IOP Institute of Physics

Innovation in services: the role of science, technology, engineering and maths (STEM)

Institute of Physics response to a Royal Society study

A full list of the Institute's responses and submissions to consultations can be found at www.iop.org

27 August 2008

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Nicola Berkley
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IOP Institute of Physics

Dear Ms Berkley

Innovation in services: the role of science, technology, engineering and maths (STEM)

The Institute of Physics is a scientific membership organisation devoted to increasing the understanding and application of physics. It has an extensive worldwide membership and is a leading communicator of physics with all audiences from specialists through government to the general public. Its publishing company, IOP Publishing, is a world leader in scientific publishing and the electronic dissemination of physics.

The Institute welcomes the opportunity to respond to the Royal Society study: Innovation in services: the role of science, technology, engineering and maths (STEM).

The attached annex highlights the key issues of concern to the Institute that have been linked to the some of the specific questions raised.

If you need any further information on the points raised, please do not hesitate to contact me.

Yours sincerely

Alex Connor
Technology and Innovation Policy Officer

IOP Institute of Physics

Innovation in services: the role of science, technology, engineering and maths (STEM)

a) The nature and extent of links between STEM and services sectors

Physics underpins a wide range of technologies and processes which enable innovation in the service sectors. In some cases, the contribution is at a fundamental level, such as the provision of atomic clocks for Global Positioning Systems (GPS). In others, the effect is more direct, such as the radioactive dating techniques used in archaeology, or the imaging processes used in art history.

It is important to emphasise that, although the terms of reference of this review refer to innovation in the service industries introduced over the past ten years, the scientific progress and developments that enable these innovations may be products of decades of research. Current research in physics is essential for knowledge exchange between academia and other sectors enabling innovation; however, moving existing science and technologies into a new area, such as the service sectors, is also innovation. A ready supply of scientifically trained workers and capability within industry are essential for both these processes to succeed.

The Institute has previously published case studies[1] of technologies that have been resulted from curiosity-driven physics research. The studies demonstrate the long timescales over which the process between the original discoveries and the development of products that utilise the research can occur. Four key technologies highlighted in these publications that enabled many of the technology-based innovations seen in the service sectors are described below:

Fibre optics: The development of fibre optic technologies has allowed for broadband internet connections and rapid world-wide communication of information, enabling online innovations in the service sectors such as virtual interfaces, online healthcare monitoring and remote networking. The technology has its roots in physics research by John Tyndall in the 1800s and in more recent research into photonics.

Lasers: The use of lasers has allowed for both rapid communication through broadband networks, and also for fast data storage and retrieval through CD and DVD technologies. The principle behind the laser was developed by Albert Einstein and it took more than 40 years before the first visible-wavelength laser was constructed. Researchers at the University of Surrey are currently working to manipulate quantum cascade lasers which could be used for medical diagnosis, for example, glucose monitoring for diabetics.

Liquid Crystals: Liquid Crystal Display (LCD) technology enables mobile devices through light-weight, low-power consumption and low-cost screens. The original scientific research that underpins LCD technology was conducted more than 100 years ago, with further development in the second half of the last century. Simple LCD displays are found in watches and calculators with more complex displays now in mobile phones, computer monitors and TVs.

[1] www.iop.org/activity/policy/Publications/Case%20Studies/page_29803.html

GPS: The ability to accurately determine the position of an object or person has enabled innovations such as internet-based theft tracking of cars and satellite navigation. GPS is underpinned by a wide range of physics research, from atomic clocks to the theory of General Relativity, combined with space science and technology.

Additionally, it is important to note the large and direct contribution that long-timescale, fundamental physics research has made to innovations that are occurring in medical technology. Such technologies are perhaps the clearest example of where physics is integral in the services. In fact, the role of physics in underpinning medical imaging techniques is a huge area in its own right. Virtually all medical imaging techniques (X-rays, MRI, EEG, PET scanners, ultrasound, infra-red, terahertz, optical probes) are underpinned by physics and a range of treatment techniques, particularly those involving lasers, such as laser eye surgery, are also reliant on physics.

In the application of technologies in the health sectors with their roots in science and technology, we would recommend reading the *Perspectives* series produced by the Institute of Physics and Engineering in Medicine[2] (a partner society of the Institute of Physics). The publications outline technologies of both medical care, and the role of physics and engineering in assisted living technologies.

Further applications of STEM in high economic impact areas include the finance sector, for example, work to understand the properties of non-linear systems now allows physicists to develop models of the financial markets. One of the Institute's series of Vision Papers, *Physics in Finance*[3], outlines some of the broader contributions physics has made to the world of finance. Looking ahead, the field of quantum cryptography has the potential to create a system of secure communication where it is impossible for a hacker to eavesdrop without destroying its integrity in a detectable way.

Finally, within the leisure sector, an understanding of the science and engineering of materials and aerodynamics, has enabled substantial developments in sport, leading to faster and higher achievements at the Olympics. Examples of the application of STEM which have shown considerable reward at the recent Beijing games include bike frames, swim suits, javelins, pole vault poles and wind tunnel testing for aerodynamics. Also, the test instruments which monitor and control athlete training techniques and performance, together with the advance timing systems, accurate to tiny fractions of a second, have their origins in physics research.

These selected examples are of course only a small aspect of the role of STEM in innovation in the service sectors. For a review of the details of innovation within the service sector, we would recommend the recent report by QinetiQ and the CBI, *Excellence in Service Innovation*[4]*,* which outlines the importance and impact of innovation, and also emphasises the essential nature of technology in this process.

[2] www.ipem.ac.uk/ipem_public/default.asp?id=848
[3] http://visions.iop.org/pdf/v4%20www.pdf
[4] www.cbi.org.uk/pdf/Excellenceinserviceinnovation.pdf

b) STEM, people and services sector innovation

Perhaps the greatest contribution that physics makes to the UK economy is through the supply of trained physicists. Physics graduates provide highly skilled people in many areas of the service industries, including the information technology sector, financial analysis, environmental science, energy technology, intellectual property law and medical physics.

While there are currently no strong graduate destination data for people with physics degrees, recent surveys of the Institute's 34 000 members (most of whom hold a physics degree) have indicated that around 10% work in service sectors, dominated by those working in healthcare, consultancy and finance[5]. (Though, due to the nature of the Institute's membership, this is almost certain to be an underestimate of the proportion of physics graduates working in these fields across the UK.) Further case studies of the skills that physics graduates bring to roles in the service sectors can be seen in the Institute's *New Directions* publication[6], which is designed to offer careers guidance to physics graduates in these areas.

As part of the Institute's 'Undergraduate Physics Inquiry' of 2001[7], a survey was undertaken of the views of employers of physicists. This pool of employers included those from finance and other service sector industries. The survey suggested that there is strong demand for physics graduates and that employers believe that physics degrees give:

- flexibility and versatility to tackle a wide range of technical and non-technical subjects;
- good analytical and problem-solving skills;
- good mathematical and IT skills;
- a good breadth of technical interest and ability;
- a good understanding of fundamentals from which to approach new situations where traditional approaches do not work;
- analytical problem-solving capabilities (in some sectors, including the financial sector, emphasis is put on the advantages of a research training in enhancing these skills);
- an ability to grasp concepts quickly and in a quantitative way (more important than knowledge of a particular specialism); and
- an ability 'to argue on one's feet'.

Furthermore, the Institute has previously commissioned a study[8] into the career paths of physics postdoctoral research assistants (PDRAs), with the aim of identifying the main business sectors and occupations in which physicists who had undertaken one or two PDRA positions were employed. The survey highlighted that while the major employers were more traditional physics roles in industry, the other main private sector 'users' of physics PDRAs were business/financial and software/computing companies in occupations including: financial/business analysts; actuaries; and commercial managers. The five most frequently cited skills/competencies gained from PDRA research experience were (in descending order):

- subject specific knowledge;
- presentation and communication skills;

[5] Institute of Physics Salary Survey 2007
[6] http://www.iop.org/activity/careers/Careers/Resources/Career_resources/page_3964.html
[7] www.iop.org/activity/policy/Projects/Archive/page_6337.html
[8] www.iop.org/activity/policy/Publications/file_26615.pdf

- technical research skills;
- individual initiative and self motivation; and
- problem solving skills.

These skills are in even higher demand today. Anecdotally, we often hear that the financial sector is keen to employ theoretical physics PhDs in preference to most other disciplines, due to the highly-numerate, analytical and problem solving skills that are acquired during their training. The *Quant and Mammon*[9] report further examines the attraction of physics graduates to the City and indicated that at that time, 100 PhD graduates from physics every year were entering the finance industry and it is likely that this has since increased.

[9] Quant and Mammon, EPSRC 1998

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