree courses with a strong technical content in areas which appeal to students and deliver industry's needs. For this purpose universities should recognise excellence and innovation in the design and delivery of their courses and reward such excellence in promotion criteria, bonuses and salaries. Also they need to engage actively in promoting science and engineering initiatives in schools.

Industry is recommended to commit to active long-term relationships with university engineering departments, for example, by supporting advisory boards and providing visiting professors, lecturers and industrial tutors. Two-way staff exchanges, mentoring of young academics, student placements and visits would also be helpful, as would feedback on the quality of graduates and the relevance of their education. Industry can also help by promoting science and engineering in schools and engaging with the institutions in the accreditation of professional engineering.

The institutions are invited to recognise excellence in university teaching, for example through high profile awards for excellence and innovation and by sharing best practice in education by supporting interest groups and by the organisation of education events and conferences. Universities seeking to establish multi-disciplinary degrees would welcome support from the institutions by setting up processes to create, develop and give accreditation to such courses.

In their recent report entitled *Educating Engineers for the 21st Century* the Royal Academy of Engineering has made a number of recommendations about engineering education to meet the evolving requirements of industry as well as motivating students to become engineers on graduation. One recommendation was that a working group of experts from academia and industry should be set up to develop an experience-led engineering degree which integrates technical, operational and business skills. The RAEng has submitted a proposal to DIUS.

In the general discussion a number of members of the audience raised questions concerning the best methods of advising the young about careers in science and engineering before they make their career decisions. Reportedly these decisions are often made in junior school, but in general schools and teachers are not particularly well informed about the work of scientists and engineers. Too many schools were said to be driven by league tables. Teachers who are responsible for careers advice need more opportunity to gain experience and knowledge of industry.

When selecting scientists and engineers to visit schools under the Schools Ambassador Scheme it may be preferable to chose the younger candidates because pupils may be better encouraged and inspired by meeting someone closer to their own age.

It was agreed that degree courses should be designed to encourage innovative skills and that we need to try to increase the number of science and engineering graduates.