The Royal Society of Chemistry

House of Commons Science & Technology Committee
Inquiry into 'Strategic science provision in English universities'

Written evidence from the Royal Society of Chemistry

Executive Summary

The importance of science

- UK chemical science provision is at a critical point in its history.
- Chemistry and its practical applications are is the key to understanding the natural world and to economic and social development, health care and environmental improvement.
- Chemistry is also the key to future scientific developments in areas such as novel energy sources, new materials, nanotechnology, conservation of natural resources and new medicines.
- Industries based on the application of chemistry make a huge contribution to national wealth of over £5bn/year to the balance of payments, £5bn/year to taxation and provide over 250,000 highly skilled jobs in the high technology sectors of the economy.

The need for action

- The current numbers applying to study chemical science courses in universities are around the long-term average of 3000/year and reflect the continuing popularity of the subject.
- Inadequate support for teaching chemistry has led to the cost-driven closure of a number of University Chemistry Departments without regard for regional and national needs.
- If allowed to continue the national and local infrastructure will be irretrievably damaged due to short-term, cash-flow driven decisions forced upon many Vice-Chancellors to focus on low cost subjects.
- A clear national and regional strategy for research and education in chemistry is essential for the success of the Government's 10-year Science and Innovation Plan, the development of new businesses and employment, and the sustenance of our industrial base.

The failure of the current funding formulae

- The current funding formula applied by HEFCE is at the heart of the problem.
- Figures from HEFCE show that funding provided for teaching chemistry, an expensive laboratory based does not meet the costs incurred.
- The QR funding for a moderately sized chemistry department rated 5* would be over £1M higher than a department rated 4 – yet teaching is required in both institutions.
- Preliminary data from an RSC study into the costs of chemistry departments indicate that the majority are operating at substantial deficits of up to 60% of gross income. Precious research funds are being used to subsidise teaching.

Increasing access to HE

- We support the Government's 'Access Agenda' to increase participation in Higher Education.
- Science & engineering are a key part of providing the diversity of subject provision that responds to student choice and employer needs.

- Without course provision in centres of international and national excellence distributed geographically to provide access to students, many potential entrants to HE will be denied places or be forced to study courses which are neither their first choice nor area of talent.

The economic evidence

- The RSC supports the Government in striving towards a high added value economy with the well paid jobs that this will bring.
- The value to the individual of completing a degree is £129,000 more that non-graduates with similar backgrounds which translates into a 12.1% annual rate of return over a life-time of earnings. The rate of return for chemistry graduates is higher 25% higher.
- It follows that fully funding science courses will lead to considerable additional returns to the state and the individual. Considering only the short-term cash costs neglects the long-term cash and other economic gains for the Government and society.

Working together

- Well-informed sources have told the RSC to expect further closures of science departments even before HEFCE gives its advice to the Secretary of State on the need to support strategic subjects in 2006. A broader-based HEFCE review of the funding of teaching will not be available before 2008. Long-term regional and national damage to our chemistry infrastructure, the appearance of regional 'chemistry deserts', will result during this time if nothing is done immediately.
- The RSC is willing to work with Government to develop a considered and structured national and regional approach for chemistry.
- Meantime in the next 3 years, £300 million is needed to preserve our current science infrastructure.
- Action is needed now.

Introduction

Chemistry is a premier intellectual pursuit that makes a distinctive contribution to knowledge and to culture. It is the key to understanding the natural world and to economic and social development, health care and environmental improvement. Through a study of chemistry we are educating the leading citizens of tomorrow as well as providing the skills for a subset of them to become future practitioners. Chemistry stands on its own merit in the university curriculum, and underpins many other science disciplines, as well as being vital to the country. A high quality education in chemistry may be expensive relative to some other disciplines, but the economic returns from chemistry graduates more than exceeds the increased cost to the state of the initial education. The cost of provision of university chemistry education is an investment in the true sense of the word.

Chemistry is key for future scientific developments. The human genome has now been sequenced using techniques developed by chemists and we are now just beginning to realise that genomic information, controlled by subtle and complex molecular processes, is stored, expressed and utilised in ways that are barely understood. Thus it will continue to be advances in understanding how molecular processes control fundamental cellular pathways that will lead to, for example, new medicines that will treat and cure many diseases. Chemical sciences will be at the forefront in translating this priceless information into an understanding of the molecular mechanisms that regulate complex biological pathways. Similarly, better understanding of natural phenomena coupled with novel synthetic procedures will improve our environment, conserve precious natural resources and help generate new energy sources. Advanced materials and new insights into molecular processes will stimulate commercial exploitation of new technologies, including nanotechnologies, with significant savings in energy, consumables and side products.

The RSC welcomes the Select Committee's request for written evidence and the opportunity to present our serious concerns about science teaching and research, particularly in the chemical sciences, in English universities. Our concerns remain those set out in our submission to the recent Comprehensive Spending Review [CSR] and are reproduced in Appendix 1. When the outcome from that exercise was published, we believed that the Government had accepted our points and that urgent action would follow. The CSR promised that science and innovation would have priority:

- it promised more money for science and education, and accepted the urgent need to secure the future of UK university science and technology;
- it provided foundations from which the UK could meet the global challenges and proposed plans to secure the scientific building blocks, including chemical sciences.

Six months on, whilst the RSC welcomes the recent announcement that research councils will pay 80 percent of the full economic cost of projects, we are still waiting for the promised help for strategically important subjects. It appears that there will be no genuinely new money until at least 2008: this will be too late.

In our submission to the CSR we set out why the UK needs a strong base in chemical sciences:

- chemical sciences provide the core expertise for scientific, technological development, and are key to underpinning industrial sectors;
- the chemical and pharmaceutical industries are one of the UK's largest manufacturing sectors;
- together, chemical and pharmaceutical industries contribute £5bn to the balance of payments, £5bn tax revenue each year and provide over 250,000 jobs in the high tech sector;
- chemical sciences are a vital component of a vast variety of downstream businesses such as the food industry, consumer products, energy, mining, high technology and protecting the environment.

Neither England, nor the UK as a whole, can afford to lose more teaching or research capacity if it is to have a viable long-term chemical sciences component in its innovation plans, or to have sustainable activities in related areas such as biological sciences, the food industry, energy and the environment.

The timing of this inquiry is especially important as the Government seeks to establish its Science and Innovation Investment Framework against an apparent accelerating pattern of university science department closures.

The UK produces about 3000 graduate chemists annually - around the long term average - of which about 80% are from English universities. As the 2002 "SET for Success" report[1] states:

> "..*graduates and postgraduates in these strongly numerical subjects* [including chemistry] *are in increasing demand in the economy - to work in R&D, but also to work in other sectors (such as financial services or ICT) where there is a strong demand for their skills. Many areas of biological science research increasingly rely on the supply of these skills*."

However, since the publication of the Science and Innovation Investment Framework in July, another two universities have announced that they are to stop teaching chemistry (Exeter University and Anglia Polytechnic University), with the loss of the Exeter degree course alone potentially resulting in a 2% cut in the annual number of places for chemistry undergraduates. This rate of loss leads us to the conclusion that unless action is taken now, the success of the Government's Science and Innovation agenda will be seriously undermined. It also calls into question the Funding Councils' and universities' commitment to the implementation of the Investment Framework, particularly when the reason behind these closures was not lack of student demand for places, but short-term financial pressures within the individual universities. The RSC was disappointed that it took until December 2004 for the Government to ask HEFCE to review the provision of strategic subjects across Higher Education. The RSC is now pressing for an accurate, speedy review, resulting in strategy development and its urgent implementation and will help in anyway possible.

Action is needed now before the UK loses its leading position in research and teaching in science. The RSC:

- asserts that the UK needs a long-term strategy for provision of science and technology in universities so that it can at least maintain current capacity to meet national and regional skills capability, and research and innovation needs;
- reiterates the urgent need for investment of £300m to secure the short-term viability of science teaching and research in universities;
- considers that regional accessibility and diversity of science courses must be explicitly accommodated as part of the overall contribution to meeting the wider UK needs.

These actions are particularly pressing because:

- a strong university science base is essential for the success of the Science and Innovation Investment Framework and to make the UK the partner of choice for investment in R&D;
- if SET teaching and research in universities is to be sustainable, they cannot be run on short-term business models – they must be developed strategically to provide the necessary longer term capacity for training and research;
- SET needs new money now. The "new" money cannot merely be a redistribution of existing funds – these are already insufficient – but must be a strategic deployment to underpin national research capacity and guarantee the facilities needed to educate the UK's future scientists;
- the UK continues to suffer delays in the effective implementation of the Comprehensive Spending Review/Science and Innovation Investment Framework. These delays are forcing universities to close departments of strategic UK importance.

The RSC respects the autonomy of the universities. However, we believe that the recent decisions to close departments are "fire fighting" by Vice-Chancellors in a bid to meet their short-term financial targets rather than a considered structured approach to ensure longer-term viability for science within the university structure. Our evidence shows that recent decisions to close university chemistry departments have not been based on reduced student demand. Indeed, the overall application figures for chemistry 2004 show an increase of 6.5% in the numbers of students applying to study at the undergraduate level. Student demand for chemistry at Kings College London; Queen Mary, University of London; and Exeter University, where recent closures have been announced, were buoyant and still the decisions to close were made.

There is no dispute that teaching and research in chemical sciences are more expensive than some other subjects. Student numbers are limited by access to available laboratory space, and laboratories can only be

[1] "*SET for Success: the supply of people with science, technology, engineering and mathematical skills*", the report of Sir Gareth Roberts' Review, Department of Trade and Industry, April 2002

used for practical work. The real costs of science provision are simply not accounted for in current HEFCE funding models and this is a very serious issue. HEFCE recognises that within its funding model the allocation for teaching does not provide sufficient monies to cover the full costs for teaching laboratory-based subjects such as the chemical sciences. In fact, HEFCE undertook a major consultation exercise to explore how the funding model might be changed to reflect better the real costs of teaching chemistry during 2003. The proposed changes were rejected by the HEFCE Board because of the impact that redistribution of funds would have on other subjects. Instead HEFCE did agree to a review of the full cost of teaching but this is unlikely to report before 2008, but clearly severe damage will be done in the meantime.

The RSC is currently undertaking its own study to establish income and expenditure on chemistry in universities. Data supplied to the RSC in confidence indicate that the majority of chemistry departments are operating at substantial deficits. The pilot phase of the study identified deficits of between 24 and 60 percent of gross income. The RSC hopes that when the study is complete the income and expenditure data will go some way to quantify the deficit that chemical sciences within UK universities face.

The Research Assessment Exercise has seriously affected longer-term science provision. Despite only focusing on research activities, the RAE continues to be seen as "the only game in town" by many Vice-Chancellors when assessing the credibility and quality of academic units regardless of student numbers or quality of teaching (*eg* Chemistry at University of Wales, Swansea). The outcome following the RAE 2001 was disastrous for those departments graded 4 or below in England and Wales. Managing the financial consequences has led Vice-Chancellors to redeploy funds from grade 4 departments to "reward" their more highly graded activities. This approach appears to be a major component of planning exercises currently under way to position institutions ahead of the RAE in 2008. Universities are looking at a limited pot of government money designed - but which fails - to meet the demands of a strong portfolio of academic research. Coupled with the high costs of running adequate laboratory facilities, a grade 4 or below physical science department is highly problematic for universities when there are other departments which are cheaper to run that are also making demands on limited resources.

The RSC is also becoming increasingly concerned that while financial worries are used to justify individual closures, there appears to be a growing culture amongst universities of not allowing a grade 4 or below science department to remain for reasons of overall academic credibility. And this is despite the fact that a research grade of 4 reflects national excellence in virtually all of the research activity submitted, and some evidence of international excellence.

The RSC, in partnership with the Institute of Physics [IoP], has commissioned an independent report from PricewaterhouseCoopers on the economic returns to both the individual and to the state from studying various degree subjects. The full report is included in Appendix 2. The report shows that, in today's terms, the value to the individual of completing a degree is £129,000 more that non-graduates with similar backgrounds which translates into a 12.1% annual rate of return over a life-time of earnings. The rate of return for chemistry graduates is higher at 15.0%; as is the case for physics (14.9%) and engineering (15.5%). The rate of return [based upon increased tax revenues] to the State for the investment in providing these courses is 12.1% for chemistry graduates; 13.0%; for physics, and 13.1% for engineering. Therefore, directed allocation of increased resources to science courses would lead to increased returns to the state and the individual: consideration only of the short-term cash cost neglects the long-term gains that the Government will receive and the future economic needs. For the first time there is clear evidence of the economic benefits from studying science and engineering in HE: while the short term cash costs are high the overall cash return to the individual and to the state more than repay the initial investment. This evidence must be used to guide how Government and the Funding Councils allocate resources.

Despite some additional monies, even the Government has acknowledged that it is still not fully supporting the science it already has underway[2]. More worryingly, it has taken almost six months following the publication of the settlement for the Department of Education and Skills to task the Funding Councils to address strategic science provision in universities. In the summer there was not the luxury of time for review and debate when the science and innovation framework was first published. But the recent spate of closures shows that the area is in even worse health now. We look to Government and HECFE to work with us to promote science in a co-ordinated and effective way.

[2] *"Science and innovation investment framework 2004 – 2014",* HM Treasury, July 2004

The impact of HEFCE's research funding formulae, as applied to Research Assessment Exercise ratings, on the financial viability of university science departments

The RSC appreciates that the HEFCE funding formula for teaching and QR funds is used to calculate each individual university's block grant, and that these are distributed to universities for them to spend as they see fit in order to fulfil their various missions. However, the monies made available for QR funding are inadequate especially given that funds distributed through the research councils have significantly increased in the last few years. Whilst the introduction of the full economic cost model for research will provide more research funds, QR money should allow institutions to invest money strategically and to support the development of young staff. Currently it does not.

It is increasingly the case that the HEFCE funding formula affects the way in which individual universities distribute monies to individual departments. Many Vice-Chancellors feel that they are under pressure from their staff to follow HEFCE's lead in respect of subject weightings and use these in their internal financial models. Consequently, subjects which are under funded in the institutional block grant have inadequate funds passed to them through university systems.

The weighting used for different RAE grades are well known but it is worth reflecting on the impact that these grades have on individual departments. In England, 3a and 3b rated units of assessment no longer receive any QR funds, and 4-rated departments receive considerably less funding than they did following the 1996 RAE. The two reasons for this are the increasing proportion of units of assessments rated 5 and 5*, and changes in the grade weighting to give more funds to higher rated units of assessment.

To look at some typical figures: a 4-rated chemistry department with 25 category A staff might receive QR funding of £450,000. The same size department rated 5 or 5* would receive £1,255,500 or £1,512,900 respectively. In other words QR funding of £18,000 per academic member of staff might be earned in a 4-rated chemistry department in contrast to £60,516 in a 5* rated department (similar figures were used by Exeter University in contrasting the QR monies earned by Biological and Chemical Sciences with Physics). Or put another way, for a moderate sized chemistry department the difference between a 4-grade and a 5*-grade is over £1M in QR income.

The impact of QR funding on the viability of science departments cannot, however, be looked at separately from teaching funding. Chemistry is significantly under funded by the subject weighting applied to teaching (and research). In consequence, income lost by obtaining a 4 research rating serves further to worsen the deficit from teaching and tempts Vice-Chancellors to cut their losses through closure. In the current climate, every 4-rated chemistry department must be regarded as vulnerable.

The RSC knows that a number of science departments use research funds to subsidise their teaching activities and believes that the introduction of TRAC could exacerbate financial problems in under resourced science departments.

Even Departments which are apparently financially healthy are under pressure from management to increase the number of overseas students, since the fees paid by these students are much higher and compensate for under-funding of home students.

A HEFCE consultation in 2003[3] looked at the funding method for allocating teaching funds. As part of the supporting data for that consultation, HEFCE reported that the money universities spend on chemistry is 37% per student more than pharmacy, 19% more than the biosciences, 17% more than earth and environmental sciences and 12% more than with engineering, to take four examples, yet all are in the same band and therefore funded equally through the HEFCE funding formula. HEFCE proposed that more expensive band B subjects, including chemistry, should be allocated more funds in the funding formula than those that are less expensive. In the event the proposal was not implemented but rather a fundamental review of the cost of teaching was called for and this is unlikely to report before 2008.

[3] Developing the funding method for teaching from 2004-05

The HEFCE data call into question the practice of funding according to a small number of very broad bands. A more granular approach would, within the same overall cost, more closely match subject income to expenditure, reducing the under funding (or, indeed, in some cases over funding) of subjects. The ability, and willingness, of universities to provide teaching in a particular discipline would not be dependent on cross subsidy from other subject areas.

The desirability of increasing the concentration of research in a small number of university departments, and the consequences of such a trend

Concentration of research in a small number of universities is likely to have a number of undesirable consequences:

- Further reduction in HEFCE funding to 4-rated departments in order to fund higher rated departments is likely to lead to the closure of both the teaching and research functions. Closure of teaching and research in chemistry at Kings College, London; Queen Mary, University of London; University of Wales, Swansea; and University of Exeter, was essentially due to financial pressures from their research ratings;
- Closures of teaching will lead to a net reduction in the number of places available to study chemistry at undergraduate level. It is unlikely that a smaller number of universities would have sufficient laboratory space and other facilities to make up for the loss in capacity, and there would be strong resistance to new buildings. A chemistry department that is closed and staff dispersed is unlikely to be reopened: the capacity is lost for ever;
- Closure of provision could lead to 'regional deserts' which will affect the ability of students to study chemistry locally. In particular the closure of chemistry at Queen Mary, University of London affected members of ethnic minorities groups who by tradition live at home and study at their local university. These individuals are now unlikely to study chemistry but will probably find another subject at Queen Mary. In an era of increased student debt, the financial attraction of living at home will be strong for many students and their subsequent choice of subject will be determined by what is on offer at their local university.

The RSC fully accepts that to compete on the world stage in research requires expensive equipment and infrastructure which means that there must be selectivity in funding research. However, research selectivity must not be the sole driver for undergraduate teaching policy.

The implications for university science teaching of changes in the weightings given to science subjects in the teaching funding formula

The detail on this point has been given above. The RSC believes that science and engineering teaching in universities is under funded in general and that subjects such as chemistry are more under funded than some others. Even if HEFCE's 2003 proposals on a differential band B had been implemented, although the position of chemistry would have improved relative to other subjects, chemistry would still have been under funded but it would have been in a better position than now.

Chemistry is relatively expensive for a number of reasons. The education of high quality chemistry graduates requires that students spend a considerable time in a laboratory, space that is inflexible in the sense that it cannot be used for other activities out of term time. Chemistry makes demands on consumable budgets, for example the purchase and disposal of solvents, as well as requiring capital items such as glassware, small scale stirring systems, and routine spectrometers. However, as indicated above these increased costs are more than repaid over a life time of earnings from the students on consequent tax receipts by the State: the raw cash cost is a poor indicator of relative economic cost.

The optimal balance between teaching and research provision in universities, giving particular consideration to the desirability and financial viability of teaching-only science departments

The vast majority of chemistry departments remaining in the UK are in pre-1992 universities. The majority of these institutions regard themselves as research and teaching institutions. However, the same institutions appear to place a premium on their overall research profile as judged by the RAE grades of their research schools, and, as has already been pointed out, recent closures of chemistry departments have occurred in spite of healthy undergraduate numbers.

The key issue here is that by the current funding model science and engineering is under funded for teaching and research. In the case of the more expensive subjects like chemistry and physics, the resulting larger teaching and research deficits mean that closure is more likely than for some other departments. RSC evidence suggests that it is unlikely that a teaching only chemistry department would be viable under current funding models because in most chemistry departments there is cross-subsidy of teaching by research. For a teaching only department to be viable significantly higher student-staff ratios than is the norm would be required and this would bring into question the quality of teaching provision given the high contact hours required. The RSC is concerned at the reduction in the diversity of chemistry provision as witnessed by the loss of courses at HND and HNC level. This loss has occurred at least in part because the traditionally teaching orientated institutions have found that it is not viable to provide such courses despite the demand from industry for the students - the well trained technicians - from these courses.

The importance of maintaining a regional capacity in university science teaching and research

Planning for the RAE in 2008 is affecting regional provision and the diversity of courses offered in all institutions, hence the current impact on chemistry. One serious consequence is the risk of the appearance of 'regional deserts' – regions where those students who, for whatever reason, wish to study from home, are prevented from doing so. Students who wish to study chemistry locally in East London can no longer use Queen Mary, University of London; students in Penzance who do not wish to move 200 miles away to study chemistry find that they must nevertheless do so.

The 'regional deserts' affect industry. Those businesses and industries who wish to use their local universities to develop specific skills or undertake focused research or innovation activities may find that their local institution does not have chemistry teaching or research. Such a development is in total contrast to that recommended in the Lambert Review[4]. For example, companies based in East Anglia who wish to train employees [part-time] locally in chemical techniques are no longer able to. It is vital that regional capacity is maintained in university science to allow access for students to subjects like chemistry and to allow local industry to interact with a local university.

Increasing student debt, and stories in the media about that debt, means that increasing numbers of students will look to their local university and their subject choices will be determined by what is on offer in that institution. Furthermore, it is difficult to predict how the introduction of higher fees in 2006 will affect student behaviour. Whilst the RSC recognises that, from 2006, fees will no longer be required to be paid upfront, the fact that the fees will be higher than currently may result in increasing numbers of students being forced to minimise their costs by living at home. Additionally, among some ethnic groups it is preferred that students live at home while studying, so once again among these groups subject choice will be determined by what is on offer locally.

The extent to which the Government should intervene to ensure continuing provision of subjects of strategic national or regional importance; and the mechanisms it should use for this purpose

Proper financial support for the chemical sciences is essential if the 10 Year Plan for Science and Innovation is to be realised and if we are to combat the real challenges of climate change, improved energy efficiency, the need to discover new medicines and achieve sustainable development. The UK cannot afford to see subjects like chemistry die largely due to a university financial system that inadequately funds subjects of key strategic importance.

The RSC believes that the UK needs a national strategy for science and part of this should be the comprehensive regional provision of teaching in chemistry. The key determinant here should be that a potential student should be able to study chemistry at a 'local' university – not necessarily the nearest university but one which is accessible in a reasonable commuting time. Industry should also have access to chemical science research expertise at a local university, again not necessarily the nearest university but one that is reasonably close.

University research and teaching in chemistry is under funded and even departments where student numbers are healthy suffer financially, and this situation is exacerbated if the departments in question have RAE research grades of 4 or lower.

[4] *"Lambert review of business – university collaboration"* Final Report, HM Treasury, December 2003

The RSC contends that Government should ensure that a set number of chemistry departments are adequately funded for teaching and research at a world-class standard across the whole of the UK, and that any gaps in local provision for chemistry teaching are filled by adequately funded chemistry departments whose mission is predominantly, but not exclusively, teaching. Action is needed now.

Further information:

The RSC is the largest organisation in Europe for advancing the chemical sciences. Supported by a network of 45 000 members worldwide and an internationally acclaimed publishing business, our activities span education and training, conferences and science policy, and the promotion of the chemical sciences to the public.

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Appendix 1

RSC's Submission for Chemical Sciences to the Comprehensive Spending Review

See http://www.rsc.org/lap/polacts/spendingreview.htm

Appendix 2

The Royal Society of chemistry and the Institutive of Physics

Economic Benefits of Higher Education Qualifications

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See http://www.rsc.org/pdf/policy/PWCreport05.pdf