Institute of Physics

Science, technology, engineering & mathematics policy review

An Institute of Physics response to the Conservative Party's STEM Policy Taskforce

13 July 2006

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Ms Sarah Chilman
STEM Task-force
House of Commons
London SW1A 0AA

Institute of Physics

Dear Ms Chilman

Science, technology, engineering & mathematics policy review

The Institute of Physics is a scientific membership organisation devoted to increasing the understanding and application of physics. It has an extensive worldwide membership (currently over 35,000) and is a leading communicator of physics with all audiences from specialists through government to the general public. The Institute believes in and promotes ethical integrity in all scientific activity, including education, research, publication and the exploitation of knowledge. Its publishing company, Institute of Physics Publishing, is a world leader in scientific publishing and the electronic dissemination of physics.

The Institute is pleased to have been given the opportunity to submit its views to the Conservative Party's STEM Taskforce's policy review of science, technology, engineering & mathematics.

The attached annex highlights issues of concern to the Institute which are related to some of the themes listed in the call for input.

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

Yours sincerely

Dr Robert Kirby-Harris CPhys FInstP
Chief Executive

Institute of Physics

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The scope of a national strategy for STEM

A national strategy for STEM must be simple in structure (i.e. minimal bureaucracy) and focus on the following key issues:

- The balance of the specialisation of school science teachers must be addressed. There is an extreme shortage of specialised physics teachers that is being masked by the overall numbers of graduates in other STEM disciplines going into science teaching.

- A major concern has been the steady decline in the number of entrants to physics and mathematics A-levels and Scottish Highers. Unless this is addressed, the number of suitable students in a position to apply for first degrees in physics and cognate subjects will dwindle.

- Practical and experimental work are key to enthusing school pupils in science subjects (especially girls), and large class sizes and a lack of resources make it difficult to provide pupils with this experience.

- It is imperative that an educated student market is created. A significant problem facing science, and particularly physics, is that students are making ill-informed subject choices between the ages of 12-15. Teachers, parents, careers advisors should be in a position to highlight the benefits and the wide variety of career options that are available from science.

- Over 30% of physics departments have disappeared since 1994. At present, there are only 47 UK universities (out of 125) offering a provision for undergraduate physics, which has led to a number of regions in the UK (such as East Anglia) with no undergraduate physics teaching.

- The UK's Funding Councils should reconsider the allocation of their teaching funds for STEM subjects, in particular physics and chemistry. A recent survey of the finances of physics departments in England, commissioned by the Institute, concluded that in 2003-04 all of the departments surveyed were in deficit on a full economic costing (FEC) basis. In part this reflected their very heavy dependence on public funding and the metrics used to allocate those public funds.

- The government in recent years has made a significant commitment to the science base, by doubling the science budget, which followed years of chronic under funding. Curiosity-driven research, particularly in physics, is long-term in its nature, and the Institute hopes that the money invested into the science base will continue to support this research through responsive mode research council funding.

- To enable the UK to reap more of the commercial benefits of its physics base, university physics departments and related groups should have more mechanisms in place to exploit their research in industry. The RDAs have a role to play in facilitating links, but the Institute is not convinced that the RDAs are at present the best channel for government money to help form business-university linkages. The RDAs need to improve their performance and play a more active role in exploiting the research undertaken by universities, not just germane to their regions, but nationally with better co-ordination between the RDAs.

- In addition to a national strategy for STEM, there is the urgent need for a robust co-ordinated structure within government for dealing with science policy issues, i.e. HM Treasury, DfES and DTI working more in tandem.

The relative importance of applied science and 'blue skies' research

Curiosity-driven research

The government in recent years has made a significant commitment to science, by doubling the science budget and, of course, after such a commitment it would expect a comparable return on investment. Curiosity-driven research, particularly in physics, is long-term in its nature. In many cases, exploitation will not be seen for many years, possibly decades. Money has been pumped into managed programmes, following a number of spending reviews, but government must be patient, and not continue this trend if it is at the expense of curiosity-driven research.

The Institute endorses the comments made in the recent report of an independent panel of eminent international physicists and astronomers entitled, *International Perceptions of UK Research in Physics and Astronomy 2005*[1]*,* which states:

"Curiosity-driven research is important in its own right and attracts the most able people into physics and astronomy, but it is also the foundation for the improvement of quality of life and wealth creation in a knowledge-based society. The Panel has noted that some new money entering the science base has been tied up with specific initiatives. Many of these initiatives may be of strategic importance to the UK. However, the Panel is concerned that this could be a creeping trend that would undermine the opportunities of physicists and astronomers to follow their instincts in research, and the UK's ability to pursue curiosity-driven research at the highest level. The Panel recommends that the research councils monitor the balance between targeted and curiosity-driven research and maintain a healthy balance between the two funding streams."

Applied science

Applied science is also very important in its own right and has been hit hard by the RAE peer review process, in terms of not receiving the recognition it rightly deserves. It is imperative that excellence across all types of research should be recognised. Excellent research undertaken with industry or other users should be recognised as being of equal value to excellent academic research. An important issue here is the metrics used in the RAE to assess applied research. The issue of the difficulty of assessing multi-disciplinary activity and industry-linked research in a consistent way is a critical one. Appropriate recognition and credit to reward multi-disciplinary work and collaborative research with industry is vital – it is hoped that the 2008 RAE will

[1]www.iop.org/Our_Activities/Science_Policy/Projects/International_Review/index.html

address these concerns. Furthermore, it is imperative that an additional, dedicated stream of (new) funds is established in order to support this important area of research.

Interdisciplinary research

While the conventional departmental structure in universities is fine for undergraduate teaching, it is very poorly adapted to the more interdisciplinary demands and opportunities in research. A much more flexible research structure, cutting across conventional departmental boundaries is needed. It is a real challenge for universities to put this in place, as increasing transparency of costs makes collegiate strategic decision-making harder. By making university cost centres take more control of their finances, interdisciplinary collaboration has been severely disadvantaged.

The key research areas that need to be developed and/or retained

The international panel in their report commented that, since the previous review undertaken in April 2000, there has been a general improvement in the research environment for the UK's research effort in physics and astronomy. Progress has been made and the UK is now well placed to reap the benefit of the recent investment. This progress, however, is predicated on maintaining the increased level of funding that has taken place over the last few years.

Even though the outlook depicted by the international panel for UK physics research is very positive, there are a number of concerns they highlighted that need to be addressed. In particular, caution is needed in basing long-term strategies on existing areas of science. A consistent feature of UK research funding, relative to our main industrial competitors, has been the lack of flexibility in identifying new areas and responding to funding needs. In the physics area, two recent examples have been spintronics and nanoscience. In both cases, the science had been recognised as vital for the 21st century by our competitors before UK funds had been provided. It is of concern to note that the international panel in their report commented that nanoscience is a research area still requiring attention (following on from a similar comment made in 2000), as the UK lacks coherence and international visibility in the field. In addition, despite the prominence given to interdisciplinary activity by the research councils, as long as they concentrate narrowly in their own areas, too many exciting and innovative research proposals will fall between the cracks.

Low success rates and funding for the physical sciences

A long-term issue of concern to the physics community has been the low success rates for grant applications for curiosity-driven research, which was also commented on by the international panel in their report. In response to these concerns, EPSRC, a major funder of physics research, has raised the issue that there is a gap developing in the science budget – engineering and the physical sciences are being seriously under funded, and are on the wrong trajectory, in comparison with the biological sciences.

The Institute supports the views expressed in a letter to VCs and Principals from EPSRC in 2004 where it reports that, "The UK's research capacity in engineering and the physical sciences is heavily dependent on the university sector. But the base of permanent staff is shrinking in these core subjects as is research income and research outputs such as the number of published papers. This partly results from a deliberate shift of resources toward new scientific opportunities in the life sciences. There is a need to sustain the UK's research capacity in important areas of the physical sciences and engineering by increasing the *quantity* of high *quality* research, and reducing the dependence of that capacity on student numbers."

In addition, EPSRC report that, "The reduction in the UK's research capacity in engineering and the physical sciences has happened over a long period... This contraction will continue and could severely hamper improvements in competitiveness in the UK economy. The restored research capacity has to be in the UK; if it is elsewhere we will begin to lose the ability to understand and use developments elsewhere and will not maintain the research environments necessary to produce trained people. This will require concerted action by a number of bodies."

The most effective mechanisms for the successful exploitation of STEM

The Institute's report, *The Importance of Physics in the UK Economy*[2], highlighted that physics underpinned 43% of UK manufacturing by 2000, and the percentage is growing. While "conventional" physics based industries (PBIs) are doing well compared with UK manufacturing as a whole, exciting new areas of industry are emerging based on developments in physics-based research over the past 20 years. However, there are some worrying trends that threaten to hinder the performance of PBIs. In particular:

- investment in PBIs does not match that of other manufacturing sectors and there is limited availability of venture capital for start-ups and SMEs; and

- commercialisation of physics-based research is limited, despite its potential for exploitation.

Therefore, a key challenge for the UK is to raise the overall demand for research by business. Despite some high-profile spinout activity in the UK, there appears to be a low rate of commercialisation of academic research in physics compared with other disciplines. There is significant potential for exploitation and the RDAs have a role to play in facilitating links, but the Institute remains unconvinced that the RDAs, certainly as currently staffed and operating, are the best channel for government money to help business-university linkages.

Business innovation can be hampered due to a variety of factors such as a lack of market knowledge, market uncertainty, risk associated with the adoption of new technologies, absence of standards, and a lack of access to relevant skills and expertise. Many of these barriers can be reduced by ensuring that the infrastructure is well developed so that companies can secure necessary help easily and effectively. Companies want to work with the universities with the most relevant skills and interests to support their business. In many cases these will not be in the same region. Indeed, for high technology-based businesses, solutions to problems are most unlikely to be provided solely by regional interactions. Hence, there needs to be a balance between innovative regional support for links and national support and co-ordination – a challenging role that the RDAs need to rise up to.

[2]www.iop.org/Our_Activities/Business_and_Innovation/Publications/Physics_Based_Industry_Report/page_4388.html

The methods and mechanisms of attracting and retaining students/leading experts

The international panel in their report highlighted that the environment in which physics and astronomy research is undertaken has improved vastly in recent years, in part, due to the increased investment in infrastructure through the JIF and SRIF initiatives. This has had a significant impact on attracting and retaining academic staff, who are now working in modern/refurbished laboratories and buildings. In addition, they welcomed the additional direct investment in human resources, such as the much-needed adjustment of stipends for PhD students to an acceptable level, without which many PhD students would not have been able to start or complete their studies.

However, many concerns persist, including the effect of successive RAE exercises that have led to the concentration of the best researchers into fewer university departments, and a ‘one size fits all’ policy by government to address issues affecting individual STEM subjects.

Perennial concerns of PDRAs

The international panel highlighted the perennial concerns relating to PDRAs who are still going from one short-term research contract to another, with the associated uncertainty of whether they will secure a permanent academic position, which is not the ideal environment in which to nurture young academic talent. The RCUK Academic Fellowship scheme was introduced as a measure to offer PDRAs more attractive and stable paths into academia. However, its impact is not yet clear. What is needed is greater flexibility in postdoctoral salary structures, coupled with advice to PDRAs on long-term career prospects at an earlier stage in their careers.

Physicists into industry

The flow of high-quality professional physicists into industry is also an issue of concern. Physics graduates are particularly well suited to the needs of industry and business. However, many of those with a four-year MPhys qualification have accumulated debts during their undergraduate study, which will be exacerbated by the introduction of tuition fees. However, they appear to be attracted by the salaries and conditions in the City and other sectors, where their intellectual strengths are recognised and rewarded. The result is that too few of them are staying in research in academe and industry. The problem, primarily, requires attention to the salaries, status, conditions and prospects pertaining to careers in research, both in academe, but particularly in industry. The Institute believes government should provide financial incentives in order to encourage high-quality graduates to train in research. Industry must similarly review the benefits package it offers its researchers.

Careers advice

Looking at the issue of attracting students to STEM, the problem starts at school. The supply of scientists and engineers is dependent on the choices young people make between the ages of 12-15, and these in their turn are determined by the nature and quality of science teaching earlier in their schooling. The woeful lack of specialist teachers particularly in the physical sciences is of utmost concern, as only those with confidence and competence can teach a subject well, engaging and enthusing pupils, and motivating them to pursue science and engineering careers.

The Institute is very concerned that students are not being given accurate careers advice at a sufficiently early age to allow them to make informed choices. Currently, careers advice tends to be reactive and does not provide students with a full picture of the consequences of subject choices. This is exacerbated by recent changes to the structuring of the careers service where insufficient attention has been paid to the skills and knowledge of those required to give useful and accurate careers advice. It is imperative that an educated student market deciding what degrees to undertake is created.

<u>Girls and women in physics</u>

There has been a 38% decline in the recruitment of students to A-level physics since 1990. Over this period the participation rate of girls in physics has remained fixed at around 20%. If girls were more proportionally represented, recruitment to physics A-level could be improved substantially. The emerging evidence is that key determinants of students' attitudes to physics are:

- How relevant students see physics being to them both now and in the future;
- Their experience of school physics; and
- A personally supportive physics teacher.

Negative experiences in these areas appear to have a greater impact on girls than boys. Therefore, the key issues to address are:

- Strategies to engender greater engagement and participation by girls in physics;
- Helping teachers to improve their understanding of gender issues and implement change;
- Quality of careers guidance in science and the awareness of careers advisors and teachers of the gender dimension in relation to STEM; and
- The extent to which the National Curriculum portrays an accurate and contemporary picture of the role of physics in the modern world and supports students' understanding of professional and technical careers.

The proportion of young women in physics after A-level remains at around 20% through undergraduate physics and postgraduate physics but thereafter declines at every level in both academia and industry. In academia, a particular barrier for women wishing to have children is the series of short-term contracts that is required prior to the first permanent appointment, for which the average age is 35. Therefore, funders of higher education and research should continue to press for positive action on the recruitment, retention and promotion of female researchers and academic staff.

The Women and Work Commission's report, *Shaping a Fairer Future*, made several recommendations on increasing the role of part-time and flexible working in higher status jobs. These recommendations should be followed through.

The remit, organisation and management of the Research Councils

<u>Large Facilities Council</u>

The future organisation of the research councils is dependent on the outcome of the government's proposals for the formation of a Large Facilities Council (LFC). In summary, the Institute in its formal response to the proposals[3] welcomed the formation of an LFC, provided that the whole suite of PPARC activity, including its grant giving function, is combined with that of CCLRC to ensure that the exploitation of large facilities research is not separated from its operation and management. The Institute would like to stress that care must be taken to ensure that the balance of funding of research areas across all of the sub-fields, irrespective of whether PPARC's grant giving function is transferred to either EPSRC or an LFC, is sustained.

Research Councils UK

There is a need for RCUK to play a greater role in improving the effectiveness of the research councils. RCUK should be a mechanism for the individual research councils to work more flexibly with each other to strengthen cross-disciplinary collaboration between, for instance the physical and the medical and the life sciences. Good progress is being made with a number of cross-council initiatives (such as Basic Technology, e-Science, Sustainable Energy etc.), and the Institute is keen to see further examples. But there is a need for RCUK to encourage the research councils to share best practice in their operating procedures, and to rationalise schemes where possible.

The impact of EU and international research collaboration in STEM

Problems with EU funding

The main problems with EU funding have included the amount of bureaucracy associated with the funding, the low level of overheads and the need to link EU funding to other sources. In many physics departments, EU funding is used as a supplement to national funding but takes a disproportionate amount of administrative effort. In much of physics, there are natural and very strong European collaborations, particularly in areas where large facilities are required, such as astronomy and particle physics. However, there are also strong collaborations in other areas. The essential feature of successful European collaborations is that there should be genuine complementarity between groups. Perhaps the best way forward might be to link EU funding to national funding, to cover the FEC of the programme and to ensure that the European dimension genuinely adds value. Reducing the administrative burden would be a distinct advantage.

Framework 7 Programme

A key issue for FP7 will be continuity between itself and FP6. In the past there was little attempt by the EC to see through initiatives started in one programme and which may not have found a natural home in another. This was a loss of useful investments already made as well as a tendency to avoid some of the infrastructure projects that may have lacked glamour.

FP7 will need to strike an appropriate balance between applied research and curiosity-driven research. It must also strike a balance between top-down, directed priorities and responsive mode, allowing researchers to respond quickly to recent discoveries and sudden improvements in techniques. FP7 will need to attract excellent researchers and focus on research excellence. Mobility between academia

[3] www.iop.org/Our_Activities/Science_Policy/Consultations/Science_Base/page_3049.html

and industry is good for raising awareness on both sides. Incentives to achieve this by overcoming practicalities are essential.

Another consideration for FP7 will be EU enlargement. Enlargement brings both opportunities for new research collaborations, and threats such as a potential reduction in funding available to individual research groups as a result of the incorporation of new Member States. Many new Member States are still engaged in a huge transition process and lack the national infrastructures to help companies work closely with their national science base let alone a European one.

European Research Council

Curiosity-driven research for the Framework Programmes could in the future be a lower priority, if the European Research Council (ERC) comes into force. The ERC is an important new venture to fund and foster collaboration and excellence in curiosity-driven research across Europe. For it to succeed, it must be autonomous of the EC, provide funding to all research disciplines based on a robust and transparent peer review system, and be totally de-coupled from the bureaucracy that has plagued the Framework programmes. Plus it must operate on a few simple criteria – beginning with academic excellence. It is essential that the ERC is supported by additional EU funding, and not from re-directed existing funds from the national research councils.

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