

A degree of concern? UK first degrees in science, technology and mathematics

A report on phase I of a project considering the future supply and demand for science, technology and mathematics graduates

Summary

This note summarises a full report¹ setting out the background information and initial findings of a project to explore the background to the widespread concerns over the supply of skilled people needed to maintain the UK as a leading knowledge economy. Phase I of the project concentrates on science, technology and mathematics (STM) first degree courses in the UK. The report is designed to underpin a wider study of the fitness for purpose of UK STM Higher Education (HE) into the middle of the next decade and beyond, and includes a wide range of data on STM A-levels, STM first degree courses and the first destination of STM graduates.

The report, based on a detailed analysis of relevant statistics, draws attention to:

- the need to place UK developments in an European and global context, including the contributions that both students and staff from overseas make to UK HE;
- the importance of a high degree of flexibility throughout the education system;
- the importance of looking in detail at individual disciplines, not just broader subject groupings;
- the mostly downward trends in numbers taking STM A-levels and undergraduate degrees;
- our re-analysis of the Higher Education Statistical Agency (HESA) data, which has shown that the recent apparent large rise in first degree graduates in mathematics and biology is essentially a misleading reflection of changes to the way students on joint courses are attributed to subjects and how subjects are classified;
- the lack of fluency in basic mathematical skills shown by many entrants to undergraduate courses;
- the significant premium placed on STM graduate skills by employers.

Our analysis has identified a number of issues concerning first degree STM courses including: the need to take account of changes to the 14-19 curriculum; the balance between depth and breadth in first degree courses; the place of four year integrated masters courses in some STM disciplines; and the need to be closely involved with and influence related developments in Europe including the Bologna process, to ensure that the UK HE system remains world class into the next decade and beyond. Further work will be required to provide a more comprehensive look at HE up to PhD, and we shall be taking this forward within phase II of this project.

While any attempt at estimating the total number of graduates with particular skills is fraught with obvious difficulties, we can be confident that the development of the UK as a major knowledge-based economy will require:

- an excellent and vibrant university research base, with a wide spread of subjects;
- a sustained supply of STM professionals, including school and college teachers, university faculty, researchers and technicians, with appropriate skills, knowledge and experience;
- a good mix of discipline backgrounds, crucially including science and engineering, within the general graduate workforce.

Royal Society policy document 32/06

October 2006

ISBN-13: 978-0-85403-634-9
ISBN-10: 0 85403 634 2

This report can be found at www.royalsoc.ac.uk

¹ A degree of concern? UK first degrees in science, technology and mathematics, Royal Society October 2006; a pdf version is available at www.royalsoc.ac.uk/policy.

The post-16/HE interface

A-levels and, for Scottish school students, Highers and Advanced Highers, are currently the most common route into STM subjects at HE level. We have identified some concerns about trends in the number of students with suitable qualifications for first degree STM courses and the potential for mismatch between the prior knowledge expected from entrants and the actual knowledge of school- and college-leavers.

Trends in A-level entries and combinations of subjects

The number of A-level entries in the UK grew by 10% between 1992 and 2006, from 731,000 to 806,000. Within this context of increasing overall numbers there have been decreases of 6% in the number of entries to chemistry (from 43,000 to 40,000); 34% in physics (from 41,000 to 27,000); and 13% in mathematics and further mathematics (from 72,000 to 63,000) with the decrease occurring mainly in mathematics rather than further mathematics. Entries to biology A-level have fluctuated but increased 13% overall during this period (49,000 to 55,000). Entries to science and mathematics Highers have fallen over the same period, although the fall in mathematics appears less marked than for A-levels.

There are two particular concerns surrounding the potential pool of first degree undergraduates:

- Since entry to medicine, dentistry and veterinary sciences courses is highly competitive, often requiring three A-grades at A-level, these subjects take a high proportion of the students achieving the top grade in A-level/Advanced Higher chemistry and biology. Medical school places have been expanding rapidly – up 70% between 1997 and 2004 – during a period when numbers of entrants to chemistry A-levels have decreased. The combination of these two trends puts real pressure on the pool of good students who could take first degrees in chemistry.
- The number of students taking A-level mathematics is a limiting factor for any increase in the physical sciences and engineering at first degree level.

Students are studying an increasingly diverse range of subject combinations at AS and A-level. Traditional three and four subject combinations of science and maths A-levels have fallen substantially between 2001 and 2003. Whilst the increased breadth of knowledge that stems from studying more subjects post-16 is valuable, for many first degree STM courses particular combinations of A-level subjects remain important. Students aiming for particular courses in HE must therefore have access to appropriate advice about the implications of their choices of A-levels for entry to those courses.

Bridging the mathematics gap: 16-19 to HE

We are concerned about the gap between school or college level study and HE. The mismatch between students' mathematical skills when they enter HE and the demands of STM first degrees appears to be a particularly acute problem. There are two main issues:

- lack of fluency in basic mathematical skills such as basic algebra and the properties of logarithmic, exponential and trigonometric functions; and
- the fact that A-level syllabuses now exclude topics relevant to certain first degree courses that were previously covered.

Of these, the first is of fundamental importance and requires urgent investigation since, even if treated with special courses in the first year in HE, it severely reduces the confidence and motivation of students over the theoretical parts of the undergraduate curriculum in a wide range of subjects. It is also clear that any action taken to improve the basic mathematical or other skills of new undergraduates takes time that would otherwise have been spent on other parts of the first degree curriculum.

The second issue could become an increasing problem if the 14-19 curriculum is broadened, and needs to be accommodated by the HE curriculum adapting to reflect changes in the 14-19 curriculum. In parallel with this, it is important for the HE community to be clear about the skills, knowledge and experience it seeks in new undergraduates and to continue to be involved, alongside other stakeholders, in shaping the future development of 14-19 education. The Society, with the Advisory Committee on Mathematics Education (ACME), is currently engaging with the Qualifications and Curriculum Agency and science and mathematics education stakeholders, including those from HE and employment, on the ongoing development of new 14-19 curricula and qualifications that will suit the learning needs of young people.

First degrees: students and courses

Consistent data on graduate numbers

Trends in undergraduate participation in STM subjects are complicated; there are no simple headlines. Increasing overall participation in HE, year on year fluctuations in student numbers, changes in subject classifications and student categorisation, and the need to look at the trends in individual subjects not just subject categories all add to the complexity of the situation.

Most analyses of trends in student and graduate numbers are based on data published by HESA in its annual *Students in HE institutions* volumes from 1994 onwards. Several factors make comparison of the data published by HESA difficult. In particular, there were major changes to the way in which students were counted and classified from 2002/03 onwards.

The Society and the Office of Science and Innovation jointly commissioned HESA to produce data on a consistent basis for the whole period 1994/95 to 2004/05, to offset in particular the discontinuities introduced in 2002/03. From these new data, it is clear that the apparent large rise in student numbers in mathematics and to a lesser extent biology is actually just a consequence of the change in the way that HESA has classified students on joint courses and education (initial teacher training) courses since 2002/03.

STM first degrees within the first degree sector

An increasing proportion of all first degrees are being awarded in the sciences broadly interpreted – up from 31% in 1994/95 to 37% in 2004/05. Much of this increase is attributable to the categories of computer science (up from 3.7% of all degrees in 1994/95 to 6.3% in 2004/05, but now decreasing) and subjects allied to medicine (up from 4.9% to 9.8%).

There has also been marked growth in biological sciences (5.7% to 9.5%), but, within this, psychology increased from 33% to 47% of the subject category and sports science from under 10% to 19%. Indeed, biology students now account for only 17% of the biological sciences category, down from 31% in 1994/95. Similarly, the drop in the physical sciences category from 6.2% to 4.4% of all first degrees has been accompanied by a drop in chemistry from 29% to 21% of the subject category and an increase in forensic & archaeological science from 2% to 8%. These examples highlight the importance of looking both at the broad subject categories and in more detail at individual disciplines. They also illustrate the changing nature of student choices at undergraduate level.

International dimension

The total number of first degrees awarded to UK-domiciled students grew from 220,000 in 1994/95 to 270,000 in 2004/05, an increase of 23%. However, the student body is becoming increasingly internationalised, and numbers of students domiciled outside the UK, and especially outside the EU, are increasing even more rapidly. Of the 238,000 first degree graduates in all subjects in 1994/95, 92.5% were UK-domiciled, 3.1% were domiciled elsewhere in the EU and 4.4% were of non-EU domicile. In 2004/05, there were 306,000 first degree graduates, with 88.2% UK-domiciled, 4.5% domiciled elsewhere in the EU and 7.3% of non-EU domicile. In biology, chemistry, physics and maths, however, the proportion of first degree graduates who are UK-domiciled is higher than these averages.

At postgraduate level, too, the student body is becoming increasingly internationalised. The percentage of masters degrees awarded to UK-domiciled students decreased from 68% in 1994/95 to 48% in 2004/05, and the percentage of PhDs decreased from 67% to 61%, although the absolute numbers of UK-domiciled students continue to increase. These trends are important for the future development of HE and the employment market in the UK.

Within the European Union, the Bologna process is working towards developing a coherent European HE space to foster employability and mobility in Europe and to increase the competitiveness of European HE. A key aspect of the process is the harmonisation of European HE systems, including the length of study required for different qualifications – notably at masters level. There is a risk that the UK's minimalist approach to Bologna could cost competitive advantage in relation to other EU Member States, for example in attracting the best students from throughout the EU. The UK should use its current chairmanship (until May 2007) of the Bologna discussions to stimulate HE institutions to become more engaged.

Demand for graduates and the purpose of first degrees

First destinations of STM graduates

In 2003/04, 33% of physics graduates, 34% of chemistry graduates, 24% of mathematics graduates and 23% of biology graduates were participating in full time further study or training six months after graduation, compared with 15% of engineering & technology graduates and an average of 16% for all graduates. The proportion of STM graduates entering employment within six months of completing their courses remained relatively unchanged between 1994/95 and 2003/04, ranging from about 40% for physics to 70% for computer science. The reworked HESA data show that fewer first degree STM graduates are entering the 'manufacturing R&D' industrial sector than was thought at the time of the 2002 Roberts report *SET for success*.

These first destinations statistics are a snapshot six months after graduation, which has limited value as an indicator of long-term career patterns. We welcome HESA's plans to complement their annual first destinations surveys with longitudinal follow-up surveys on a sample basis at three and a half years after graduation.

Demand for STM graduates

The importance of having an adequate supply of skilled scientists for professional functions and for general functions throughout the economy has been mentioned already. So, too, has the difficulty of estimating from these requirements the optimum numbers of students studying STM subjects at A level and undergraduate level. Rather than seeking detailed quantitative predictions, policy-makers should focus on ensuring that HE courses at all levels are satisfactory as a start to life-long learning, and that they equip their graduates with the flexibility to change directions as required.

It is important that any changes to the HE system should retain this degree of flexibility for both graduates and employers. It is also important that the quality of STM first degree courses is maintained at the highest possible level both to meet the future requirements of employers and to attract the best students from within and beyond the UK.

What should a first degree prepare students for?

Graduates from STM first degrees enter a wide range of occupations, some of which will directly use the technical knowledge gained through their degrees and some of which will draw mainly on wider skills. While this report is mainly concerned with STM first degrees as a preparation for a professional STM career, where the chosen discipline should be taken as far as possible within such courses, it is highly desirable that science and maths graduates should also enter other areas of the economy. Indeed, STM first degrees are seen by employers as a valuable preparation for a wide range of other careers.

It is widely recognised that there can be tensions between first degrees as specialist training and first degrees as generalist education. First degrees in STM should be able to serve both of these aims, especially since many undergraduates are still uncertain about their future career plans, and many graduates who successfully pursue other careers benefit from the high level of practical, analytical, mathematical and modelling skills that STM first degrees develop. But some undergraduates might find special 'practical-light' options in the final year of value, where other modules could be taken in place of a project or some of the practical work.

Such changes would have impacts beyond first degree courses. There would be a need to develop routes to postgraduate study, perhaps through specialist masters courses, for those who after taking a more general science course wished to pursue scientific research or a more specialised STM career. There would also be associated implications for the total length of time that such a student would take to reach doctorate level.

Future developments

Our report is intended to provide a reliable foundation for further work on aspects of HE policy and we hope that those concerned about HE from whatever perspective will find it of value. The analysis has highlighted a number of unresolved issues that demand attention from those concerned with the future of STM in the UK. We will be addressing some of these in a successor project, *Science HE 2015 and beyond*, which is considering whether the overall STM HE provision in the UK will be fit for purpose by the second half of the next decade. Key issues here will include: the nature of the benefits that students acquire from studying an STM subject at HE level; current discipline boundaries and whether a general science first degree option could be appropriate; the increasing number of students who choose to study later in their lives; the financial impact upon students who undertake HE study; the significance of the Bologna process; and the impact on the UK of international flows of students and STM professionals.

Higher Education Working Group and Secretariat

Chair:

Professor Judith AK Howard CBE FRS, Head of Department of Chemistry, University of Durham

Working group:

Dr Kathy Barrett, Higher Education Careers Adviser, UCL Careers Service (part of The Careers Group) & Honorary Senior Research Fellow, Department of Anatomy & Developmental Biology, University College London

Professor Amanda Chetwynd, Pro-Vice-Chancellor, Lancaster University

Professor Patrick Dowling CBE FREng FRS, Chair, Royal Society Education Committee

Professor Laurence Eaves CBE FRS, Professor of Physics, University of Nottingham

Professor Alexander Halliday FRS, Professor of Geochemistry, Oxford University

Professor Edgar Jenkins, Emeritus Professor of Science Education Policy, University of Leeds

Mr Geoff Mason, Senior Research Fellow, National Institute of Economic and Social Research

Dr Andy T Merritt, Global Director of Outsourcing and Molecular Tools, GlaxoSmithKline R&D

Mr Philip Ruffles CBE FREng FRS, Former Director Engineering & Technology, Rolls Royce

Dr John Spicer, Reader, Marine Biology and Ecology Research Centre, University of Plymouth

Professor Joan Stringer CBE, Principal & Vice Chancellor, Napier University

Professor John Wood FREng, Chief Executive, CCLRC Rutherford Appleton Laboratory

Secretariat:

Ms Sara Al-Bader (to October 2005)

Ms Sarah Revell

Dr Keith Root

Ms Alice Sharp Pierson (from January 2006)