Higher Education in STEM Subjects

Institute of Physics response to a House of Lords Science and Technology Sub-Committee I inquiry

A full list of the IOP’s submissions to consultations and inquiries can be viewed at www.iop.org

16 December 2011
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Elisa Rubio  
Sub-Committee I Clerk  
Science and Technology Select Sub-Committee I  
Committee Office  
House of Lords  
London SW1A 0PW

IOP Institute of Physics

Dear Ms Rubio,

Higher Education in STEM Subjects

The Institute of Physics is a leading scientific society promoting physics and bringing physicists together for the benefit of all. It has a worldwide membership of around 40,000 comprising physicists from all sectors, as well as those with an interest in physics. It works to advance physics research, application and education; and engages with policy makers and the public to develop awareness and understanding of physics. Its publishing company, IOP Publishing, is a world leader in professional scientific communications.

The IOP welcomes the opportunity to respond to the House of Lords Science and Technology Sub-Committee I’s inquiry into ‘Higher Education in STEM Subjects’. The attached annex details our response to the questions 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,

Professor Peter Main  
Director, Education and Science
Higher Education in STEM Subjects

Summary of key points

16-18 supply

- It is well understood that many entrants to undergraduate physics degrees are ill prepared to cope with the mathematics contents of their degrees, due to the removal of mathematical content from the physics A-level, in order to allow physics to be a stand-alone A-level. This situation could be addressed if A-level physics allowed the subject to be described with the appropriate level of mathematics.

Graduate supply

- The proposals in the HE reforms to liberate student numbers could have a number of unintended consequences: the AAB+ equivalent policy could lead to the recruitment of high-performing students to non-science subjects where the cost of teaching them is less than the income available from tuition fees; and the policy to allocate places to HEIs charging £7,500 or below will benefit HEIs 'lower down' in the sector that do not have the capacity to teach laboratory-based science subjects, nor will have the ambition to do so.

- The HE reforms may also have an adverse impact on uptake for the four-year integrated Masters degrees, which are now the norm for those considering a career in university or industrial R&D. Financial constraints are certainly a factor in some able students choosing to study a three-year degree, instead of taking-up the extra year which would mean another year of debt accumulation. HEFCE teaching funding provision will need to ensure that STEM departments can continue to afford to offer four-year courses.

- There is an intimate relationship between teaching and research, in terms of space and facilities, financial sustainability, student contact with researchers, academic staff time and workload, and the supply chain of new researchers. A more coherent approach to teaching and research in STEM subjects by the research councils and the funding councils is essential.

- More research needs to be carried out into what societal factors influence different groups in making subject choices, and what practical approaches are proven to work with young people to build a culture that recognises that STEM subjects are appropriate for all.

Postgraduate supply

- EPSRC’s policy to discontinue the provision of project studentships on its research grants and fellowships, coupled with the squeeze on doctoral training account funding means it will be very difficult to allocate studentships to the small-scale projects which are often the generators of research breakthroughs. The policy will
have an impact on UK PhD student recruitment and will also severely disadvantage the recruitment of high-quality European students.

- Centres for doctoral training have focused studentships in too small a number of research areas and locations, resulting in a landscape that is extremely patchy both geographically and across research fields. Other ways of achieving economies of scale in postgraduate training need to be considered, such as the regional alliances, which offer joint training to graduate students without the concomitant narrowing of the subject base.

- Serious consideration should be given to supporting Masters degrees with state funding, especially in areas that are of national importance such as nuclear physics.

**Industry**

- The Confederation of British Industry has reported that there is growing demand for STEM skills, particularly in the low carbon, and digital media sectors. However, there are issues with employers experiencing some difficulty in hiring staff with the requisite STEM skills, and therefore having to pay a premium for them.

- There is much scope for developing STEM students’ generic ‘workplace’ skills over the course of their degrees and employers can play a positive role by offering summer work placements or internships.

- Positive statements on the importance and sustainability of careers in STEM from senior government ministers in reports and public statements, especially in the current financial climate, must continue to be made to encourage potential students to consider a STEM subject at university. Senior politicians and leaders of business must continue to make statements emphasising the potential jobs in the STEM sectors. This is particularly true in the current financial climate where companies are laying off staff.

**General questions**

**What is the definition of a STEM subject, and a STEM job?**

1. Physics is one of the most highly valued and respected STEM subjects. Since physics deals with the fundamentals of matter and energy as well as being the origin of a great deal of instrumentation, it underpins a wide range of technologies. In addition, the reductionist and mathematical approach of physics provides tools and techniques that underpin other STEM subjects.

2. A ‘physics’ job is one that can be defined as one that requires specialised intellectual, technical and practical skills applied to solve complex problems using quantitative techniques, to develop technical products and services, and assemble and operate highly specialised equipment and facilities. As a result, physics graduates can be found in virtually every sector of the economy, satisfying important national requirements for highly skilled people in many areas, including information technology, financial analysis, engineering, environmental science, energy technology, intellectual property law and medical physics. The IOP considers that a physics graduate employing physics skills in areas such as these has a STEM job.
Do we understand demand for STEM graduates and how this could be used to influence supply?

3. A recently published report by the Science Council has revealed that 20% of the UK’s workforce – 5.8 million people – is dependent upon scientific skills in order to do their jobs, and that this is projected to rise to 7.1 million people by 2030.¹

4. In addition, the Confederation of British Industry (CBI), based on a survey of employers, has reported that there is growing demand for STEM skills, particularly in the low carbon, and digital media sectors, but employers report some difficulty in hiring such staff.² This message has been echoed in the report *Employability Skills Review*,³ published by the National HE STEM Programme⁴, of which the IOP is a partner organisation, where it was stated that:

“The hi-tech, science and IT sectors are all reporting difficulties in recruiting STEM graduates and predicting even greater difficulty in future years. These employers rate STEM graduates highly, not only for their technical competency but also because of the analytical, problem-solving, numeracy and intellectual rigour skills that they bring with them.”

5. One important factor in increasing applications to STEM subjects has been the increased emphasis given to STEM by successive governments, beginning in 2006 with the chancellor’s statements regarding the importance of STEM graduates to the economy. Statements such as these from senior government ministers in reports and public statements, especially in the current financial climate, can only help potential students to consider a STEM subject at university, which will lead to an increased pool of graduate talent which will help satisfy the demands of employers and help to rebuild the economy.

16-18 supply

Are schools and colleges supplying the right numbers of STEM students and do they have the right skills to study STEM first degrees?

6. Physics suffered over many years from a substantial drop in the numbers of A-level students; entries fell by around 40% between 1985 and 2007. However, results published this year, by the Joint Council for Qualifications, showed an increase for the fifth consecutive year in the number of students sitting examinations in physics and, for the first time since 2002, physics is back in the top 10 most popular subjects. The total number of students entered for physics A-level has increased by 6.1%, from 30,976 in 2010 to 32,860 in 2011, which is encouraging in view of the government’s target of 35,000 by 2014. Over the last five years, the number of A-level exams taken across all subjects has risen by 7.7%, but the growth in the number entering for physics is far stronger – a 19.6% increase over the last five years.

7. The encouraging result at A-level is supported by a continued increase in AS-level numbers, with the number of entrants increasing from 45,534 last year to 58,190 this year. The 27.8% increase is partly explained by a change to funding rules for maintained schools in England, but far outstrips the average increase across all subjects of 17.9%.

¹ The current and future UK science workforce; The Science Council; http://www.sciencecouncil.org/content/science-workforce
² Building for growth; business priorities for education and skills; http://www.cbi.org.uk/media/1051530/cbi__edi__education___skills_survey_2011.pdf
³ HE STEM: Employability Skills Review; http://www.hstem.ac.uk/sites/default/files/employability_skills_review.pdf
⁴ The National HE STEM Programme; http://www.hstem.ac.uk/
8. Despite the period when physics suffered a dramatic fall in A-level numbers, entries to UK physics degrees remained reasonably stable over the same period. And, of late, we have noted increases in the number of applications and accepted applicants to physics degrees.

9. However, the most common complaint from HE admissions tutors in physics and engineering subjects is that the entrants' knowledge base is weaker than it used to be. Part of the reason for this is that the students have a broader range of skills than they used to, particularly in the ICT area. But there is a specific problem in the mathematical content of A-level physics. Broadly, in order to allow physics to be a stand-alone A-level, a great deal of the mathematics has been removed. Not only does this make the physics less satisfying, it also means that students do not actually realise the nature of the subject and it certainly means that they are not adequately prepared for university entrance. The IOP strongly recommends that A-level physics be reviewed to allow the subject to be described with the appropriate level of mathematics.

10. This recommendation is strongly supported by the findings of a report commissioned by the IOP from EdComs; *Mind the Gap: Mathematics and the transition from A-levels to physics and engineering degrees*[^5], which gathered the opinions of both physics and engineering academics, and first- and second-year undergraduates in physics, engineering and computer science. The report expressed the views of academics that current mathematics and physics provision at A-level leads to students learning by rote rather than developing their understanding and independence. More than half of the academics surveyed asserted that their first year undergraduates were not very/not at all well prepared to cope with the mathematics content of their degrees and, although only a fifth of the students felt mathematically ill-prepared for their courses, many of the students' comments from interviews acknowledged a gulf between the mathematics they were taught at school and the requirements of their degrees.

11. The report recommended that this situation could be addressed with a number of solutions, including that changes should be made to the A-level structure – both the way in which mathematics is taught at that level, and also to the amount of crossover between mathematics and physics at A-level. Students reported that the approach of teaching mathematics solely in order to pass the A-level exam did not provide them robust knowledge that could be applied to their physics learning.

What have been the effects of earlier government initiatives on the uptake of STEM subjects at advanced level?

12. There have been a number of recent initiatives aimed at increasing the uptake of STEM subjects at A-level, which have been very successful. Amongst these, supported by the Department for Education, are the Further Mathematics Support Programme[^6] (which aims to increase numbers studying mathematics and further mathematics at AS/A-level, and provide training and support to teachers), and the Stimulating Physics Network[^7] (which aims to increase the uptake of A-level physics and to improve the confidence and subject knowledge of non-specialist teachers). The government has also been successful in increasing the numbers of GCSE students taking triple science, which is seen to lead to high levels of progression into science and mathematics A-levels). In addition, recent changes to teacher training recruitment have been very positive; the setting of separate targets for physics, chemistry and biology teachers and the introduction of the new physics with mathematics

PGCE will regain some of the lost ground in the recruitment of physics teachers. An observation here is that government initiatives often work best when carried out with in partnership with an external partner, such as a charity or professional body, which has no commercial interest in the project but usually has a deep professional interest in making it successful.

What effect, if any, will the English Baccalaureate have on the study of STEM subjects in higher education?

13. We are of the view that the English Baccalaureate will have a limited effect of increasing the numbers studying STEM subjects at university, despite the fact that one of its aims is to increase the take up of the individual sciences. Timetabling pressures associated with the qualification may result in fewer pupils having the opportunity to study triple science.

Graduate supply

Is the current number of STEM students and graduates (from the UK, EU and overseas) sufficient to meet the needs of industry, the research base, and other sectors not directly connected with STEM?

14. This is a difficult question to answer. As stated previously, there is great national demand for STEM graduates, and some of the Sector Skills Councils, such as COGENT\(^8\), have reported that employers are experiencing difficulties in attracting, recruiting and retaining high quality STEM skilled graduates.

15. Moreover, we are aware of important sectors, such as nuclear technology, where the UK is facing a critical skills shortage. Many experienced nuclear engineers in the UK are over the age of 50 and thus likely to be retiring within the next decade. All of the engineers involved in the original planning and building of the UK’s nuclear power stations (the first of which opened in the 1950s) have already retired. There is also a strong possibility that expertise will be lost rather than passed on. Therefore, there is a need to ensure that a new generation of nuclear engineers are trained. In addition, the energy supply sector is undergoing change and rapid expansion in many other fields that also require graduate and technical expertise, examples include clean-coal and renewables technologies.

16. Despite departmental closures and falls in the numbers studying A-level physics over previous years, the number of accepted applicants to undergraduate physics, and the number of graduates has remained remarkably steady, against a backdrop of an increase in the overall HE cohort. Numbers of accepted applicants to physics (and astronomy) rose from 3,069 in 2005 to 3,827 in 2010; the latter figures represent 0.8% of the total cohort of accepted applicants; the equivalent figure for 1994 was 1.2%.

17. Over recent years, we have observed increases in the number of applications to physics degrees, which has led to annual increases in the number of accepted applicants. This could be because the message that a physics degree opens doors to a wide range of career paths in both academia and industry is finally filtering through to students, their families and teachers. However, due to the high-costs associated with teaching physics and other STEM subjects, because of the need to provide a practical laboratory-based experience (requiring adequate floor space, consumables and often expensive modern equipment), there will always be a limit on the numbers that can be accepted onto university courses. This is an

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issue that will be exacerbated by the government’s HE reforms, which will favour cheaper subject options in the arts and the humanities, which we discuss later in the response.

Is the quality of STEM graduates emerging from higher education sufficiently high, and if not, why not?

18. With regards to physics graduates, we would like to think that the majority of them are trained to a high level, and indeed, the IOP runs a degree accreditation scheme providing an independent, rigorous and valid assessment of the content and standard of physics degree courses. However, there is the perception that the ‘level’ of STEM graduates in the UK is less than that of other comparable nations in Europe, because their graduates usually study for five years before entering the job market.

Do STEM graduates have the right skills for their next career move, be it research, industry or more broadly within the economy?

19. A survey undertaken by the CBI revealed that some employers have expressed concern that job applicants with STEM qualifications can lack employability skills and do not have much experience in the working environment⁶. But, surveys undertaken by the IOP of the views of employers of physicists suggests that there is strong demand for physics graduates and that employers are of the view that physics degrees provide:

- 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;
- 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’.

What effect will higher education reforms have on the quality of teaching, the quality of degrees and the supply of STEM courses in higher education institutions?

20. The much higher tuition fee inevitably changes the student-teacher relationship. There is likely to be an increasing tendency to view students as ‘customers’ and teaching as a ‘purchased service’. This may not necessarily happen, but one can imagine that the quality and rigour of degrees and the evaluation process will inevitably come under considerable pressure to ensure that the customers remain ‘happy’. Given our current national obsession with league tables these pressures are going to be difficult to resist.

21. In terms of the supply of STEM courses in HEIs, we have a number of concerns. Most HEIs in England that offer provision in science subjects will charge the maximum fees of £9,000 from the 2012/13 academic year. The additional income from HEFCE for Band B subjects, such as the sciences, has been estimated to be around £1,500. Transparent Approach to Costing (TRAC) data demonstrate that the cost differential between science and non-science subjects is currently of the order of £3,000-3,500. As a result, even with the additional HEFCE funding, an HEI accepting a new science student in 2012/13 will suffer a
financial penalty of around £2,000, compared to one accepting a new humanities or social science student that will produce a premium. This is a serious funding shortfall and will remain an acute problem for 2013/14 and beyond. Furthermore, this additional income of £1,500 may be forced down if HEFCE funds have to be re-allocated to cover the costs of higher than expected tuition fees, pushing science departments into the red and making them vulnerable to potential closure. If the government takes the decision to increase neither the fee level nor the additional income from HEFCE’s teaching budget, inflation will erode departmental income, and when coupled with student bursary contributions, etc., this may result in less science being taught in English universities.

22. The HE reforms may also have an adverse impact on uptake for the four-year integrated Masters degrees – the MPhys/MSci – which are now the norm for those considering a career in university or industrial R&D. Financial constraints are certainly a factor in some able students choosing to study a three-year degree, and avoiding the extra year of debt accumulation; this may particularly be the case with women, who we know, for whatever reason, are less likely to study for a fourth year. HEFCE teaching funding provision will need to ensure that STEM departments can continue to afford to offer four-year courses.

23. In addition, the government has stated that 65,000 places are to be made available for students achieving AAB grades or above at A-level or equivalent (here termed AAB+ equivalent), and that initially, 20,000 places will be allocated to HEIs whose average charge is at or below £7,500 (following waivers).

24. The core quotas for HEIs will be lowered according to the existing numbers of students achieving AAB+ equivalent, following which an HEI can freely recruit as many students at this level as it is able to attract and accommodate. With all HEIs competing freely for the students with the highest exam results of above AAB+ equivalent, there is a risk that some may prioritise the recruitment of high-performing students to non-science subjects where the cost of teaching them is less than the income available from tuition fees. We would like more information on how higher cost and strategically important and vulnerable subjects will be treated with regard to AAB+ equivalent students.

25. We also have some questions over the practicalities of unlimited recruitment of the AAB+ equivalent students. For instance, will there be a differentiation between subjects that are more difficult relative to others?9 If not, this could then lead to a decrease in the numbers of students taking science and mathematics subjects at A-level, for which the grading is more severe. A system using unspecified A-level grades makes no sense unless a decision is taken to ensure that all A-levels are of equal grade severity.

26. In addition, as it is understood, the 20,000 places allocated to HEIs whose average charge is at or below £7,500 will be made available by reducing the core quota (i.e. the non-AAB+ equivalent quota). This will benefit HEIs ‘lower down’ in the sector that frequently do not have the capacity to teach laboratory-based science subjects, nor will have the ambition to do so, as fees of £7,500 will not usually be sufficient to teach science subjects. The implication of this policy is that the national provision of science courses could reduce as certain HEIs take on more students in lower cost subjects.

27. HEFCE will need to implement levers to ensure that the provision of science courses is maintained at both the ‘top-end’ and in the middle-ranked HEIs (which will have a critical role to play in achieving the widening participation agenda) that will presumably lose some of their better students to those in higher ranked HEIs. The supposed market among HEIs may result in these middle-ranked HEIs being squeezed to no apparent benefit to anyone.

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9 Relative difficulty of examinations in different subjects (2008); SCORE; http://www.cemcentre.org/attachments(SCORE2008report.pdf
What effect does “research assessment” have upon the ability to develop new and cross-disciplinary STEM degrees?

28. It is difficult to pinpoint what precise impact research assessment will have on the development of such degrees, but we do know that, even though there have been moves to get better recognition for cross-disciplinary subjects within research assessment exercises, this remains a difficult area. A major challenge for STEM subjects is how to accommodate the increasing multidisciplinarity of research while maintaining the essence of the disciplines that make them so valuable. The nature of the RAE/REF sub-panels is to reinforce the rigidity of the discipline, and even within physics, there has been a perception that physics research closer to application has not been given sufficient credit.

29. The IOP, via the National HE STEM Programme\(^4\), has first-hand experience of developing such a degree course. Launched in 2007, *Integrated Sciences*\(^{10}\) is an interdisciplinary sciences degree developed by the IOP with the University of Leicester and London South Bank University, which combines the study of all three of the core sciences. Applications, as expected for a new course, have been modest, but are improving and there are prospects of other UK universities offering the degree course\(^{11}\).

30. Whilst we support and have been intimately involved in developing the Integrated Sciences degree, our view is that while subjects will always be fluid to a certain extent, it is essential that subject-specific degree courses do not to lose their identity, which could otherwise have serious long-term consequences. Broadly, physicists do not think like biologists, who do not think like engineers. None is better but all are necessary in their own right.

What is the relationship between teaching and research? Is it necessary for all universities to teach undergraduates and post graduates and conduct research? What other delivery model should be considered?

31. In STEM subjects, one cannot divorce teaching from research, as a direct connection between the two is essential for the functioning of HE, in terms of space and facilities, financial sustainability, student contact with researchers, academic staff time and workload, and the supply chain of new researchers. Moreover, research directly informs the content and motivation of both undergraduate and postgraduate teaching. It is the presence of this link that makes the UK a top destination for highly able overseas students, and it is precisely this aspect of our education system that emerging economies are struggling to emulate.

32. To sustain this, a more coherent approach to teaching and research in STEM subjects by the research councils and the funding councils is essential, as the teaching of physics, and other STEM subjects, is being, or very likely will be, influenced by research council policies concentrating research in fewer HEIs. This will particularly be the case for smaller departments, for which undertaking research is being made more difficult due to changes in EPSRC policy, such as the decision to remove support for project studentships on its research grants.

\(^{10}\) Integrated Sciences; http://www.iop.org/education/higher_education/stem/integrated_sciences/page_43338.html

\(^{11}\) University of Bradford is now also offering the degree course; http://www.brad.ac.uk/undergraduate/integrated-science-sls/
Does the UK have a sufficient geographical spread of higher education institutions offering STEM courses?

33. There are at present 46 UK universities that have physics departments\textsuperscript{12}, of one form or another, that offer undergraduate provision\textsuperscript{13}. This number has dropped by over 30% since the late 1990s. Despite the loss of many physics departments, through either closure or merger, the number of physics graduates has remained reasonably stable.

34. Due to these closures, there are now large areas where potential students and industry have no convenient access to a local university physics department. As the proportion of students living at home increases, and as industry becomes more dependent upon high-tech knowledge, these regions will suffer from a lack of proximity to university physics. The government, rightly, is keen on increasing the number of women, ethnic minorities, and lower-social classes in STEM. Among these groups there is a greater likelihood of students choosing to live at home. But, if they live in the East Anglia region, for instance, where will they go to study physics, unless they plan to study a degree at the Open University? There is currently no undergraduate provision for physics at the University of East Anglia, and the closest university to their region, Cambridge, would not be a realistic proposition for many.

What is being done and what ought to be done to increase the diversity of STEM graduates in terms of gender, ethnic origin and socio-economic background?

35. More research needs to be carried out into what societal factors influence different groups in making subject choices, and what practical approaches are proven to work at the school level to build a culture where STEM subjects are seen as appropriate for everyone.

36. For some years, the IOP has worked to identify and overcome the barriers to participation in physics for women, people from ethnic minority groups and people from lower socio-economic groups. The IOP’s initiatives include Girls in Physics\textsuperscript{14} to understand why only around 20\% of those taking physics post-16 are female; the Ethnic Diversity\textsuperscript{15} pilot project to explore the practical approaches that will encourage students from diverse ethnic background to choose physics; and the Raising Aspirations in Physics project to work with a school in North East England to investigate how to promote physics to students from lower socio-economic groups.

37. Research has shown that young people are influenced by a complex range of societal factors when deciding what to study. But our understanding is incomplete on how these factors impact on different groups and there is much to be learned about putting this research into practice to understand what can be realistically done within and beyond school level to moderate these factors.

38. The IOP is very experienced working with teachers, and its initial efforts to improve diversity have focused on helping teachers deliver lessons that engage the broadest range of students. The IOP is now moving towards a view that changing schoolchildren’s perception of physics involves impacting on a range of societal factors that go beyond what can be addressed inside a physics classroom. Some of these could perhaps be addressed by examining the culture of the school as a whole and the messages it gives to pupils and their parents. The IOP has begun to explore how this could be achieved, working in partnership with schools.

\textsuperscript{13}In addition, the University of Portsmouth’s Earth and Environmental Sciences department is now offering a BSc (Hons) in applied physics; http://www.port.ac.uk/courses/coursetypes/undergraduate/BScHonsAppliedPhysics/
\textsuperscript{14}Girls in physics, IOP; http://www.iop.org/education/teacher/support/girls_physics/page_41593.html
\textsuperscript{15}Ethnic diversity pilot project, IOP; http://www.iop.org/policy/diversity/initiatives/ethnic/page_42663.html
Postgraduate supply

Is the current training of PhD students sensitive to the range of careers they subsequently undertake?

39. Universities are now well aware of the fact that PhD students need a lot more than just core STEM skills if they are to be successful in the workplace. It is now becoming routine for PhD students to receive extensive training in the transferable skills that are coveted by employers (e.g. business awareness, management, presentation skills, etc.). There is probably still more to do in this regard, and we must not fall into the trap of training PhD students in too narrow a range of subjects.

Are we currently supporting the right number of PhD studentships to maintain the research base and are they of sufficient quality?

40. A recent report published by HEFCE described the characteristics of starters to doctoral degree courses in UK HEIs between 1996-97 and 2009-10\(^{16}\). In physics, the number of full-time PhD starters increased by 96% (from 425 to 835) between 1996/97 and 2009/10 compared to an overall increase of 81% (from 9,990 to 18,075) in all subjects. Of full-time starters in physics in 2009/10, 535 were UK domiciled, 150 EU domiciled (excluding UK), and 155 were domiciled outside the EU.

41. In terms of quality, the UK’s best PhD students are on a par with their counterparts from the UK’s competitor nations. But we are well aware of the general view that UK physics PhD students are well trained in their narrow sub-fields, but can lag behind their counterparts in countries like Germany in their level of maturity and the range of their skills. For instance, the level of mathematical skills is a concern, which appears to be linked right back to school science. Moreover, the length of the UK PhD has traditionally been shorter than in most other EU countries. Some moves towards reducing this difference have been made by the research councils. For instance, EPSRC has supported the provision of collaborative postgraduate teaching and allowed universities to spend their doctoral training grant flexibly to offer longer studentships – typically an extra six months; but the latter has been at the expense of supporting fewer students.

42. A major change that will impact on the future number of trained PhD students in the physical sciences is the decision taken by EPSRC to discontinue the provision of project studentships on its research grants and fellowships from 31 January 2011. The squeeze on EPSRC doctoral training account (DTA) funding and increased targeting of that funding by universities (with encouragement from EPSRC) on large strategic initiatives means it will be very difficult to allocate studentships to the small-scale projects, which are often the generators of research breakthroughs and new ideas. As well as the impact this policy will have on UK PhD students, there is the added concern that the recruitment of high-quality European students will be severely disadvantaged, as project studentships were the principal means of funding such students.

43. Discontinuation of project studentships, at a time of reduced DTA awards, is a major threat, particularly, as we understand that DTA studentships are not costed on an fEC basis, which creates uncertainty relating to the support of students using equipment and facilities that have significant costs; project studentships allowed for the true costs of doing PhD level research to be recognised and properly supported. The EPSRC policy will impact on

\(^{16}\text{HEFCE, PhD Study Trends and profiles 1996-97 to 2009-10; http://www.hefce.ac.uk/pubs/hefce/2011/11_33/}\)
research within the UK, its global reach (via those PhD students going abroad to do postdoctoral research), and on employers.

What impact have Doctoral Training Centres had on the quality and number of PhD students? Are there alternative delivery models?

44. The general perception is that the centres for doctoral training (CDT) have focused studentships in too small a number of research areas and locations, resulting in a landscape that is extremely patchy both geographically and across research fields. CDTs do allow good training in a few highly targeted areas, but many other areas that are key to the UK economy are completely unrepresented. The organic approach adopted by EPSRC does not lend itself to an overarching strategy. There are many centres of excellence around the UK, such as those supported by EPSRC Programme grants, or major funding initiatives such as the Wellcome/EPSRC Medical Engineering Centres, which have no access to CDT funding.

45. The concept of CDTs has merits (e.g. better provision of skills training), which other research councils have adopted and are implementing in sensible ways. For instance, BBSRC is now directing HEIs into consortia with a minimum threshold of funding, to ensure the background for doctoral training is as strong and supportable as possible. EPSRC seems stuck in the mode that it will continue with its model in the face of all subsequent innovations, essentially because EPSRC was the first to do it this way. The model adopted was created to tackle the very specific issue of building up strength at the life sciences interface, but is wholly inappropriate to the support of doctoral training across the whole EPSRC portfolio. This is particularly the case for sub-fields that rely upon small and flexible research teams that work independently and primarily through one-on-one PhD supervision, such as mathematical physics.

46. Despite our issues of concern, the CDTs have shown that it can be more efficient to provide training to PhD students in larger cohorts. This economy of scale is particularly valuable in providing training in generic skills. However, as mentioned, the CDTs also have the less welcome aspect of channelling studentships into a relatively small number of subject areas, squeezing other areas which might be more popular with students. Consequently, it makes sense to find other ways of achieving economies of scale in postgraduate training. Among the most successful ways of achieving this critical mass have been the regional alliances, such as SUPA, SEPNet, MPA, etc., all of which offer joint training to graduate students without the concomitant narrowing of the subject base.

Should state funding be used to promote Masters degrees and is the balance right between the number of Masters degree students and PhD students?

47. In the case of physics, the RCUK Review of UK Physics noted that physics departments provided a small number of stand-alone Masters degrees compared with other STEM disciplines. The reason for this could be explained by the change in funding of Masters degrees by the research councils.

48. The IOP is of the view that state funding should be very much considered for Masters degrees, especially in areas that are of national importance such as nuclear physics. EPSRC stopped funding for all nuclear MSc programmes a few years ago, jeopardising many previously viable courses related to nuclear technology. Currently, there is no funding mechanism to support MSc courses and a solution to this problem needs to be found.

17 RCUK Review of UK Physics; http://www.rcuk.ac.uk/documents/reviews/physics/review.pdf
urgently, particularly in the case of nuclear physics, as there is not a strong industry to finance the courses, but without them, there will be skills shortages in the future.

**What impact will higher education reforms have on the willingness of graduates to pursue a research career?**

49. A challenge will be the long-term effect of the HE reforms on the uptake of STEM subjects at the postgraduate level, in particular, as the increasing burden of debt may have a deterrent effect on those contemplating an academic research career. At present, it is too early to tell and the downturn in the economy has obscured any possible decline but this is an area where it will be necessary to monitor the situation carefully. In addition, as mentioned earlier, the integrated Masters degree is now the preferred route to postgraduate study, and many prospective students may decide against studying the fourth year on financial grounds.

50. In addition, the duration of a PhD course can vary between three and four years and, while studying a PhD may not cause students to accrue much further debt, they do not allow loans to be paid off either. As certain industrial and academic sectors require specific skills and the experience that only PhD study can provide, this may lead to negative repercussions for the research base in the future and on the long-term health of the economy. We are pleased to see that postgraduate funding and support will be addressed in a forthcoming HEFCE consultation exercise, and hope the government will monitor the impact of the new fees regime on the transition from undergraduate to postgraduate study.

**Industry**

**What incentives should industry offer to STEM graduates in order to attract them?**

51. There is much scope for developing STEM students’ generic ‘workplace’ skills over the course of their degrees and employers can play a positive role by offering summer work placements or internships. To support such programmes, the IOP is running a ‘work placements bursary scheme’ to support penultimate-year physics undergraduates who wish to undertake placements in the UK or Ireland. The scheme provides bursaries of up to £2,000 to students over the course of eight-week placements, enabling students from all backgrounds to apply for such positions.

52. In addition, employers have to offer better pay, which certainly has been the case with the financial sector, which has openly recruited the best physics PhD graduates. As mentioned earlier, the CBI has stated that employers are finding it difficult to recruit workers with skills in STEM subjects and therefore have to pay a premium for them.

53. Because the skills developed by studying physics are so well-regarded by employers, physics graduates tend to be better paid than those who do most other subjects. This earnings premium may be a particularly important consideration with the coming increase in university tuition fees, as students increasingly see a degree as an investment for their future and want to extract the best value for money from it.

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18 Work placements scheme; http://www.iop.org/careers/university/placements/index.html
What steps are industry and universities taking together to ensure that demand for STEM graduates matches supply in terms of numbers, skills and quality of graduates?

54. The previously cited report, Employability Skills Review\textsuperscript{3}, published by the National HE STEM Programme, recommended the following steps that industry and universities could take to address such issues:

“Encourage HEIs to explore ways of engaging with employers to develop employability support plans that will help ensure their graduates have the relevant practical skills that are required for the workplace; deliver an enhanced capacity for employer engagement supported by training and a commitment by employers to financially support programmes which provide clear benefit; encourage HEIs to utilise ‘in-house’ careers advice and guidance support resources; and increase HEI awareness of the developing methods of providing both direct and indirect experience of employers, and support their wider adoption across STEM.”

55. We are of the view that there is little hard evidence about what skills employers need. Much of what they state is anecdotal and parochial, and there is a danger of making HE too narrow in its provision. Enlightened employers realise that generic skills and flexibility are the prime virtues of HE training and that specialised training is their responsibility.

56. An issue for both sectors, but particularly universities, is the difficulty in recruiting technical staff\textsuperscript{19}. Most universities have discontinued apprentice schemes and there is no financial incentive (primarily because technicians do not attract fEC income) or willingness from the universities to make a long-term career commitment to technical staff. Many research groups have technicians over the age of 50 who were the last participants on university technician apprentice schemes. There is no next-generation being trained to replace such people, and a similar situation has arisen in terms of laboratory assistants in schools.

**International comparisons**

What lessons can be learnt from the provision of higher education in STEM subjects in other countries? Which countries provide the most helpful examples of best practice?

57. An issue that has never been properly addressed in the UK is the Bologna Process for the reform of HE in Europe. Across much of the rest of Europe, this reform has led to major structural change in HE. One area where the UK is out of line with the process is in the route to a PhD where, across most our European competitors, the 3+2+3 model has been adopted. Anecdotally, we are aware of issues where UK trained graduates have experienced difficulties seeking overseas employment and postgraduate opportunities, due to the fact they are perceived to be less well qualified than their European peers.

58. The Quality Assurance Agency has asserted that the UK system is consistent with the Bologna model\textsuperscript{20}, so there will be no pressure from government or the funding councils for universities to change their systems. However, there have already been cases of UK

\textsuperscript{19} More information on this issue can be found in the following report which the IOP was involved in: Technicians under the microscope; A study of the skills and training of university laboratory and engineering workshop technicians; http://www.gatsby.org.uk/~/media/Files/Education/6%20Paul%20Lewis%20report%20on%20HE%20technicians%20April%202011.ashx

\textsuperscript{20} The Bologna Process in higher education; http://www.qaa.ac.uk/Publications/InformationAndGuidance/Documents/BolognaLeaflet.pdf
graduates with four-year integrated Masters qualifications, such as the MPhys, not being accepted for a PhD in another European country and there is an increasing number of UK academic positions being taken by scientists who have not been educated in the UK. Potentially, this situation could lead to serious problems in the future by which time it may be too late to act.
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IOP Institute of Physics
76 Portland Place
London W1B 1NT

Tel: +44 (0) 20 7470 4800
Fax: +44 (0) 20 7470 4848
Email: physics@iop.org
Website: www.iop.org
Registered Charity No. 293851