CHAPTER 6
SCIENCE EDUCATION

This Chapter concentrates on science in the formal education system, and at its boundaries. There are a vast number of other places where informal science education takes place, some of which, such as libraries, museums and the media, are examined elsewhere in this document.

6.1 The purposes of science education

In designing a system of scientific education, it is necessary to determine the ultimate purposes of the endeavour. Broadly speaking, there are three reasons why public money should be spent on teaching science.

First, in a modern democracy that is dominated by technology, everyone deserves the opportunity to participate in public debates about scientific and technological issues. As outlined in Chapters 1 and 3, science plays an important part in policymaking and in developing the technologies that are part of our lives on a day-to-day basis. The recent Government debate about genetically-modified foods was one example of how some citizens were empowered by a basic appreciation of the nature of science to make arguments both in favour of and against new technological applications.

Second, many people require scientific knowledge, understanding and skills to earn their living, and to contribute to the national economy. At one extreme, university, industrial and public sector researchers require the kind of substantial and detailed scientific understanding associated with having a relevant honours degree and a doctorate in science. Many other professions require scientific and technological skills at different levels, as well as familiarity with the scientific method. The major contributions that science can make to the economy have been discussed in some detail in Chapter 1, but on a broader scale scientific knowledge is also of professional use to many people who would never be described as scientists.

Third, a true education involves learning about a huge variety of aspects of human endeavour, of the nature of our planet, and of the workings of the universe. As outlined in Chapter 2, it would be a characterless population in which few people had the chance to appreciate the ways in which scientific research progresses or to marvel at some of the astonishing puzzles about the universe that scientists have solved and uncovered. Science is just as valuable a part of our culture as history, literature, sport and other curriculum topics.

> "If Britain is to compete effectively in the global market place, we must advance the full and equitable participation of all its citizens in science and technology."
>
> *Dr Elizabeth Rasekoala*
> *African-Caribbean Newtwork for Science & Technology*

These three purposes are not by any means mutually exclusive, and the education system should aim to achieve all of them. But there will undoubtedly be tensions between and within them. For example, a balance must be strick in the curriculum between what is suitable for the minority who wish to specialise in science and what might be more valuable for the majority who will not become scientists.

In order to achieve these three aims, two policies are crucial. First, **science must remain part of the curriculum throughout compulsory education.** Giving up science at any earlier age would mean that students would be limiting their options of subject choice far too early on, and would mean that not all students reached a basic level of science knowledge to which they are entitled. Following the recent decision to remove modern languages from the core subjects for the 14-16 age group, the Government was surprised to find that at least a quarter of students have now opted to study no foreign language at Key Stage 4. The same should not happen to science lessons.

Second, **the UK should be spending at least as much of its national wealth on education as the average among European countries.** At present only Romania, Ireland, the Czech Republic, Slovakia and Greece spend a lower proportion of their gross national products on education than the UK does. In 2000, we were only putting 4.41% of GDP into publicly-funded education and training[1]. Yet the UK's overall levels of public investment is higher than in many comparable countries.

These figures account for spending at all levels of formal education, that is, primary school, secondary school, further education colleges and higher education institutions. Some of the issues facing science education today cut across these categories of educational institution, while others are specific to one or two of them. In the following sections we look at these problems and potential solutions in turn.

6.2 Vertical continuity

The interfaces between different educational stages appear to be particularly difficult to manage. The problems are not unique to science; for example, many five-year olds are now known to struggle with the changes in style and content between reception classes and the first year of the formal curriculum[2].

However, interruptions during a pupil's path through the education system are likely to be far more significant in subjects which are accumulative, and which depend greatly on previous knowledge and skills. Thus, many teachers believe that some of the problems of interfaces are at least as great in science as in other subjects.

The transition between primary and secondary school

The transition into secondary level education, where in most cases pupils receive specialist subject teaching for the first time, has received particular attention. Education authorities have an important role to play in making the move more efficient.

There needs to be a greater clarity in the roles that exam boards, Local Authorities, the Qualifications and Curriculum Authority (QCA) and individual schools have to play in making the transition from primary into secondary school more efficient.

Many support materials have become available in recent years to help with this transition, including specialist websites run by independent bodies or by Local Education Authorities[3]

Educational suppliers are also marketing materials that claim to help with the issue of transition[4]. These increased efforts are in part a consequence of the National Numeracy Strategy. In some areas, lesson exchanges have been arranged between primary and secondary schools, but these are difficult to arrange for many schools, especially where resources are limited.

“I don't think the syllabus has been radically changed in terms of topics covered but it has been slimmed down to the essentials, those being the problem-solving skills necessary for their other undergraduate courses, and some of the material has been very closely linked to other courses. There is certainly more basic material than there was five years ago, to join on more smoothly to what they do at A-level.”

Dr Paul Radmore, University College London, on the mathematics component of Electronic & Electrical Engineering courses

Efforts to address the issue have been widespread but patchy. **A serious study is needed into what types of initiative are most effective at smoothing the transition fro m primary to secondary school,** with a view to ensuring national improvements. This is just one example of a situation where the DfES has not realised its potential for carrying out effective and functional research.

The DfES needs to ensure that practical research is carried out that will enable the early identification of problems and ensure the most effective policy solutions can be put in place.

The interface between secondary school and higher education

The Deans of Science in the UK's universities have reported a significant mismatch between what their institutions expect undergraduates to know when they arrive, and what schools actually teach seventeen and eighteen year olds. Almost half of Deans believe that a majority of first-year students lack the appropriate experimental skills required to begin a university level science course[5].

The Qualifications and Curriculum Authority needs to liaise more effectively with higher education institutions in order to address the issue of the interface between school and university science courses.

6.3 Horizontal continuity

As well as the need for better links between different educational stages, science education would benefit from better linkage between different subjects. The most obvious example is the case of mathematics (see Box 6.1), but there are many other cases where cross-curricular subjects could be taken better advantage of to improve students' experience of science and of other disciplines.

Citizenship and other subjects that include an element of science studies

There is also room for greater coordination with other curriculum areas. This idea was highlighted when a biology-teacher reported[6] that it is necessary for her to cover essay-writing techniques when delivering the A-level curriculum, as these skills have not been adequately or suitably handled in English language lessons at Key Stages 3 and 4.

It is also pertinent to look at links between science and other National Curriculum subjects when considering the role and purposes of new courses in 'science for citizenship'.

Box 6.1
The Mathematics Curriculum

A survey of the Deans of Science in British universities revealed that on 70% of science courses, fewer than half of undergraduates arrive with the appropriate mathematical skills.

Secondary school teachers' opinions on the balance between mathematics and science lessons are also illuminating, as Figure 6.1 shows.

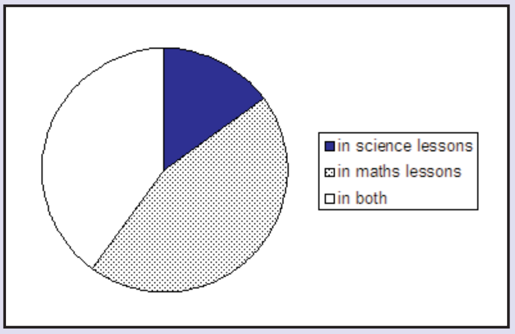

Figure 6.1. Proportions of secondary school science teachers in England believing that the mathematics relevant to science is best taught in science lessons, in mathematics lessons, or in both [Source: *Survey of Secondary School Science Teachers,* SBS, 2004].

Individual teachers have suggested that: "…the mathematical knowledge required for the science syllabus is still too great in some cases. The mathematics syllabus should be reformed to include more numeracy, and work where students can see the applications of mathematics."

A significant number of questionnaire respondents included comments on this issue on their own initiative, indicating that this is an area which provokes strong feeling among science teachers. Several teachers mentioned the importance of students' awareness that their mathematical skills are transferable. The overriding message was that there is a need for coordination between departments. This can be achieved on a school level, in institutions where maths and science teachers have sufficient opportunity to work together. However, teachers report that **there is also a need for improved coordination between the science and mathematics on the part of the Qualifications and Curriculum Authority.**

Many of the topics that science teachers may be expected to deliver in such courses would sit more naturally in a range of disciplines such as media studies, politics, history or religious (moral and ethical) education. Secondary school teachers are expected to have the equivalent of two or three years full time subject training at undergraduate level, following on from two years of studying for relevant A-level qualifications. Since there is no reason to suppose they have this level of exposure to many the history of science, policial apsects or moral dilemmas in science, specialist science teachers may not be the first choice to deliver an entire 'science for citizenship' course.

The school curriculum must recognise that Science Studies form a vastly different discipline from Science, and should therefore not be considered a suitable substitute for the core science requirement.

There is a risk with any new subject that the courses come to be regarded as 'a dosser's subject,' where the only homework required is to read a newspaper or internet article, and where pupils will learn little and fail to develop skills that they did not already have. If 'science for citizenship' courses are to avoid this route, great care must be taken in the development of the curriculum and in the planned delivery of the courses in schools.

If 'science for citizenship' is to exist as independent course, there are two ways of ensuring that the teaching is of an appropriate standard. The course could delivered in collaboration by teachers from different departments, sharing out the teaching of separate topics as appropriately as possible. The alternative would be that science teachers would be required to deliver the course, which should require the completion of thorough, assessed, training scheme, to bring them up to standard in a subject which is vastly different from the one that they originally trained to teach.

A curriculum-based alternative to either of these measures would perhaps be more appropriate. Rather than creating new qualifications, a more joined up approach could be to modify existing courses to include a science-related element. As with the improvements required to the links between the maths and science curriculum outlined in Box 6.1, this would require improved coordination.

Examples of places where this could be achieved include:

⇒ Opportunities to develop young people's experience of engineering at school would lie in links between Science and Design & Technology curriculum areas

⇒ The History curriculum could be enhanced by a range of historical disciplines which would include some history of science

⇒ Advantage could be taken of current popular interest in linguistics in both language and science lessons

⇒ English language lessons could include an analysis of the development of new words and their entry into English and international usage, with examples such as 'nanotechnology' or even 'computer'

⇒ As the Religious Education curriculum is broad-

> “Science has a major role to play in the whole curriculum through its contribution to safety, health and environmental education, technology, the development of language and mathematical skills, art, PE, historical perspectives, geography and the development of economical and industrial understanding.”
>
> *One school's policies on the provision of science education*

ened to include non-religious and non-theistic standpoints, the coverage of ethics and morality issues is increasingly important. There will be many opportunities for coordination with the science curriculum for discussions of topical issues
⇒ Technical writing styles could be covered in English language classes alongside other genres, such as literary forms or advertising text.

It would be advantageous for aspects of science to be studied throughout the curriculum; a free-standing course in ‘science for citizenship’ is not necessarily the most appropriate way to include this.

6.4 Numeracy

The numeracy strategy, introduced in the late 1990s, appears to have brought about significant improvements in the achievements of primary school students, largely by the provision of structured lesson plans, support and materials.

Figure 6.2 shows the rise in the percentage of young children achieving the required level in national mathematics tests. Although performance appears to have levelled off since 2000, there was a rapid and substantial rise in performance following the introduction of the numeracy strategy.

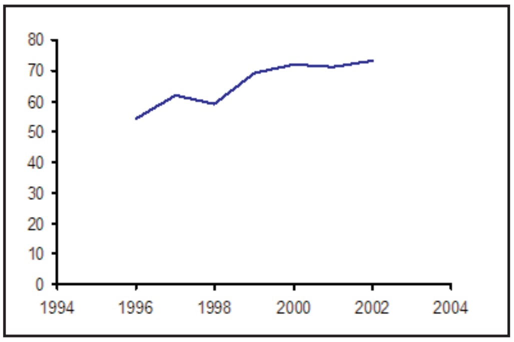

Figure 6.2 Percentage of all pupils achieving Level 4 in mathematics in Key Stage 2 National Curriculum Tests at age 11 over the past few years [Source: www.standards.dfes.gov.uk/performance].

The quality of mathematics teaching in primary schools is currently rated higher by Ofsted than the quality of teaching in any other subject, with 70% of schools rated as good or better[9].

Some caution should be exercised in equating improvements in test results with real improvements in the quality of young people’s educational experience. It is important to remember that exam results can only reflect the efficiency with which students have been prepared for an exam, and not their understanding of topics that are not directly covered by the syllabus, or their enthusiasm and interest in the subject. The following example illustrated this point.

At Key Stage 1, students are expected to learn division of whole numbers, in order to carry out simple arithmetical calculations such as 8÷4 or 15÷3. It is not uncommon for this to lead pupils with inquiring minds to ask questions such as ‘what happens if you divide a number by zero?’, a question that happens not to be covered by the Key Stage 1 syllabus. This should not present difficulties for a properly trained teacher, but for a teacher with little confidence in mathematics, current Numeracy Strategy guidelines would be of little help.

Anecdotal evidence has shown that in some schools this sort of problem can actually lead to the mis-education of young pupils[10].

Primary school teachers' maths and science training should go well beyond the requirements of the curriculum they are expected to deliver.

6.5 Practical work

Science and engineering are inherently practical subjects, and consequently, practical classes form a crucial part of any science education.

Practical experience at primary school

There are two important educational outcomes that are desirable from science education for young children. The first is for them to learn that trial, error and improvement can help to uncover the best ways of doing something.
The second is that on assessing practical successes and failures, one can begin to discern underlying patterns that reduce the need for future trials. Children should be exposed to these experiences at primary level in order to enable them to understand practical experimentation and scientific theory at later stages.

Science in primary school should be based around technology and hands-on experience. To achieve this, primary teachers need to be confident in their ability to run practical classes for the benefit of their pupils.

Most primary school teachers are not trained scientists (for example, 47% have no physics qualification of any kind). Partly as a consequence, they lack confidence in their own ability to engage children with scientific topics. About half of primary school teachers say they do not have 'a lot of confidence' in teaching science, appreciably lower than the two thirds who are self-assured in teaching English (see Figure 6.3). Anecdotal evidence strongly suggests that children and young people pick up on this lack of confidence, and learn that science is hard, or that it is reserved for a small number of people, or perhaps that it unimportant.

Teachers' lack of confidence in teaching science is not their fault. It is unreasonable to expect them all to be trained in science, and they are hardly unusual if they feel overwhelmed by the tidal wave of scientific material in the media, which they know to be a tiny proportion of the world's rapidly accumulating body of research.

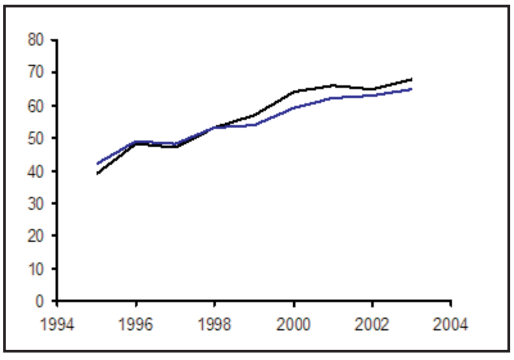

Figure 6.3. Percentage of good or better teaching in primary schools [Source: *Science at a Glance 2002/03,* Ofsted, 2004].

Clearly, there is a need for appropriate support and materials to be provided to primary school teachers, to build their confidence in engaging children with the basic concepts of trial and error and of deduction from observation.

This could be achieved through a science-based equivalent to the National Numeracy Strategy, supplying training materials for teachers, as well as ideas for activities for students, and a time set aside for science.

A National Science Strategy is needed in education, similar to the national numeracy strategy, to boost current standards throughout primary schools

Policies for the continuing professional development of teachers are laid out in a later section, but in the case of primary school teachers, who are expected to deliver all National Curriculum subjects to their pupils, it is particularly important to ensure that the full range of subject training is included in their continuing professional development.

Continuing professional development for primary teachers must include some element of science and mathematics subject specific training.

Practical work at secondary school

Secondary school should develop the practical experience of primary science with more detailed experiments of various kinds. Unfortunately, 77% of secondary schools in England are currently cancelling practical classes, with behavioural problems, lack of equipment, and large class sizes being the three major causes[11].

83% of secondary school science departments describe their funding as inadequate. When asked about their experiences, school teachers commented: 'Textbooks had to be shared, sometimes with very uninterested and even obstructive people. I used the web regularly and was lucky enough to have a private tutor but not everyone can do this'[11]. No allowances are made in secondary school budgets for the depreciation of capital items, which need to be replaced every five to ten years.

Schools and their departments should be routinely allowed to carry funds over from one year to the next in order to make more significant purchases of equipment.

Alongside increases in funding, other solutions can be found to improve students' experience of practical science. Informal schemes are in place in some schools to reuse equipment that has been handed down from universities and other laboratories. Such initiatives could be developed through better publicity and the development of contacts with institutions which may, perhaps for geographical reasons, not already be involved. Further to this, some schools are able to use equipment that has been donated by local companies. At present this type of activity is limited by geographic locations as well as the time and capabilities of particular science teachers.

A national scheme for sharing equipment donations may help to deliver an improved standard of education to all students.

Behavioural problems

English schools, 46% of teachers are canceling practicals because class sizes are too large, and poor student behaviour is more likely to be disruptive in larger classes[12]. There are currently no official limits to class sizes, and at present some science teachers are expected to supervise groups of over 30 students carrying out experiments.

The Scottish system of limiting all classes with a practical element to 20 pupils should be adopted throughout the UK.

Changes to regulations regarding the exclusion of difficult pupils would also have a significant impact on science, as a subject with a significant practical element.

Field centres

Field centres offer one successful model for offering children access to practical scientific work. There is 'substantial evidence' that fieldwork raises standards of attainment and that residential courses, away from the normal school environment, have a range of wider social and educational benefits[19]. At field centres, children have the opportunity to learn about (for example) biological and geographical material using specialised resources that would not be available elsewhere.

Unfortunately, schools and teachers now fear being prosecuted when accidents occur, and are more reluctant than they used to be to take children into environments that are not closely controlled by school authorities.

To enable as many children as possible to benefit from the practical experience of field trips, regulations must be put in place to support teachers in taking students out of school rather than leaving them open to significant risk of litigation on the rare occasions when accidents occur.

There is no intellectual reason why the concept of specialised centres should be limited to the kinds of work that is traditionally carried out at field centres. Indeed, with the price of modern equipment far outstripping the ability of almost all schools to afford it, one model for allowing the majority of children access to a wide variety of scientific experiences may be the creation of well-equipped chemistry or physics laboratories that do not belong to any one school, but are shared among many, as the resources of field centres are.

There is already a suggestion that specialist science colleges should share their facilities with neighbouring schools; this idea is indicated in the conditions for gaining specialist status. For example, one of the National Union of Teachers' proposals is that 'Specific funding to support collaborative arrangements between schools should be available to schools from Government and local authorities. It should be a requirement that specialist facilities developed by individual schools should be available to schools in the wider community'[20].

Enhanced efforts are required to ensure the best advantage is taken of science facilities in specialist science colleges.

6.6 Specialist teaching at secondary level

While the majority of schools deliver a combined science curriculum to their students up to Key Stage 4, the majority of teachers entering training have specialized in only one subject.

Two thirds of those who teach physics to 15- and 16-year olds do not have a degree in physics and one third do not even have the equivalent on an A-level[13]. One in ten of the people who teach chemistry to students between the ages of 11 and 18 do not have any qualification in Chemistry. 9% of Biology teachers have no biology qualification[14]. Only 64% of secondary school lessons in general and combined science are taught by people who claim to have a degree in the subject. 74% of Biology lessons 78% of Chemistry lessons and 72% of Physics lessons are taught by people with a relevant degree, but these figures include teachers with general science degrees[15].

It is insulting to, say, Physics teachers in general to say that children can cope without them because Chemistry and Biology teachers can do the job just as well. Nobody would suggest that within the arts and humanities, the children can cope without a History teacher because the French teacher should be able to do just as well.

Figure 6.4 shows the breakdown of specialist subject training of those training to be science teachers.

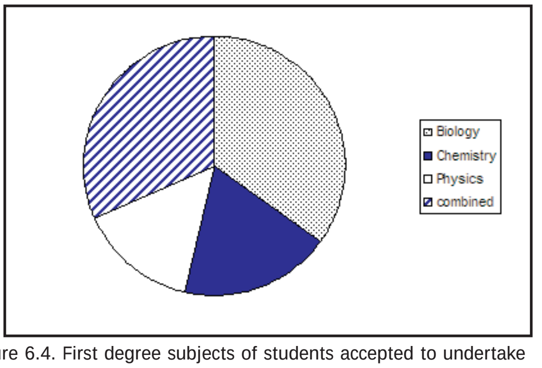

Figure 6.4. First degree subjects of students accepted to undertake courses leading Postgraduate Certificates in Education in 2003 [Source: *Annual Statistical Report*, GTTR, 2003].

Every student at Key Stage 4 should have the opportunity to be taught by specialist teachers trained in physics, biology and chemistry.

Peripatetic specialists and 'ambassador' schemes

One element of a strategy to ensure pupils encountered teachers from all scientific disciplines might be the provision of peripatetic science specialists. Care would be needed to ensure that the system did not reinforce the impression that science was for a limited few rather than for everyone.

The Undergraduate Ambassador Scheme is one example of an attempt to bring children in to contact with more specialist science experience. University students spend a ten half days in schools, working alongside teachers, in an attempt to engage pupils in science and mathematics. It is plain that the undergraduate students benefit substantially from the scheme, improving their communication skills and enabling them to make better-informed choices about whether they wish to pursue careers in teaching.

However, the scheme has had 'little impact' on the pupils' engagement with science, or on aspirations for pupils to study science further. Having a young student in class did not induce children to like science and mathematics any more than they had previously[16].

Anecdotal evidence suggests that schemes for introducing scientists into the classroom do have a greater potential than this negative report would suggest to improve pupils' learning experience. It is apparent that successful schemes would need to be more strongly oriented in favour of the needs of the pupils, not just the interests of the specialists, but beyond that further guidance is needed in order to ensure that schools are able to get as much as possible out of these schemes.

Clearer guidelines are needed on how to make the most of scientists and science students who visit schools in a way that will be constructive for science learning.

If the factors that make some of these projects more effective than others can be identified, then it may be appropriate to make the schemes more widely available.

The perception that science is 'not for everyone'

One concern about schemes that rely on specialists who come into schools for brief spells is that children will obtain the impression that science is 'not for everyone,' that it is somehow reserved for a small group, with admission requiring some undefined skill or property[17].

The Undergraduate Ambassador Scheme appears to suggest that, in general, this may not be a serious problem. There has been no reported evidence that the scheme reinforced the view that science is not for everyone, and some reason to suppose that pupils benefited from having a new person in the classroom[18].

As part of the development of science ambassador schemes, research should be undertaken by the DfES to investigate the effective learning involved in being taught by a subject specialist.

6.7 Science after the end of compulsory education

At least in theory, compulsory education provides the majority of people with a basic grounding in science and mathematics. Most people sit GCSE exams in both mathematics and science, and are supposed to leave compulsory education at the age of 16 with the ability to perform everyday numerical calculations and with some experience of scientific theory and practice.

For those who will stay on in education, there are currently four broad pathways with relation to science. Youngsters can:

⇒ give up science altogether, and pursue either academic studies in the arts and humanities or vocational training that excludes all technological elements
⇒ pursue a vocational course of education which includes some element of science or technology
⇒ study for a combination A-levels, including both some science subjects and some arts and/or humanities
⇒ study A-level courses exclusively in science subjects and/or mathematics

There is great variation in the quality of the education experienced both within and among the four groups of students defined by these pathways.

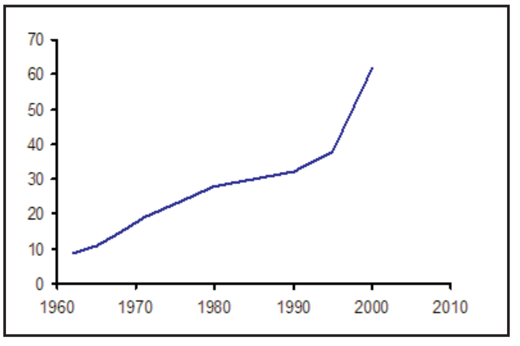

Figure 6.5 Percentage of A-level/AS-level students studying a mixture of science and non-science subjects [Source: *The Supply of, and Demand for, Scientists and Engineers,* SBS, 1997 and *Survey into Subject Combinations for Students in their First Year of Curriculum 2000,* UCAS/QCA, 2001].

Breadth of the academic syllabus

The current A-level system in general is too narrow, even for people who study a mixture of science and arts subjects, which as Figure 6.5 shows, has become an increasingly popular course of action.

In comparison to this, Figure 6.6 shows historical trends in the percentage of A-level students taking three arts or three science subjects. While the proportion taking a mixture of arts and sciences has increased, this has been almost entirely at the expense of the numbers studying only science. There has been no tendency for students inclined to specialise in the arts and humanities to study some science.

We should not take these graphs as an indication that there is any need to protect the sciences by offering students less choice and attempting to encourage those students who chose science A-levels

Box 6.2

Specialist Science Colleges

Specialist Science colleges are some of the few schools that are adequately equipped for a practical education. Teachers in schools with science specialisms claim:

⇒ *"The larger items are purchased on a less frequent basis but are identified according to the needs of the department. The science curriculum area were provided with £20000 of new equipment two years ago, following years of under- funding in terms of replacement equipment."*

⇒ *"Our department is only [well funded for ICT equipment] because we have science college status".*

At present only 12% of schools with a specialism are science specialists. As Figure 6.7 demonstrates, the average number of new science colleges being established per year is currently higher than for any other specialism.

The fundamental point is that under the present arrangements only a small proportion of schools will be able to take full advantage of the funding that they need to properly fulfill their pupils' practical science education.

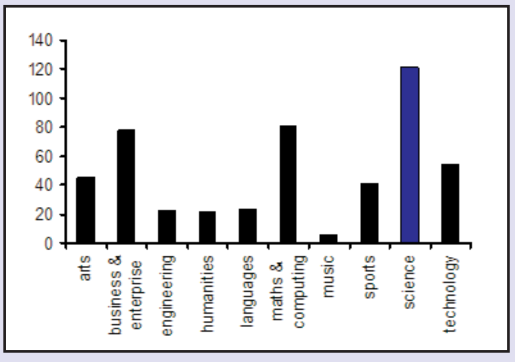

Figure 6.7. Average number of new specialist colleges being formed each year [Sources: www.specialistschools.org.uk/about/historyofthetrust/default.aspa www.standards.dfes.gov.uk/specialistschools/excel/All1955specialist_Ver04b.xls?version=1].

to avoid any study of arts subjects. It would be damaging to science if young scientists were limited in their experience of other disciplines. As young people have voted with their feet increasingly to study a mixture of different subjects, the educational establishment has not kept pace with them.

A post-16 educational system should be set in place to ensure that students who specialise mainly in the arts and humanities are encouraged to develop interests in the sciences.

Although the introduction of a new system of academic qualifications in 2000 has clearly increased the scope for student to choose a mixture of disciplines, it is widely perceived to have failed more generally. For example, the number of people sitting A-level mathematics has fallen dramatically, as students choose to drop mathematics after finding the AS level difficult relative to other subjects (see Figure 6.8).

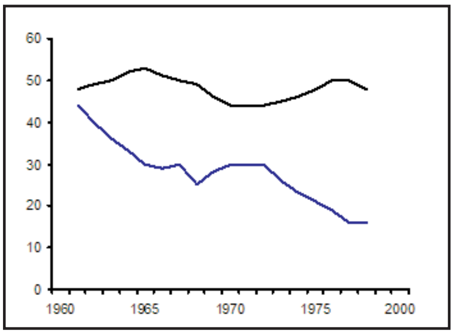

Figure 6.6. Percentages of the A-level cohort studying three sciences or three arts and humanities over the past forty years [*The Supply of, and Demand for, Scientists and Engineers,* SBS, 1997 and *Survey into Subject Combinations for Students in their First Year of Curriculum 2000,* UCAS/QCA, 2001].

Clearly, a better system of broadening the curriculum for 16-18 year old students is needed.

A broad baccalaureate-style post-16 curriculum would serve the interests of the nation and of individual students better than the current system.

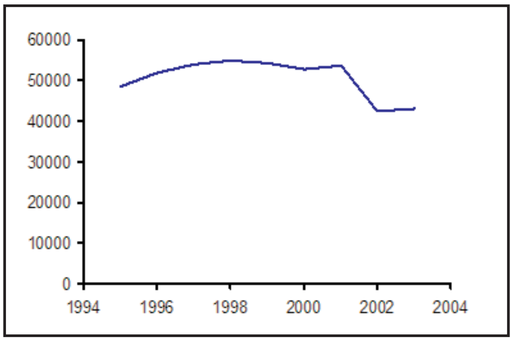

Figure 6.8. Number of 17-year olds sitting A-level mathematics since 1995 [Source: *GCE/VCE A/AS Examination Results for Young People in England 2002/2003,* DfES, 2004, and previous editions].

Curriculum reforms should ensure that whichever route a student takes, he or she will be able to learn useful techniques from the sciences, for example through the use of statistical methods for those studying history.

The uptake of science post-16

It is widely acknowledged that an increased uptake of science subjects at secondary school level, particularly 16-18, would be desirable. Under the present system, students make choices when they are 15 that to a large extent determine their career paths and their options at university. It would be preferable if students were able to delay such significant decisions until a later stage in their education, or if there was more room for flexibility at later stages.

In section X, the importance of students gaining personal returns on their investments is outlined. While students may be put off the sciences on the basis that they expect to get lower grades, later in their academic or professional careers, a student with C or D grades in the physical sciences may have better prospects than a student gaining higher grades in other subjects.

The uptake of science subjects in higher education is determined for the vast majority, young entrants to university courses, by experiences at school level. Further figures on the uptake of the sciences are shown in later sections.

Improvements to the suitability of the curriculum and the practical facilities available outlined above will all have an important impact on the uptake of the sciences. One of the most significant factors, the recruitment of quality science teachers, will be dealt with in section x. However, there are further specific points to bear in mind.

If the compulsory mathematical element of post-16 education is too off-putting, it may deter students from choosing to study science at all. As one English teacher commented: 'I certainly wouldn't have taken biology A-level if they'd made me do maths with it!'.

Clearly, little is served by forcing students to study specific compulsory elements of the curriculum at this level of education. However, if a full curriculum is to be established, it is equally clear that everyone studying for a post-16 diploma should be studying some element of mathematics.

Although some mathematical element should be required of anyone awarded a baccalaureate-style diploma, the appropriate level of detail will vary among students.

Mathematics should be studied by everyone engaged in the broadened curriculum for post-16 education, with different modules appropriate to different students depending on factors such as the balance of other subjects they are studying.

6.8 Careers advice

When asked about their experiences at school and college, a group of science undergraduates in the UK unanimously believed that at every stage of their careers, there had been a failure to provide them with adequate information on which to base their choices. They felt that 16-year olds were advised very badly about the kinds of careers that are open to science and engineering graduates. Many pupils had been given to understand that a degree in media studies or one of the humanities would be a passport to a well-paid, fashionable job either in the media, or in business or the City. Science qualifications were presented as being appropriate only for those who wish to pursue a career in science as a 'boffin', and not as a means to either an interesting job or a well-paid one[21].

> "There are numerous books and information sources on careers in law, medicine, media but minimal coverage on fuel cell technology, nanotechnology and bioinformatics in reference material readily accessible to advisers. Effective and informed guidance on the implications of subject choice needs to be grounded on objective and well researched information on trends in the current and likely future job market."
>
> *Mike Hill, careers adviser*

For several years, now, chemistry staff at Saint Andrew's University have been providing a training day for careers advisers in Scotland, to try and help plug the gap in information about careers in science. Further such schemes are needed, along with suitable publications in order to reach careers advisers in every school or local authority.

Careers advice is crucial. We now see universities closing chemistry departments and expanding forensic science because students want to study a subject they have seen on a television series. This is especially frustrating because a degree in chemistry is highly valued in the forensic science profession.

The Government needs to do far more to ensure that careers advisers are well informed of the job market and the opportunities available to young people. A new service or information portal should be developed aimed at informing careers advisers.

6.9 The supply of science teachers

By far the most serious problem for science education is the supply of suitably trained teachers, particularly at secondary level. The Department for Education and Skills and its executive bodies set a number of initiatives in place in attempt to address the problem, but to date these measures have been far from adequate.

An inspiring teacher is the often most important aspect of anyone's science education. But at the present time, many school pupils in the UK are missing out. Even some young people who have chosen careers in science have remembered their school teachers as 'unenthusiastic or, more usually, simply unqualified to teach the material for which they were responsible'[22].

Many students will have been put off from science subjects altogether by their experiences. Other school students have found their science education disrupted by strings of several replacement teachers within a two year course, or struggled to follow teachers for whom English is not a first language.

At the present time, we are risking turning a whole generation off science. Furthermore, as long as we are short of qualified teachers, there is going to be pressure to reduce the amount of mathematics and science taught.

Extent of the problem

The shortage of trained science and mathematics teachers at secondary level is severe. In mathematics alone, the country is short of about 3,400 teachers, which means that even if 40% of all British mathematics graduates were to become teachers for each of the next few years, there would still be barely enough to provide a good mathematical education for all pupils[23].

Figure 6.9 shows the number of graduates in different disciplines accepted on PGCE courses in recent years.

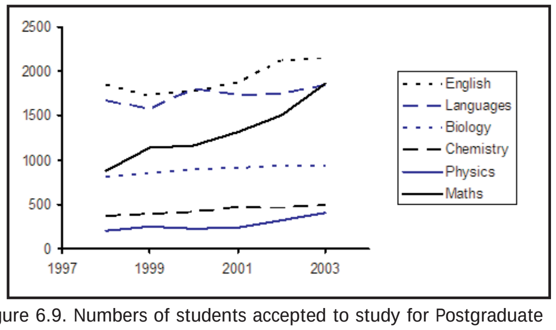

Figure 6.9. Numbers of students accepted to study for Postgraduate Certificates in Education in different specialist subjects since 1998 [Source: *Annual Statistical Reports*, GTTR, 2000 and 2003].

There is not only a problem in the recruitment of sufficient trainee teachers, but also in the recruitment of trainees of a high enough quality. Only about 65% of those training to teach physics, mathematics and chemistry have an upper second class degree in their subject, compared to 95% of those training to teach history[24].

In 1999 40% of those training to teach physics had a third class degree or worse. Educational research shows that there are clear links between subject knowledge and quality of teaching; being a good science teacher takes more than simply being on top of the course content and possessing pedagogical skill.

Although many aspects of the teaching profession are equally problematic for all subjects, these shortages are especially severe in science and mathematics. There are more than twice as many schools in which a lack of mathematics teachers is 'adversely affecting pupils' as there are in which the problems of recruiting English teachers are having the same effects. Moreover, the problems are more acute in the UK than they are, on average, in other industrialised nations[25].

As well as the shortages in permanent staff, there are few temporary science teachers available to cover lessons. Aside from being damaging to pupils' experience in itself, the pressure this puts on full-time teachers can be a contributory factor in putting people off teaching as a career.

Three general approaches are needed to solve the teacher shortage. The first and most pressing is to recruiting new teachers. Measures are also needed to retaining existing ones, and improve the skills of those already in work or training.

Initial recruitment of science teachers

At least part of the problem in recruitment is that the teaching profession commands very much less respect that it used to, or than it does in some other countries. The profession has received bad coverage in the media, although there is evidence to suggest that some of this has been a realistic reflection of teachers' experiences.

A recent study of mathematics undergraduates revealed that those who had a greater knowledge the teaching profession through family connections were less likely to consider a career in teaching[26]. There are complex cultural issues behind the value a society places on education, and on teachers specifically, but at the same time there are some obvious factors that do contribute, such as the maximum salary for a regular classroom teacher of just over £30,000.

Remuneration of science teachers

Another recent study looked into the factors that put young people off teaching as a career, comparing the attitudes of trainee teachers with those of other university students. Figure 6.10 shows the main reasons among those who had already decided against teaching as a career, with comparative figures for trainee teachers.

The same study showed that the top concerns before and after the 'golden hellos' were introduced remained largely unchanged, with pay still top on the list.

Another study looked into the issue of retention.

Here pay was naturally enough further down in the list of issues, but the top categories were remarkably similar to those given by recent graduates.

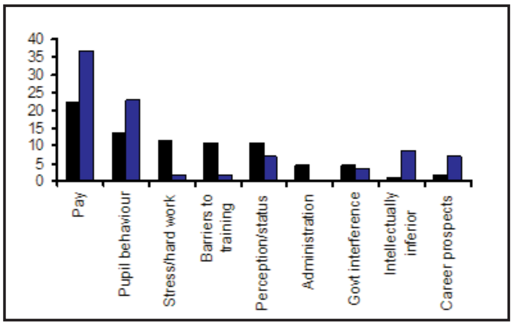

Figure 6.10. Percentage of trainee teachers (black bars) and other university students (blue bars) saying that particular factors were deterrents to a career in teaching [Source: *Supply, Recruitment and Retention of Physics Teachers*, Teacher Training Agency, 2001].

Table 6.1 shows the main reasons given by teachers for their decision to resign from the profession.

Factor	Percentage of teachers
Workload	57.8%
Pupil Behaviour	45.1%
Government initiatives	37.2%
Salary	24.5%
Stress	21.6%
Status/recognition	19.6%

Table 6.1. Percantage of resigning teachers saying that particular factors affected their decision [Source: *Teachers Leaving*, NUT, 2001].

Neither of these studies was specific to mathematics or science, but they reflect general problems of recruitment into secondary teaching. When teaching suffers recruitment problems in general, the situation will inevitably be worse in subjects where graduate recruitment is competitive. It is widely acknowledged that mathematics and science are two subjects where the problem of teacher recruitment is particularly severe, partly because competition for graduates in these subjects is high (see Figure 6.11). Schools are being left with a lower calibre pool of candidates (see Table 6.2), so that poorer quality lessons in turn makes those subjects less popular among the next generation of potential science teachers.

Providing differential pay for certain subjects is a sensitive issue, and many people within the education system are not comfortable with the idea. However, the principle has already been established, with the one-off 'golden hello' paymets that are made in shortage subjects (including science). It will take more this single payment to lure many more science graduates into the classroom.

The maximum potential earnings for classroom science teachers need to be increased in order to attract more graduates into the profession.

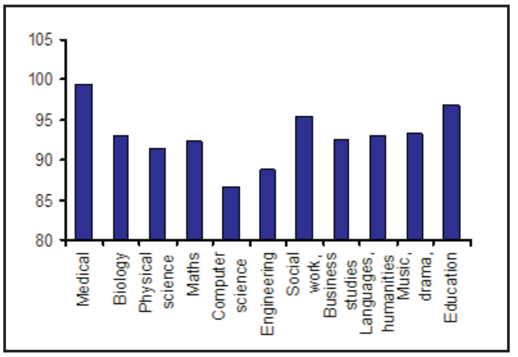

Figure 6.11. Percentage of graduates in various subjects in employment or further study [Source: *Performance Indicators in Higher Education in the UK 2002/03*, HESA, 2004].

Subject	Percentage of students without at least a lower second class degree
Physics	37.7%
Mathematics	36.5%
Chemistry	33.8%
Biology	15.2%
Geography	7.4%
English	6.9%
History	5.3%

Table 6.2. Degree classes of teacher trainees [Source: *Science and Society,* 3rd Report of the House of Lords Select Committee on Science & Technology, Session 1999-2000].

Enlarging the pool of candidates

Another way to increase the numbers entering teaching is to widen the pool of potential entrants, rather than attempting to increase the proportion of applicants that are appointed. The Teacher Training Agency has recently put a scheme in place specifically to do this in mathematics and science.

As a medium term-solution, more courses are needed to enable those with limited subject knowledge to train as science and mathematics teachers.

The Department for Education and Skills has been slow in commissioning its own research into the recruitment of quality science teachers. The problems have been known about for a long time now, and yet only in October 2004 was their first major study into 'The deployment patterns of Science and Mathematics Teachers' begun.

There have been problems in terms of 'joined up thinking' between the Departments' various agencies, when it comes to both research and initiatives on teacher recruitment.

There is a need for more effective research to inform

strategies for increasing the quality and quantity of teachers recruited.

Continuing professional development for teachers

The General Teaching Council was given some of the responsibility for improving the image of education since 2001. Improved continuing professional development is most likely to improve the quality of pupil experience, and may go some way to tackle retention issues provided additional training is properly recognised and rewarded.

The new Science Learning Centres, set up around the country in existing institutions, provide continuing professional development for science teachers at all levels as well as for technicians. The idea is unquestionably a positive development, but may do little for schools where they are most needed. The discounted cost of training courses will be around £50-200, which schools will be expected to meet. On top of this the school will have to pay for travel expenses, possibly accommodation, and for a suitable cover teacher, if one is available.

There is still no mandatory continuing professional development for teachers, as there would be in many other professions, and for those schools which were already unable to find the resources to train their science teachers, the new centres will not go far enough to make continuing professional development possible.

School teachers should be allowed sabbatical periods in which to update their subject knowledge by carrying out a project with a company, university or other institution.

> "My job is supporting students in stereotypically unchallenging subjects like Hairdressing and Beauty. The amount of microbiology they must learn to pass their exams is startling. Explaining the difference between a temporary style (held by hydrogen bonding in beta-keratin) and permanent styling (disulphide bridges) may not require an in-depth knowledge of chemistry but hairdressers are expected to know this, and understand it well enough to explain it."
>
> *Lecturer in a Further Education College*

Similarly, there should be more opportunities for scientists in universities and industry, particularly those carrying out research for their doctorate, to gain some experience of teaching in schools.

The continuing professional development strategy of 2001 went some way toward improving this situation, but bursaries and sabbaticals are still not widespread enough, and may not be sustained throughout a teacher's career. There remains significant variation in whether or not teachers can take advantage of continuing professional development. The National Union of Teachers estimates that £1000 per head per year would be needed to support sufficient training for all teachers[27].

Time and money must be made available for teachers to undergo continuing training, as well as to pay for the direct costs of the courses themselves.

6.10 Further Education

The further education sector represents much of each of the purposes of science education outlined at the beginning of this chapter. Vocational training develops the specialist skills and knowledge that people will need in their professional lives, and other adult education courses contribute significantly to the knowledge required for active citizenship, particularly through numeracy courses. The further education sector is at present the main provider of vocational learning other than employment based provision. Further education colleges also provide an alternative learning environment for young people to cover aspects of the school curriculum or prepare for academic courses in higher education.

The UK has a high take-up of adult education in general, with the highest participation among 25-64 year olds of all the countries in the European Union. While the average participation rate is at 8.5%, in the UK it is nearly 23%[28]. Based on figures for council-funded post-16 learning, only 3% of these learners are likely to be taking courses which are purely maths and science based. However, courses in subjects which often include a significant component of maths, science and engineering, amount to more than 40% of the total. 9% are also engaged in foundation programmes, which are designed to lead on to academic study in the HE sector[29].

Vocational and academic education

It is possibly as a consequence of the confusing plethora of FE qualifications available, that to date, policies relating to further education have tried to impose false uniformity on the sector, rather than to encourage a diverse set of options suitable for a wide variety of people.

The concept of 'parity of esteem' between vocational and non-vocational routes, while admirable in seeking to give vocational training proper recognition, has been confused with 'parity,' to the detriment of the vocational education and training that is available for those young people who have the aptitude and motivation to become highly skilled members of the workforce.

By insisting that a particular vocational qualification is worth a particular number of points, equivalent to those used to score A-level grades, the system has not served young people or their employers well. Many universities and employers do not, in fact, treat the vocational and non-vocational points as equivalent, and to some extent vocational courses have been forced to include spurious academic content in order to justify the parity.

This woolly thinking has pervaded plans for the future in which young people are told they 'should be able to opt for a substantial element of vocational learning within their programmes, but should not specialise in specific occupational areas'[30]. This is a bizarre concept, totally at odds with what the word 'vocational' actually means, and utterly useless to a young person who wants to have a balanced education that includes learning how to be a good plumber, lawyer, doctor or physiotherapist.

Vocational courses must be properly valued in their own right, and should not include irrelevant academic content.

In fact, the Adult Learning Inspectorate found that achievements in further education courses in engineering were higher than in any other area, and attributed this primarily to the fact that most provision was based in employment[31].

It is essential that vocational courses are properly linked with employers both at the design stage and in their delivery.

For years, further education has been the poor relation of British education. It is not only the curriculum and subject provision that is in need of reform, but also the infrastructure. Further education colleges are underfunded even by the standards of the other parts of the country's educational system.

Further to the lack of funding for teaching itself, the poor infrastructure extends to training systems for further providers. While the Adult Learning Inspectorate plays the equivalent role to Ofsted in the schools sector, the diversity of the sector has meant that there can be no equivalent body to the Teacher Traning Agency. This affects some subjects more than others.

The UK's system of further education needs a detailed and serious examination, without political interference, leading to credible and ambitious reform. The mechanism most likely to achieve this would be a Royal Commission.

Scientific content and numeracy

The current proposals for educational reform aim in particular to improve the curriculum for vocational learning, both during compulsory education and within further education.

An increased scientific content could help to raise the standard of vocational courses in their own right, without the inclusion of spurious academic content.

Adults in the UK have the third worst quantative numeracy skills of any OECD country. Over half of adults included in a recent survey were found to be 'performing at below the minimum required for coping with the demands of life and work in the knowledge society'[32]. While this may be interpreted largely as a sign of continuing problems in the school education system, the further education sector has an important role to play in improving the situation.

6.11 Higher Education

Higher education relates especially to the purposes outlined at the beginning of the chapter in that it will serve to train professional scientists. It is also crucial in contributing to the cultural life of the nation, as outlined in Chapter 2, and in providing individuals with a higher level of scientific training to industry. Higher Education science courses are also the main route into teaching science at secondary school level.

In order to fulfil the second of these purposes, contribute to the cultural life of the nation, and at the same time to provide students with transferable skills **all scientific HE courses should include some component of science communication skills.**

The expansion of higher education

As the number of students in higher education expands, so the funding mechanisms are changing.

More educational opportunity for more people is always an advantage. The view that educational opportunity should not be expanded because it is not easy to see how the costs can be met is nothing new. For example, when state-funded elementary schools were introduced in 1870, parliamentarians complained that it was expensive and inappropriate, even though there were sufficient exemptions from compulsion that most families could probably avoid sending their child to school in any case[33].

Just as the Earl of Shaftesbury was wrong to oppose the sending of working-class children to school because it would 'deprive parents of the earnings of their children,'[34] so modern critics are wrong to argue that educational opportunity should not be extended to as many people as possible, from as many backgrounds as possible.

The expansion must be of appropriate courses. Nineteenth century educationalists diversified the universities as they realised that there were other ways to engage in higher education than in studying law, medicine or theology. Likewise, the current system must take account of the fact that not everyone will benefit from the kind of teaching and learning experience that was the norm twenty, or even ten, years ago.

Moreover, greater efforts are needed to ensure that new university places are distributed to the people who are best placed to benefit from a university education, because of their aptitudes, interests and abilities. Figure 6.12 shows how the expansion of higher education since the 1960s has benefited those whose families work in professional and non-manual occupations at least as much as, if not more than, young people with manual and unskilled family backgrounds.

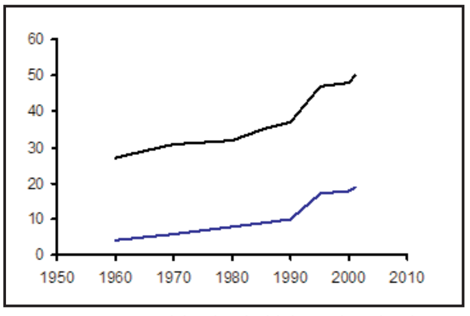

Figure 6.12. Percentage participation in higher education by young people from professional and non-manual backgrounds (black line) and from manual and unskilled backgrounds (blue line) [Source: *Consultation on Key Issues Relating to Fair Admissions to Higher Education*, Admissions to Higher Education Steering Group, 2003].

However, the continued disproportionate success of people from wealthier backgrounds cannot be blamed on the universities themselves. It stems largely from the underachievement of state schools in some deprived areas. Youngsters who have been let down until the age of 18, and who have not been able to develop their knowledge, confidence and skills will not perform well in their public examinations, in university entrance examinations, or in admissions interviews.

The distribution of university places will continue to favour the wealthier as long as they can obtain an educational advantage in earlier parts of the system. Thus, action to redress the shortage of science teachers in inner-city comprehensive schools would almost certainly do more to bring more disadvantaged youngsters into higher education than a bureaucracy aimed at forcing arbitrarily-defined 'fairness' on universities that are in any case working hard to ensure that advantages are available to all.

Universities must retain the freedom to choose students who will be best placed to benefit from courses.

Providing higher education opportunities for young people from backgrounds that have traditionally been underrepresented will require changes in the ethos of the educational establishment.

Accreditation of courses

Universities are moving towards a credit framework, in which students can spend a period of time taking a series of modules and then take a break from higher education - perhaps to earn the money to finance the next stage. In many cases, some credits will be obtained from one institution but later credits will be awarded by another.

This system provides two significant challenges, one for the institutions themselves and one for the regulatory authorities.

The universities will need to develop more and better ways of ensuring that students have the capacity to integrate their knowledge and skills across modules. Modular degree courses present a greater challenge than traditional, continuous, courses of study in examining the ability of students to apply what they have learned in one module to help understand material that is included in a different one.

The regulatory authorities will need to rethink their attitude to failure. If the system is designed for students to treat individual courses as separate entities, valuable in their own right, it is illogical to use terminology such as 'drop out' and 'failure' for people who successfully complete one or more modules, but who do not continue in higher education in the short term.

Universities and regulatory authorities must work together to develop an undergraduate system capable of giving credit for any achievements made, including those that are below the level required to obtain a bachelor's degree.

Geographical provision of science subjects

Another important issue for the changing provision of higher education is the geographical provision of courses in different subjects.

Because financial pressures make it far more likely that students live with in the family home than used to be the case, there is a stronger case than in the past for ensuring that institutions in each area can provide courses in a full range of subjects.

It is already the case that parts of the UK no longer have any universities offering undergraduate courses in physics. If a student from Norwich, for example, who wished to read for a physics degree while living at home, he or she would either have to be successful in the fierce competition for places at Cambridge (60 miles away) or would have to travel over 100 miles to find a university that offered physics[35].

The reason for this problem is that many physics departments have closed, largely because of financial pressures. Since 1993, 30% of university physics departments have closed and 10 chemistry departments. This occurred during a period when the total number of university students increased by 11%"[36]. Each decision to close the relevant department was taken at a local level, with no mechanism for taking into account national needs. Chemistry is currently going through the same process that physics has experienced, and there are serious concerns that existing policies do not appear to allow for any national planning for provision of courses[37].

National responsibility needs to be taken by the government in ensuring the availability of higher education provision in a range of disciplines throughout UK.

Financing the expansion of higher education

Whatever methods the universities use to deliver the expansion of opportunities in higher education, the costs are increasing dramatically.

Current reforms envisage graduates repaying up to £3,000 for each year that they spent at university, and it is supposed that this will bring approximately an additional £1billion into the system, substantially less than most informed parties believe is necessary to achieve the quality and level of education that the public wants and the nation's prosperity may need.

Reasons for the introduction of this system include that limited public resources are better targeted at education problems in schools (which affect everyone, not just the proportion of people who are lucky enough to go to university) and that it is only fair for graduates, who benefit personally from their university education, to make some contribution to the cost[38].

These points are not unreasonable, although the debate has been clouded by unhelpful political positioning, such as the utterly unfounded assertion that current graduates will earn an average of £400,000 more over their working lives than non-graduates[39].

In reality, the public and personal benefits of investment in higher education, are in economic terms, currently about equal, although, as Figure 6.13 shows, the individual benefits relatively less in the UK than in most other industrialised countries.

Apart from Italy, all of the other countries included in the survey weight the ratio of benefits more heavily in favour of the individual student than is the case in the UK. The private rate of return includes the lower risk of unemployment among graduates and the direct effects of public funding for students.

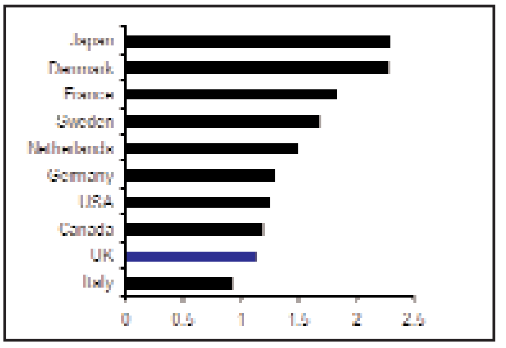

Figure 6.13. Ratio of the private to public rates of return on tertiary education in different countries. The larger the bar on the graph, the more the individual student benefits relative to the taxpayer. Private rate of return is the return on an individual student's investment in their education and public rate of return is the return to the economy of public funding from the taxpayer. The rates are calculated by comparing the costs and economic benefits of tertiary education relative to upper secondary education [Source: *Education at a Glance: OECD Indicators 2002*, OECD, 2003].

Thus, while there are reasonable arguments in favour of individual students contributing a higher proportion of the overall cost of their education, future students will legitimately be looking to ensure that their studies bring them at least as much personal benefit as has been the case up until now. In short, they will become more demanding.

Recent changes to the funding of higher education mean that, whereas universities used to receive twice as much public money for every science student they taught as they did for each arts or humanities student, now they will receive only 1.7 times as much[40]. In other words, the scales have been tipped against the sciences.

In the short-term, the Higher Education Funding Council should restore the ratio of two-to-one between funding for science students and arts students; in the longer-term public investment should be based on the real costs of high-qulity teaching.

Changes in the way that higher education is funded have the potential to bring elements of a market into the system.

The market in higher education

For example, the introduction of variable fees could mean that some subjects are cheaper to study than others, or that it is more expensive to study at some institutions than at others.

While a market among institutions is entirely compatible with the provision of high-quality science education, it would be of concern if in reality, the principal effect of new funding mechanisms was to create a market among subjects.

Good science courses are more expensive to run than courses in many other subjects, partly because of the need to include a substantial element of practical work, most of which is carried out on expensive equipment.

If this leads to differential fees among subjects, it may introduce a disincentive for students to study science, especially those from less wealthy backgrounds. In a perfect market, students would continue to choose science courses even if they were expensive, because they would have good information about their likely potential earnings. For example, graduates in physics and chemistry typically earn substantially more over their lifetimes than graduates in history or lingusitics[41].

However, students currently have poor information. The issues of careers advice are outlined in section 6.8 and students report that they receive a poor standard of information about employability and the earnings potentual associated with science qualifications[42].

Whether or not schools and colleges actively promote the idea that science and engineering are not remunerative subjects to study, it appears to be one that young people readily pick up. It is just one example of the impediment to the working of an idealized market in higher education.

One of the jobs of Governments is to correct market failures. If the introduction of top-up fees, or some future development has a negative effect on the number of young people choosing to study science at university, such that the nation is unlikely to be able to meet the demand for scientific skills, it will be necessary for the universities to offer financial incentives that make the study of science more attractive.

Although some universities are already considering doing so, and ministers in the Education Department believe that it is a 'racing certainty' that physics courses will be offered almost free of charge[43], ministers with overall responsibility for science have said that universities cannot routinely offer substantial discounts on expensive science courses because they need to "cover their costs of doing a subject"[44].

Fees charged to students in the sciences must be at least as low as for other disciplines. Government support is needed to account for the higher costs of running courses in practical work and other time-intensive aspects of higher education.

Current figures from the Higher Education Statistics Agency show that 40% of young undergraduate entrants are studying among the sciences. The distribution between disciplines is shown in Figure 6.14.

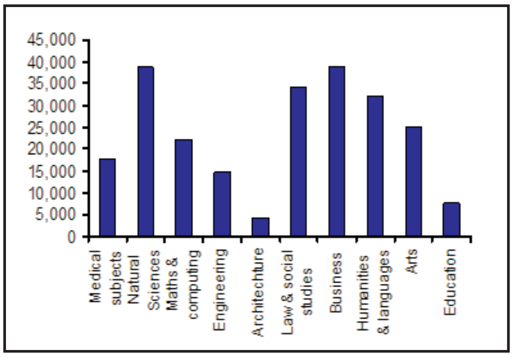

Figure 6.14. Number of students beginning higher education courses in various subjects in 2003 [Source: *Annual Data*, HESA, 2004].

The proportion of students studying science, maths and technology subjects in tertiary education in the UK is lower than in seven other European countries and higher than in 18 European countries.

Meeting the official targets for the European Union as a whole would necessitate at least a 15% increase in the actual number of mathematics, science and technology graduates.

However, in a recent document, the Department for Education and Skills revealed that it had no intention of attempting to increase the *proportion* of graduates in this sector, but rather was aiming to achieve the goal simply by increasing overall numbers entering high education: 'assuming the current (fairly stable) patterns of choice persist, the UK will achieve this target if 50% of 18-30 year olds are taking part in higher education by 2010'[45]. Given that Government officials claim, on good evidence, that patterns of choice are not, in fact, fairly stable, but that many science subjects are becoming less popular[46], this policy is unlikely to succeed.

Shortly after this publication, the then Secretary of State announced that he was asking an eminent researcher 'to spell out what more needs to be done by performing a comprehensive gap analysis on the Lisbon skills agenda for the UK. This will give us specific actions - not more words - that we can work towards over the coming five years'[47].

Responding to an international market

As discussed in Chapter 5, there is an increasing international mobility among academic staff. A similar trend can be found among students.

While the UK continues to attract significant numbers of international students, our proportional share of all who choose to study abroad is in decline[48]. Similarly, fewer UK students choose to study abroad. Just 1.35% of British students at undergraduate level study overseas, compared with 2.55% of French and

2.60% of German students.

Several studies have looked into the reasons why prospective international students might be put off from a particular course, or from studying abroad at all. These provide some sort of guideline as to the changes that are needed in order to continue to attract a good share of international students to the UK.

The UK needs to maintain an international standard of university research, as outlined in Chapter 5. It is also vital that university staff are able to maintain the high standards of teaching, tutorial and pastoral care currently available in many institutions.