TEACHER PROVISION IN THE SCIENCES

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Commissioned by the British Association,
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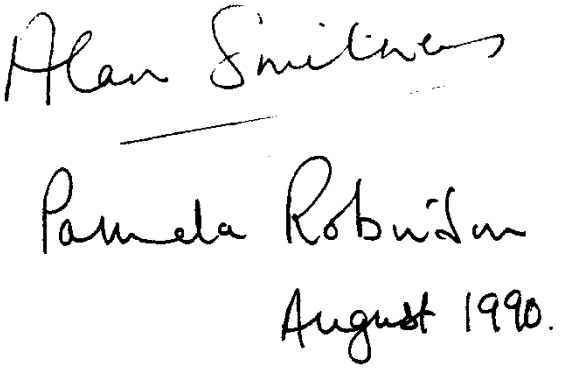

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Contents

Summary

This study is a step towards implementing the British Association's Charter for Action on Science in the Nineties. It is based on a five per cent random sample of schools in England and Wales stratified by type; 195 (87.4%) took part. Extensive questionnaires were completed by: (1) headteachers, (2) heads of science and (3) individual teachers. Interviews were conducted with a ten per cent sub-sample of heads of science, and local authority advisers.

The survey reveals for the first time the nature and extent of 'mismatch' – the lack of fit between a teacher's qualifications and subject taught. It is of two kinds, arising from: (1) not enough physical scientists, particularly physicists, in teaching and (2) the introduction of 'balanced science' into a system where teachers have hitherto mainly identified with the separate sciences.

The lack of physical scientists means that much of science teaching up to age 16 is covered by biologists, an assortment of scientists and engineers, and, in some cases, teachers from outside the sciences. Even at A-level, 30 per cent of physics courses and 20 per cent of chemistry courses are taught by those whose main qualification is not in the subject. But some of those apparently not appropriately qualified, with degrees in, among other things, environmental science, naval architecture and geology, hold PGCEs in physics.

Science teachers are spread very unevenly across schools. Only 10.5 per cent of science staff in maintained schools to age 16 had qualifications in physics, compared with 20.6 per cent in maintained schools to age 18 (among which sixth form colleges fared best) and 22.6'per cent in independent schools. Only 22.7 per cent of the teachers of science in maintained schools to age 16 had a good (first or a 2i) or a higher degree in the sciences compared with 33.7 per cent in maintained schools to age 18 and 49.1 per cent in independent schools.

Over a third of schools (35.6%) indicated that they had not the right balance of staff to teach the National Curriculum in science. About a quarter of the teachers felt that they lacked the experience to teach some of their science courses and a fifth the necessary skills and qualifications. Doubts about experience, skills and qualifications were expressed most often by teachers in secondary modern schools and comprehensives to age 16. Courses in 'balanced science' were seen as the major in-service need of teachers.

Recruitment to teacher training is difficult, particularly in physics, where applications for PGCE courses are on a downward trend in spite of the availability of a bursary. Only about a quarter (27.2%) of the entrants to PGCEs in science are the most recent graduates, the proportion of whom coming forward for teacher training has fallen away steeply over the past decade.

There is over 20 per cent wastage from the training process itself. Teacher retention is also a problem with turnover rates now running at 12.3 per cent for physics, 13.5 per cent for chemistry and 16.7 per cent for biology.

Physical scientists hold an above average number of incentive allowances – 77.7 per cent of chemists (with 33.7% at D and E) and 72.3 per cent of physicists (with 36.9% at D and E) compared to the national average of 60.5 per cent (with 19% at D and E). This suggests that schools may be using the allowances to attract and retain scarce staff, but it carries with it the risk that they are promoted more rapidly out of the classroom.

Staff shortages in the sciences are biting not only in terms of subjects being taught by those with inappropriate qualifications, but also in courses being withdrawn (9.5% of schools) and courses not being put on (12.8% of schools). Over half the schools reported inadequate facilities/equipment and not enough technicians, and 45 per cent indicated insufficient laboratories. Again there were major differences with type of school.

About two-thirds of maintained schools expect to offer 20 per cent science for all pupils in implementing Key Stage 4. Very few (only about 10 per cent of comprehensives to 18) plan to continue to offer separate sciences, but this is the intention of over two-thirds of the independent schools.

Staff shortages and other constraints have meant that AS Exams in biology, chemistry and physics are not being offered in over four-fifths of schools, and where they are available this is rarely as separate courses.

The position for staffing our schools in the sciences seems bleak. We seem to have got into a downward spiral of not enough physical science graduates -> not enough teachers -> not enough young people coming forward -> not enough physical science graduates. It is a vicious spiral which threatens the chances of the young and the prosperity of the nation, and some way must be found of breaking into it.

Recommendations

1. ***That*** ways be found to try to ensure that high quality staff in subjects in short supply are available to foster the enthusiasm of the young in 11-16 schools, and are not mainly drawn off into sixth form teaching, or away from the maintained sector.

2. ***That*** further research be conducted to discover why so few physics graduates are attracted to teaching, and why so few females are attracted to physics.

3. ***That*** research be undertaken to discover to what extent there are teachers in schools with qualifications in the physical sciences not actually teaching these subjects – and what they are, in fact, doing.

4. ***That*** the subject departments in higher education (rather than just the education departments) be involved to a greater extent in science INSET for teachers.

5. ***That*** a more generous programme of support be made available for INSET to underpin the introduction and implementation of balanced science in the National Curriculum, and current provision be fully evaluated to identify what improvements can be made.

6. ***That*** the impression of teachers that initial teacher training is out-of-touch with the needs of the National Curriculum Science be investigated.

7. ***That*** the DES gives careful attention to the targets it sets for science and is clear about how many teacher training places it wants to see offered in balanced science and in biology, chemistry, physics and other sciences.

8. ***That*** a computerised database be set up which would follow all teachers from the start of training to leaving or retirement.

9. ***That*** a broad A-level Diploma be established based on the expectation that all students at this level will continue with some mathematics and/or science after sixteen. In time this should mean more people coming through into the sciences, and to science teaching.

10. ***That*** teacher provision in the sciences is inadequate and demands attention.

I. Introduction

1.1 Last year at its Annual Meeting in Sheffield the British Association launched its Charter for Action on Science in the Nineties. It proposed a four-point programme: (1) encourage the young, (2) start in the classroom, (3) support research, and (4) invest in a future. Over a thousand people in key positions have added their names to the list of signatories since the Charter was first published in the Daily Telegraph in September 1989.

1.2 In carrying forward the second proposal, the British Association, in conjunction with the Association for Science Education and the Royal Society, commissioned the Education and Employment team in the School of Education at the University of Manchester to undertake a survey, in the words of the Charter, "to assess the extent to which there are sufficient teachers in the classrooms with qualifications appropriate to the science they teach". More specifically the researchers were asked:

- to establish the qualifications, training and experience of teachers of science in a representative sample of secondary schools in relation to the subject(s) taught, age range (years 1-3, years 4 and 5, sixth form), and type and location of school;
- to explore the extent of the match between qualifications and subject(s) taught, at different levels;
- to attempt to gain some information on the quality of science teaching in a sub-sample of the schools;
- to consider the balance of teachers available in science departments;
- to reveal what is not being taught due to the lack of appropriate staff, and the ways the curriculum is being tailored to fit what staff are available;
- to consider the impact of the National Curriculum on staffing requirements;
- to record the extent of turnover of teachers of science, and to show how the vacancies are being filled;
- to clearly set out the current position with regard to the requirement for, and availability of, teachers of the sciences.

1.3 In an attempt to provide some answers, existing data have been reviewed and collated, and new information has been collected in a survey of a five per cent random sample of schools stratified by type. Of the 225 schools drawn in the sample, two had closed, and of the others 195 (87.4%) participated. Extensive questionnaires were completed by: (a) headteachers, (b) heads of science and (c) individual teachers. In addition, a ten per cent sub-sample of heads of science, and local authority science advisers with particular knowledge of the schools taking part in the survey were interviewed in depth. Full details of the methods are given in Appendix A.

1.4 The picture which emerges is one of chronic shortage of teachers of the physical sciences, particularly physics. There are so few well qualified physics graduates in the system and so few coming forward that there must be grave concern as to whether the aim of broad and balanced science for everyone to the age of 16 can be realised. In extreme cases, current shortages have already meant that courses have had to be dropped, classes have had to be split and some subjects have not been offered. Very few schools in the sample were putting on .AS courses in the sciences, and most of those not doing so gave lack of staff and resources as the reason. As well as teachers, there is a desperate shortage of lab technicians, and many schools reported too few laboratories and lack of equipment.

1.5 There were however major differences between schools, with the independent schools and sixth form colleges faring best, and conditions often being dire in the secondary moderns (which still exist) and some of the comprehensives without sixth forms. With not enough science teachers to go round those schools with most to offer are taking their pick and the rest are coping as best they can. Severe imbalances are emerging, which are not only grossly unfair but inefficient from the point of view of the economy, particularly since there is evidence that scientists tend to come from a working-class background[l].

1.6 In the next chapters we set out the detailed information to substantiate these claims. We begin with the existing stock of science teachers. Then we consider the flows into and out of the system, and what this means in terms of vacancies, hidden shortages, staff imbalances, courses being dropped and classes split. We then turn to resources to see if schools feel they have adequate equipment, laboratories, and support staff to deliver the National Curriculum in science. In Chapter VII we give special attention to the introduction of balanced science and its implications for in-service and initial teacher training. We conclude by examining some of the dilemmas of science education. In particular, we ask how is it going to be possible to attract more able young physical scientists into teaching?

II. Stock

2.1 Does the country have enough science teachers? An important question to ask, but a hard one to answer for several reasons. One is conceptual in that it is difficult these days to know what is to count as a science teacher. With the increasing tendency to treat 'science' as one subject, is it still reasonable to think in terms of teachers of physics and the other sciences? And, if so, how are they to be defined – in terms of their degree or certificate, PGCE training, subject taught or the slot they occupy on the timetable?

2.2 Another great difficulty is the poor quality of the data available. One consequence of the highly' devolved nature of education in England and Wales is that there is no comprehensive and up-to-date source of information. Whatever may be said about the Database of Teacher Records (essentially the pension files), the DES, like everyone else, has difficulty in saying precisely how many teachers we need, how many we have, what their qualifications are, and how they are deployed.

2.3 Our survey was designed in part as a census to provide some new basic information. Grossing up from our sample to all schools in England and Wales (using the data of Tables A1 and A3 in Appendix A) it appears that at the time of the inquiry in April 1990 there were 33, l57.4 full-time equivalent (fte) science teaching posts in maintained schools. There were a further 6814.4 ftes in independent schools giving a grand total of 39,973.8 ftes – in round figures 40 thousand.

2.4 The estimate for maintained schools compares not badly with that found by the DES in its 1988 Secondary School Staffing Survey[2]. Based on a ten per cent sample it estimated that there were 29,464 full-time teachers with science qualifications in England. When adjustments are made to include Wales, and part time teachers, this becomes 33,187.6 ftes. At first sight this is a pleasing congruence, but it must be remembered that our figure is for subject taught and the DES's is for subject of qualification.

Table 2.1: Science Teachers by Subject of Qualification and Subject Taught[1]

Subject	Biology	Chemistry	Physics	General Science	Other Sciences	Non Science
Degree or Certificate	33.3	23.7	18.8	5.2	15.6	3.4
Main[3] Subject Taught	27.3	22.4	23.8	25.9	0.6[2]	-

1. Of full-time teachers (N=878).
2. Earth Science.
3. By length of teaching experience. Equal experience in two or more subjects treated as 'science'.

2.5 This distinction becomes especially important when we attempt to go beyond the overall figure for science teachers to try to see what the position is in the individual subjects. Table 2.1 shows major differences with the criterion – qualification or teaching – used. Essentially it reveals two kinds of mismatch: (1) subject-subject – more people teaching physics, for example, than have physics as their main qualification, and (2) specialist-generalist – 'science' being taught by those qualified only in particular aspects.

Subject/Subject Mismatch

2.6 Both types of mismatch are being bridged by specialists going beyond their particular disciplines. Table 2.2 shows that much of the science teaching up to GCSE is by biologists. Only about one in seven teachers in Years 7 and 8 (ages 11 and 12) had a main qualification in physics, though the position improved slightly for the GCSE years.

Table 2.2: Subject Qualifications of Science Teachers by Year Group

Subject of Qualification[1]	Per Cent[2] of Science Teachers		
	Years 7/8 (Age 11-12)	Year 9 (Age 13)	Years 10/11 (Age 14-15)
Biology	37.3	36.0	35.2
Chemistry	23.9	24.2	24.6
Physics	14.5	16.0	17.5
General and Combined Science	6.9	6.2	6.3
Other Sciences and Technology	13.9	14.6	13.6
Non-Science	3.5	3.0	2.9

1. Main subject of degree or teachers' certificate, full-time teachers only.
2. Of 620 for Years 7/8, 711 for Year 9, 892 for Years 10/11.

2.7 At A-level there is a specific requirement for teachers of the individual sciences, and many schools deploy their scarce physical scientists at this level. But even so, as Table 2.3 reveals, there are apparently mismatches here also. The great majority of the biology teaching is by biology specialists, but 30 per cent of the physics, and 20 per cent of the chemistry, A-level courses are taught by teachers without degrees or teachers' certificates in those particular subjects.

2.8 The 1988 Secondary School Staffing Survey has also revealed high levels of mismatch between qualification and subject taught. It shows 31 per cent of those teaching physics, 20 per cent of those teaching chemistry and 18 per cent teaching biology had no post A-level qualification in the subject. But it has never been clear exactly what the qualifications of the 'inappropriately qualified' really are. Our survey examines this in detail for the first time.

Nature of Mismatch

2.9 In fact, very few of the teachers have no post-A-level qualifications at all in the sciences, though there was a sprinkling of teachers (5.7 per cent, see Table B1 in Appendix) even up to GCSE and beyond, whose qualifications were in such subjects as art, PE, history and music, and who appeared to have picked up science as they went along. In one secondary modern school the head of the science department had a teachers' certificate in art but "had taught himself science".

Table 2.3: Match[1] between Qualifications and Courses Taught at A-Level

Subject of Qualification[2]	A-Level Courses			
	Biology (N=417)	Chemistry (N=349)	Physics (N=342)	Other Science (N=43)
Biology	90.2	2.5	0.3	18.6
Chemistry	1.3	79.9	6.3	9.3
Physics	0.0	1.3	69.3	37.2
General or Combined Science	1.1	3.5	4.7	2.3
Other Science and Technology	6.6	12.3	16.3	32.6
Non-Science	0.8	0.6	3.1	0.0

1. Percentage of courses taught by teachers with main qualifications in the subject.
2. Main subject of degree or teachers' certificate, full-time teachers only.

2.10 The shortfall in physical scientists pre-16 is met mainly by biologists and teachers with an assortment of science and technology degrees including biochemistry, metallurgy and various kinds of engineering. Post-16 teachers of physics without physics degrees usually had studied the subject to subsidiary level or had taken a not-unrelated degree. Table 2.4 shows A-level science teachers by their highest qualification in the subject. Most held degrees in the subject they were teaching though over a fifth of the physics teachers had studied the subject to no higher than subsidiary level. But they were usually graduates of subjects like materials science, metallurgy, or engineering. A number of these teachers had in fact taken a PGCE in physics, including, as well as the subjects already mentioned, some with degrees in environmental science, geology and naval architecture. As we shall be seeing in Chapter III, only about 70 per cent of those with a PGCE in physics had degrees in that particular subject so 'mismatch' (if it can be called that) begins in recruitment to the training process.

Table 2.4: Science Qualifications of A-level Teacher

Highest Level of Qualification in A-Level Taught	Biology (N=204)	Chemistry (N=176)	Physics (N=178)
PhD	0.5	7.4	1.1
MSc	1.5	4.5	0.6
BSc (1 or 2i)	30.4	25.6	18.0
BSc (Other)	51.4	42.0	48.9
BEd	4.9	4.5	5.1
Graduate Equivalent	0.0	0.6	2.2
Subsidiary Subject[1]	7.4	10.8	21.9
Teachers' Certificate	3.4	2.3	0.6
A-Level	0.5	1.7	0.6
Other	0.0	0.6	1.1

1. Or not-unrelated degree course.

Differences Between Schools

2.11 There does not seem to be enough well and appropriately qualified teachers of science to go around. Table 2.5 shows how the teachers are distributed across the different kinds of schools by subject of qualification. Schools without a sixth

form (comprehensive to 16 and secondary modern) seem to be in particular difficulties with only about ten per cent of their science staff having physics degrees or certificates, and less than 20 per cent having qualifications in chemistry. Maintained schools to 18 did somewhat better, and within this category sixth form colleges in particular had a good balance of science staff. The same also appeared true of the independent schools.

Table 2.5: Subject of Qualification[1] by School

Subject	Type of School		
	Maintained to 16 (N=191)	Maintained to 18 (N=528)	Independent (N=159)
Biology	39.3	32.2	29.6
Chemistry	18.8	22.3	34.0
Physics	10.5	20.6	22.6
General Science	11.0	4.2	1.9
Other Science	16.8	16.9	10.1
Non-Science	3.7	3.9	1.9

1. Degree or teachers' certificate.

2.12 Table 2.6 examines the qualifications of science teachers in the different types of school by level and again there appears to be a gradation from the maintained schools without sixth forms to the independents. Among the maintained schools the sixth form colleges also did particularly well in terms of levels of qualifications.

Table 2.6: Level of Qualification by Type of School

Qualification[1]	Type of School		
	Maintained to 16 (N=189)	Maintained to 18 (N=528)	Independent (N=159)
PhD	2.6	4.4	8.2
MSc	5.3	8.7	12.6
BSc (1 or 2i)	14.8	20.6	28.3
BSc (other)	40.2	51.1	45.3
BEd	14.8	4.9	3.1
Graduate Equivalent	1.1	0.8	0.0
Teachers' Certificate	16.4	5.1	1.3
Overseas	0.5	0.6	0.6
Non-Science	4.2	3.8	0.6

1. Full-time teachers only.

Qualifications and Quality

2.13 Thus far we have been talking about qualifications, but, of course, ultimately it is the quality of teaching (and what this does for learning) that counts. The heads of science and science advisers to whom we spoke in depth differed somewhat in their views on the relationship between qualifications and quality. A common view was that:

The quality of teachers bears a general relationship to their academic qualifications. In general, the more academically qualified teacher is likely to be a better classroom teacher, but this is not necessarily so, as sometimes the more qualified teachers (with a higher degree) can often be out of touch with what is required as far as classroom delivery of teaching and learning. Their expectations of the education system may be too high.

(Science Adviser, North West)

The scepticism about higher degrees was echoed by a head of science in the South East:

We've had over the past years several PhD's who were a total disaster as teachers and my experience is that although you need good science backup, personality and the ability to handle young people come first.

Some felt there was little or no relationship:

I don't think a piece of paper makes you a better teacher. I, in fact, started with a teachers' certificate, then I got my university degree and worked up. But it has not made me a better teacher.

(Head of Science, London)

But a more general feeling was that teachers benefitted from the confidence of having studied a subject in depth so that they could share their enthusiasm and feeling for it:

I think it's important too that pupils have the experience of being taught by, for example, a physics teacher because of the depth he can give to the subject.

(Head of Science, Wales)

2.14 In this chapter we have been considering the first kind of 'mismatch' – the appropriateness of a teacher's qualifications for teaching a particular science, and we shall be turning to appropriateness for teaching 'balanced science' in Chapter VII. But, so far, we have begged the thorny question of 'appropriateness' and considered match in terms of the labels given to courses. Does it matter that physics is being taught in the first years of secondary schooling by a biologist and at A-level by someone with a degree in textile technology? In terms of bringing physics alive to pupils we would have thought that it did, though some non-matching degrees will be more appropriate than others. We will be taking this further in the final chapter. For the present let us note that it reflects the difficulty of getting physics graduates to become teachers.

III. Supply

3.1 Stock is the resultant of supply and loss. If there are not enough science teachers in our schools this could be because supply is inadequate, or too many are leaving, or both. Here we examine supply and, in the next chapter, retention.

Perceptions

3.2 The experience of the headteachers in our sample is that supply is a problem. Table 3.1 shows that over half of those able to comment (some had not been in post very long, or had made very few appointments) indicated that, in their view, applications for posts had gone down over the past five years. For physics posts, 85.1 per cent said that there were now fewer applicants, and for chemistry 73.6 per cent. The position in biology was somewhat brighter but even here over half said fewer applicants. Neither is it just science. For other posts, again over half said 'fewer'.

Table 3.1: Headteachers' Impressions of Changing Number of Applicants

% Change Over Last Five Years[1]	Biology (N=125)	Chemistry (N=121)	Physics (N=128)	Non-Sciences (N=154)
More	11.2	4.1	2.3	7.1
Same	36.8	22.3	12.5	37.0
Fewer	52.0	73.6	85.2	55.8

1. In total 188 headteachers.

3.3 The headteachers' perceptions were also that the quality is lower. Table 3.2 shows that again the situation seems worst in physics, followed by chemistry, with biology not differing much from the non-sciences. Quality was not perceived to have gone down as much as quantity.

Table 3.2: Headteachers' Perceptions of Quality of Applicants

% Change Over Last Five Years[1]	Biology (N=119)[1]	Chemistry (N=117)[1]	Physics (N=125)[1]	Non-Sciences (N=148)[1]
Better	10.1	8.5	12.0	14.2
Same	58.8	42.7	31.2	51.4
Fewer	31.1	48.7	56.8	34.5

1. In total 188 headteachers commented, the others not being able to say.

3.4 The impressions of the headteachers on numbers of applicants are supported by the heads of science and local authority advisers who we interviewed:

> *I consider that so far I have been very lucky with applicants, i.e. one job, one applicant, but sooner or later the luck will run out.*
>
> **(Head of Science, London)**

> *The other vacancy which was for a physics teacher, we advertised nationally and had NO applicants at all so we are one short for next term.*
>
> **(Head of Science, South East)**

The people coming forward are able to be 'choosy':

> *We are having considerable difficulty in recruiting certain kinds of teachers, despite quite a rigorous campaign, particularly before Easter. Many candidates for first appointments were interviewed, were offered the posts, may even have verbally accepted posts, but we believe they have probably taken anywhere up to five or six interviews and are then very much playing the market. I would describe it as gazumping.*
>
> **(Adviser, London)**

London and the South East seem to have special difficulty, but recruitment is a problem, too, in other parts of the country. It also depends on the specialism:

> *We have had some very good applicants for biology and chemistry but the physics has been noticeably weak. We have just appointed a chemist and for that post we had sixteen applicants and from that we were able to shortlist about five who on paper were very, very good indeed. We interviewed three and could have appointed all three. At the same time for a physics post we had eight applicants and we interviewed three and we couldn't appoint. For biology we would possibly get 25 or more especially at this time of year (Whitsun), from a national advertisement. We had one late applicant who came in and was appointed, although I wouldn't say that I was one hundred per cent happy. If he had been one of the three chemists that I interviewed he would have been bottom of that list. As a physics post it was a case of take it or leave it.*
>
> **(Head of Science, North West)**

Trends

3.5 In order to see if these personal experiences reflect a national supply problem we need to look in detail at the figures. Essentially, there are four components of supply: new supply, moves between schools, re-entrants and overseas recruitment.

3.6 To see how many new teachers are becoming available we need to further distinguish the stages of the process: applications to courses, entries, successful completions and entry to teaching. The applications and entries also need to be considered in relation to the targets set by the DES.

Targets, Applications and Entries

3.7 There are difficulties of two kinds with the science target. First, since there is, as yet, no satisfactory model which will accurately project future trends, it is not objectively determined, but emerges from some sense of what is needed. How it is arrived at has not been made explicit and we cannot be sure how appropriate it is (why, for example, was it reduced in 1989 compared to 1988 as seems to be the case from Table 3.3).

Table 3.3: Recruitment to Teacher Training in Science 1987-89

Course	1987		1988		1989	
	Target	%Intake	Target	%Intake	Target	%Intake
BEd	185	69.7	238	57.1	239	66.1
PGCE	1471	106.3	1547	91.8	1513	95.7
Total	1656	102.2	1785	87.2	1752	91.2

Source: DES.

3.8 A second difficulty is that the target is for science rather than specialisms, and we cannot be sure what mix is intended. Taking the overall target, we can see from DES figures, Table 3.3, that entry to courses reached target in 1987, but was about ten per cent below in 1988 and 1989.

3.9 It has been the practice of the DES to divide the overall target by three to arrive at notional targets for biology, chemistry and physics and this led to the publication of some alarming figures in Hansard[3] in March this showing that physics recruitment to teacher training reached only 52.7 per cent of target in 1989, and chemistry recruitment 68.5 per cent. However, dividing by three takes no account of 'other sciences', or more particularly 'combined science', which, with the move towards 'balanced science' in the National Curriculum, might be expected to be on the increase.

3.10 Following very helpful discussions with the DES, we decided that the best way of arriving at notional targets for biology, chemistry and physics was to subtract entries for 'combined' and 'other sciences' from the overall science target (in effect, assuming target had been reached in these cases) and then dividing by three. When recruitment to PGCE courses is expressed in this way, as in Table 3.4, it can be seen that biology is exceeding target, but there are shortfalls in chemistry and, more particularly, in physics.

Table 3.4: Recruitment to PGCE Courses[1]

Subject	Per Cent of Target[2]				
	1985	1986	1987	1988	1989
Biology	96.5	97.9	104.0	108.6	110.0
Chemistry	89.6	75.9	88.3	67.6	89.2
Physics	80.7	104.4	116.2	87.0	64.1

1. University and polytechnic.
2. Targets notional – arrived at by subtracting from the overall science target entries for 'combined science' and 'other science' and dividing by three.

Source: Annual Reports 1985-89, GTTR. DES Private Communication, August 1990.

3.11 A bursary was introduced for physics in 1986 and that seems to have raised recruitment in that year and the following one, but its effect seems to have been short-lived. The bursary introduced for chemistry in 1989 increased recruitment last year (though not to target levels) and it will be interesting to see what happens. Applications to the 3 August were 600 this year compared to 577 at the same stage last year. In physics, however applications are continuing to fall, down from 553 to 407, and biology, where applications have been buoyant, has also gone down – from 808 to 730.

3.12 It is commonly assumed that PGCE courses are mainly filled by new' graduates, but the 'first destinations'[4] statistics of Table 3.5, show that few graduates are moving straight on to teacher training, and the proportion is declining. In biology the proportion has dropped to a third, in chemistry to a half, and in physics, where it has never been very high, it is now below 100.

Table 3.5: Percentage of New Graduates[1] Going on to Teacher Training

Subject	1978	1980	1982	1984	1986	1988
Biology	13.3	11.2	8.1	6.1	7.1	4.7
Chemistry	8.1	8.4	8.8	7.0	5.3	3.6
Physics	5.8	7.8	7.6	6.1	5.3	4.2

1. University and Polytechnic.
Source: University Statistics Vol II, 1978 to 1988. First Destinations of University Graduates. Cheltenham: Universities Statistical Record. AGCAS, First Destinations of Polytechnic Students Qualifying in 1978 to 1988. London: CDP.

3.13 Graduate output in the sciences has risen by over 20 per cent since 1978 (when we were just coming out of a small demographic dip) but the percentage decreases of Table 3.5 are not just relative to the increase. In each case they represent a fall in actual numbers of new graduates coming forward for teacher training – from 355 to 124 in biology, 153 to 86 in chemistry, and 100 to 96 in physics.

3.14 Even allowing that since information was only available on about 90 per cent of new graduates, the actual numbers could be ten per cent, higher, they' represent only just over' a quarter (27.3%) of entries to PGCE courses. This must mean that about three-quarters of entrants to biology, chemistry and physics PGCE courses are not new graduates in the particular discipline, but have deferred a year or two, or are mature entrants, or are graduates of another subject. This is not necessarily a bad thing. It breaks the conveyor belt from school – to higher education – back to school again. Mature and deferred entrants will bring valuable experience of the world into the classroom. But we should note that it is happening.

Table 3.6: Teacher Training[1] and Subject of Degree

PGCE	Degree						
	Biology	Chemistry	Physics	Geology	Bio-Chemistry	Other Sci Tech	Non-Science
Biology (N=141)	92.9	0.7	0.7	0.7	2.8	1.4	0.7
Chemistry (N=127)	7.9	74.0	2.4	2.4	8.7	4.7	0.7
Physics (N=106)	0.0	3.8	69.8	4.7	0.0	20.7	0.9

1. PGCE Only

3.15 We can infer from the data of Table 3.4 that PGCE courses in physics and chemistry cast their nets widely, probably because they have to rather than through choice. Table 3.6 shows that only 74.0 per cent of the entrants to chemistry PGCE courses and 69.8 per cent of the entrants in physics held

degrees in those actual subjects. Chemistry recruits quite extensively from biochemistry and physics from a wide variety of other sciences and technologies.

3.16 The relative difficulty of recruiting to the physical sciences is also brought out by the degree classes of entrants to University PGCE courses shown in Table 3.7 based on data collected by the Universities Council for the Education of Teachers. In 1988, the latest year for which figures are available, and which is consistent with previous years, over a third of the chemistry and physics entrants had a third class honours degree or lower, whereas in English, history and geography over 90 per cent had a 2.2 or better. Biology in this respect behaved more like the non-sciences.

Table 3.7: Degree Class of Entrants to University PGCE Courses in 1988

Subject	Degree Class[1]						
	Higher	1st	2i[2]	2ii	3	Pass/General	Other
Biology	10.3	2.8	35.7	38.3	6.3	3.8	2.8
Chemistry	7.1	4.5	20.1	33.2	15.7	16.4	3.0
Physics	6.1	4.3	22.0	33.3	9.1	13.9	1.2
English	5.9	3.7	45.7	35.4	4.2	3.3	1.7
History	2.5	4.7	49.0	39.1	3.1	1.6	0.0
Geography	2.3	2.3	38.2	49.8	4.9	2.3	0.3

1. Row percentage.
2. Includes undivided seconds.
Source: First Destination Survey of Students Completing University Courses of Initial Teacher Training for the Teaching Profession in 1989 England and Wales, UCET: London.

Completions and Appointments

3.17 Not only is it hard to attract physical science graduates to train to be teachers, but the training process itself appears very wasteful. In 1987-1988, Table 3.8, based on data provided by the Graduate Teachers Training Registry and UCET, shows that nearly a quarter of those taking university chemistry PGCE courses, and nearly a fifth of those taking physics PGCE, were not teaching, nor still seeking a post, in the December following their courses. Since it is not regarded as a shortage subject no comparable figures are available for biology.

Table 3.8: Flows Through PGCE Courses in Universities 1987-1988

Subject	Entries[1]	Completions	In Post/Seeking a Post	Wastage
Biology	325.5	294	na	na
Chemistry	322.5	289.5	244.5	24.2
Physics	393.5[2]	327	316.5	19.6

1. Intake.
2. Includes 19 on a two-year conversion course who entered in 1986.
Source: Annual Report, Autumn 1987 Entry, GTTR: London. First Destination Survey of Students Completing University Courses of Initial Teacher Training for the Teaching Profession in 1988, UCET: London.

Re-entrants

3.18 Newly-trained teachers are only one of the sources of supply. Table 3.9 shows that about one in eight appointments were people coming back into the

profession after taking time out. Re-entrants comprise about a quarter (24.5%) of inflow (that is, excluding moves between schools). This is the first hard information on re-entry to particular subject areas at the secondary level, since the statistics currently available are only for graduates and only for subject of qualification. It is considerably less than the overall figure[5] of nearly 60 per cent (57.0%) indicating that many returners are going to primary and nursery schools. It corresponds quite well to the estimate of 19 per cent we made for 1984-85[6].

Table 3.9: Source of Appointments[1, 2] in Maintained Schools

Subject	Young Probationer	Mature Entrant	Re-Entrant	Transfer/ Promotion	Re-Deployed
Biology (N=90)	21.1	11.1	14.4	45.6	7.8
Chemistry (N=52)	26.9	26.9	7.7	30.8	7.7
Physics (N=47)	25.5	8.5	17.0	46.8	2.1
Other Sciences (N=12)	41.7	16.7	8.3	25.0	8.3
Total (N=201)	**24.9**	**14.9**	**12.9**	**40.8**	**6.5**

1. Row percentage.
2. Based on responses of 152 Heads of Science.

Overseas Recruitment

3.19 We found very few qualified teachers (that is, having QTS) with overseas qualifications in our sample which is consistent with the national overall figure[7] of 0.3 per cent, but this is another area in which information is sparse and in view of the current attention recruitment overseas has been receiving would be worth a study in its own right.

Transfers

3.20 About 40 per cent of new appointments are, in fact, transfers from other schools, either initiated by the teacher or through re-deployment. The difficulty that schools have in filling posts represents an opportunity for teachers to move onwards and upwards. Within itself, teaching is a highly mobile profession.

IV. Retention

4.1 The other side of the 'supply coin' is retention. Holding on to the good teachers we have would reduce the need for new supply. However, the data of the Local Authorities Conditions of Service Advisory Board[8] suggest that teacher resignations are on an upward trend. In 1987 resignations from the secondary school sector were 9.8 per cent of strength, and in 1988, 11.6 per cent. The revised figures (taking into account autumn resignations) from our own study, Teacher Loss[9], which is looking at teaching resignations and appointments in detail, suggests that, in 1989 it could be even higher.

Resignations

4.2 Table 4.1 shows that resignations of full-time science staff from maintained schools in 1989-1990 were running rather above the 1988 levels at 16.7 per cent for biology, 13.5 per cent for chemistry and 12.3 per cent for physics. These compare with LACSAB's figures for 1988 of 11.1 per cent, 10.4 per cent and 11.5 per cent respectively. Resignations at the rate found in the current study suggest that the equivalent of the whole science staff is turning over every seven years.

Table 4.1: Resignations[1] of FT Teachers from Maintained Schools, 1989-90

Subject	Posts	Per Cent	
		Resignations	Vacancies
Biology	431	16.7	1.0
Chemistry	355	13.5	1.4
Physics	367	12.3	3.5
Other Sciences	115	9.5	9.5

1. Based on responses of 152 Heads of Science.

4.3 Resignations, however, do not equate to loss from the profession. They could also be to take a post at another school since teachers have to resign from one school to take appointment in another. Shortages create opportunities to move:

> *We had a physicist for one year who was so good that he has been snapped up.*
>
> **(Head of Science, North)**

> *We had a vacancy a year ago for a physicist but that was filled by someone who came from another school in the town but that same person is now leaving after a year.*
>
> **(Head of Science, South East)**

> *I think it will be quite hard to retain science graduates, particularly physicists, because they will want to go off to a sixth form. They will look at the demands of the balanced science courses and the courses I've seen so far have been quite disappointing, and I think that a lot of staff will then try to get some sixth form work.*
>
> **(Head of Science, Wales)**

4.4 Not all teachers resigning leave the profession and not all leave permanently. Previous studies[10] have shown that about half resignations are for movements between schools. This would be consistent with the appointments information in Table 3.10. But whether the person is going to another school or not is still a loss to the school he or she is leaving:

> *We had one member of staff leaving at Christmas, and we couldn't get a replacement until Easter. We managed to get some science supply, but this was rather patchy. Since then we have had FOUR people hand in their notice for the end of the year and so that has really left a big gap, the main problem being that one of them was our one and only physicist, and we have had a lot of problems getting someone who could do the A-level physics.*
>
> **(Head of Science, London)**

Vacancies

4.5 The schools in our survey were generally able to make appointments 'to the vacancies arising but some had not been filled at the time of the inquiry. Vacancy levels of about one per cent can perhaps be expected in a dynamic system with people continually moving in and out, but the 3.8 per cent in physics may reflect the difficulty of making appointments. The vacancy levels shown in Table 4.1, while of a similar pattern with physics > chemistry > biology, are rather higher than those obtained in the January 1990 DES's vacancy survey[11], of which were published on 17 July 1990 as a press release. This may be due to the method of data collection. In the DES's survey, local authorities are asked to return information on "advertised vacancies for full-time permanent appointments" whereas in the present study heads of science were asked to give details of "any vacant posts for science teachers in your school" which could therefore have included posts that had been frozen or were not for some other reason being advertised.

Table 4.2: Incentive Allowances

Incentive Allowance	Biology (N=243)	Chemistry (N=148)	Physics (N=119)	Total[1] (N=687)	National Figures[2]
E	2.9	10.1	9.2	6.7	4.3
D	18.5	23.6	27.7	21.3	14.7
C	8.2	5.4	5.9	8.3	6.0
B	23.9	24.3	23.5	22.9	25.8
A	13.2	14.2	5.9	11.4	9.6
MPG	33.3	22.3	27.7	29.5	39.5

1. Includes general science, other science and non-science.
2. **Source**: Third report of the Interim Advisory Committee on School Teachers' Pay and Conditions 30 Jan 1990, London: HMSO.

Incentive Allowances

4.6 The House of Commons Education, Science and Acts Committee in its recent report on Teacher Supply (1990)[12] proposed paying higher salaries to teachers in shortage subjects, and that has received some measure of support from the

government. In fact, as the data of Table 4.2 show, science staff treated as a group tend to hold more and higher incentive allowances than teachers generally, but this was particularly the case for the physical scientists. The biologists (who were more often female) were some way behind, particularly at the highest levels (see Table B.2).

4.7 Incentive allowances seem to be accepted as a 'hidden' way of attracting and retaining scarce science staff:

> *..... giving an A allowance to the science teacher for being deputy head of the year or careers teacher. It's quite a worry across the county that quite a lot of science teachers have responsibilities in other areas of the school's administration, which tends to cause us to lose focus. I'm not saying that that's not necessarily philosophically a bad thing but at a time of rapid development and change in science it can present organisational difficulties.*
>
> **(Science Adviser, Wales)**

But it carries with it the risk that the teacher will soon be promoted out of the classroom:

> *One thing I would like to encourage, is that science teachers are provided with opportunities for reward, promotion, incentives, for remaining as science teachers. Inevitably what happens is that you race up the promotion ladder, you get on because you're a physicist and they're short of physicists, you go into a year head role, or a deputy role, and that takes you out of the science area, reduces your time. But there are relatively few ways you can progress without getting side-tracked, so I think a very positive way to encourage science people would be to provide incentives for them to teach science and be good practitioners in that area without having to go off and take on a whole pile of other work.*
>
> **(Science Adviser, Yorks and Humber)**

One aspect of science teacher supply on which we need more information is how many teachers there are with science qualifications not teaching science because of other responsibilities.

Differential Salaries

4.8 On differential salaries, the heads of science and science advisers were divided:

> *I can see it creating' difficulties in the classroom with resentment from people who are not teaching shortage subjects, but I can see no other way of recruiting physicists and mathematicians because they can get so much more in industry and commerce that unless there is a big increase they will not come into the profession.*
>
> **(Head of Science, London)**

> *Well I suppose it's a solution to the problem, but my own feelings are there are other shortages, and science teachers are just one*

aspect. I think to pay physics teachers £2000 or so extra isn't going to solve the problem.

(Head of Science, South East)

I think it's extremely problematic, and I don't think it would be successful because we found that, possibly because of our demographic changes and cost of housing in the area, that it's very difficult to identify a shortage subject over and above everything else. I mean, for example, some schools find it more difficult to recruit a PE teacher than anything else. So it would be very difficult to identify a particular subject as a problem. The only incentive of course is for people trained in other areas to convert themselves. I don't think it would work.

(Science Adviser, East Anglia)

With performance-related pay they could see even more difficulties. In particular, how is performance to be judged, how are differences in intake to be taken into account, and how would it be comparable across subjects? The spectre of 'payment by results' was raised again.

4.9 The leaching away of staff may be affecting teacher quality:

I have seen the calibre of staff really decline over the last five or six years, and this is in most subjects. I have not yet come across a young science teacher who I could say THAT will be a future Head of Science and II think the reason is that teaching has ceased to be an attractive proposition and this is because we have lost total morale because there have been so many national changes so rapidly. We tried to keep up, but in the end we are quietly being drained and squeezed out of the profession. I think that the teacher strikes had a very debilitating effect and I don't think they will ever get back from that. I have got my application forms for Australia. I have applied for a visa and I am going.

(Head of Science, Wales)

V. Shortages

5.1 Shortages bite in various ways. Posts may be left unfilled or appointments may be made of people with less than the desired quality or qualifications. (If they are permanent appointments this causes with it the problem of prolonged mismatch). We have already looked at vacancies and the appropriateness of qualifications. In this chapter we turn to other ways in which lack of staff may be coped with – tailoring the timetable, splitting classes and not putting on courses.

Balance of Staff

5.2 Table 5.1 shows that about a third of heads of science in maintained schools with pre-16 pupils did not think that they had the right balance of staff to teach the National Curriculum.

Table 5.1: Some Hidden and Suppressed Shortages

School Type	% Not Right Balance of Staff to Teach NC	% Split Teaching of Science Classes	% Courses Withdrawn, Amended, Reduced	% Courses Not Offered
Comprehensive to 16 (N=46)	32.6	28.3	8.7	6.5
Comprehensive to 18 (N=77)	39.0	32.5	14.3	18.2
Sixth Form College (N=6)	-	16.7	0.0	0.0
Secondary Modern (N=13)	23.1	23.1	7.7	7.7
Grammar (N=10)	40.0	20.0	0.0	10.0
Independent (N=27)	-	14.8	3.7	17.4
Total (N=179)	**35.6**	**26.8**	**9.5**	**12.8**

5.3 The comments fell into three main groups – (1) lack of a particular kind of scientist, usually a physical scientist; (2) difficulties of teaching balanced science; and (3) the problems of introducing earth science:

Shortfall in Physical Science

Lack of experienced/qualified staff in chemistry.

(Secondary Modern)

More physics specialists required.

(Secondary Modern)

Need more physics and chemistry specialist staff or training for existing staff.

(Comprehensive to 16)

Deficient in physics specialists as from the end of the year due to staff member going abroad.

(Comprehensive to 16)

We are weighted heavily towards biological sciences; chemistry and physics specialisms poorly supported.

(Comprehensive to 16)

Physics teachers required, balance is towards biological sciences.

(Comprehensive to 16)

For historical reasons our faculty is staffed to provide a bias ix: the biological/agricultural science area.

(Comprehensive to 16)

The present staff are excellent but lack experience in physics, particularly with I.T. and computer-related aspects of the National Curriculum.

(Comprehensive to 16)

Too many biologists, not enough chemists.

(Comprehensive to 16)

The only chemist in the school is the headteacher, who is only available 4 to 6 periods a week.

(Comprehensive to 16)

The only teacher with a degree in. physics is part-time; the others who teach physics have physics as a subsidiary subject in their degree. One person with a chemistry degree teaches physics most of the time.

(Comprehensive to 16)

Short of physicists. We have older staff – not easy to adjust to curriculum innovations – Earth Science is a problem, will have to use geography teachers.

(Comprehensive to 18)

Stronger on the biological side, and weakest on the physics side.

(Comprehensive to 18)

Light on chemists.

(Comprehensive to 18)

Biased too much towards biological science.

(Comprehensive to 18)

Great shortage in physics.

(Comprehensive to 18)

Over-preponderance of biological specialists.

(Comprehensive to 18)

Shortage of expertise in. physics – only one teacher able to teach electronics – biologists abound.

(Comprehensive to 18)

(Only one school – a grammar school – reported being short of biologists.)

Difficulties of Teaching Balanced Science

Lack staff who can teach balanced science to GCSE.

(Grammar)

We can cope at the moment with the present balance of specialisms – I hope that as we develop balanced science more staff will be prepared to extend their range of teaching.

(Grammar)

(1) We are all specialists (2) We have started to cross fertilise but need to do this properly.

(Comprehensive to 18)

Further training is needed so that all the staff can teach all elements to the end of Key Stage 4.

(Comprehensive to 18)

I feel the development in areas beyond subject specialisms would help all.

(Comprehensive to 18)

Introducing Earth Science

We can manage, but is this ideal? Staff will have to re-train themselves to a certain extent for AT9 and AT16.

(Comprehensive to 16)

We need INSET for AT16 Earth in Space, AT9 Earth and Atmosphere, and AT12 I.T. and microelectronics. We do feel deficient in these areas but we are 'teaching' ourselves.

(Comprehensive to 18)

Earth science not catered for at all, light in the physics areas, one chemist and one biologist may create experience problems. We will be in fact short of scientists when NC comes on stream for all years. There is already going to be a shortfall this coming September which will mean drafting in help from non-specialist staff with attendant problems.

(Comprehensive to 18)

Whilst INSET and re-training are integral parts of our staff development, we are still weak in confident physics specialists, and earth science. One science staff is undertaking responsibility for technology which also weakens our chemistry capability.

(Comprehensive to 18)

Earth science knowledge and expertise very limited. Little enthusiasm among staff – training essential to foster confidence.

(Comprehensive to 18)

Earth science component of the NC is to be delivered by our Geography department.

(Grammar)

Splitting of Classes

5.4 Table 5.1 also shows that about a quarter of all schools were splitting the teaching of science classes. In some cases this was a matter of choice:

We choose to operate our GCSE Balanced Modular Science course (started in September 1989) with staff rotation so our groups are taught modules by staff with the approximate subject specialism.

(Comprehensive to 18)

But in a number of schools it was forced upon them by staff difficulties:

13-14 Biology and Physics classes. Teaching split due to lack of a physicist.

(Comprehensive to 16)

Inability of non-science specialists to teach certain aspects of General Science course 14-16 year.

(Comprehensive to 18)

GCSE courses have had to be re-arranged on a 'circus' basis to cover inadequacies.

(Secondary Modern)

One teacher not qualified to assess GCSE practicals.

(Comprehensive to 16)

Courses Withdrawn, Amended, Reduced

5.5 In about ten per cent of schools, courses have had to be withdrawn, amended or reduced because of staff shortages. Most often it was physics courses that were not being put on:

Physics – GCSE – Modular Science – lack of physicist.

(Comprehensive to 16)

Cut down the amount of GCSE physics.

(Comprehensive to 18)

We had to offer different science modules in Mode III Science to cover physics deficiency.

(Comprehensive to 18)

Cannot offer physics or chemistry other than A-level to sixth formers.
(Comprehensive to 18)

CPVE course – physics.
(Comprehensive to 18)

But we are facing a problem this year in recruiting the right calibre person for a physics post which may affect science course, including knock on effect for 1990/91.
(Comprehensive to 18)

The timetables had to be tailored in other ways also:

We have had to curtail the choice of modules.
(Comprehensive to 16)

GCSE combined science due to maternity leave and course amended to provide satisfactory coverage by part time staff.
(Comprehensive to 16)

Lack of teachers prevented two teaching groups in lower school from receiving Key Stage 3 material for 1 term.
(Comprehensive to 16)

Electronics module NEA removed due to loss of qualified teacher; replaced with less specialist module.
(Secondary Modern)

Geology; GCSE and A-level.
(Comprehensive to 18)

During 90/91 it is likely that electronics and other technology courses taught by science will be discontinued due to increased demand for science caused by introducing BS for all.
(Comprehensive to 18)

Courses Not Offered

5.6 There were also courses that schools would like to have offered but were unable to do so. Table 5.1 shows that about one in eight schools said they were limited in this way. None of the sixth form colleges (which we have shown elsewhere were generally satisfied with their staff provision) reported having to withdraw courses or not being able to mount ones they would have liked to. Courses that were mentioned as not being available due to lack of staff were electronics, technology, psychology, environmental science, science and society, and human biology ("*plenty of suitable teachers, but all have full timetables*").

AS Exams

5.7 Another casualty of staff shortages (and lack of resources) seems to have been the government plans for AS courses. Table 5.2 shows that less than one in five schools had introduced them, and very rarely were they taught separately. These

results are in line with those of a Secondary Heads Association survey[13] to be presented soon. Many schools gave lack of staff as the reason.

Table 5.2: Availability of AS Exams

Subject	AS Exams[1]		
	Taught Separately	With A-Level	Not Taught
Biology	5.9	11.8	82.4
Chemistry	0.8	8.4	90.8
Physics	1.7	14.3	84.0

1. Percentage of 119 schools with sixth forms that had introduced them.

5.8 If AS Exams are to make a major contribution to broadening the sixth form curriculum, as the government intends, they will have to be given a push by making available additional staff and resources. Otherwise cutting back on existing A-level provision or accepting some kind of modularised arrangement where they can be fitted in.

VI. Resources

6.1 As well as being short of teachers, science teaching in schools is under pressure from lack of resources. Table 6.1 shows that over half the schools reported inadequate facilities and equipment, and not enough technicians. Once again the sixth form colleges and independent schools tended to report less difficulty. But a high proportion of the other types of school were concerned about their facilities and technical support.

Table 6.1: Facilities for Science Teaching[1]

School Type	% Not Enough Teaching Rooms/Labs	% Inadequate Facilities & Equipment	% Taught Outside Science Area	% Not Enough Technicians
Comprehensive to 16 (N=46)	43.5	80.4	60.9	52.2
Comprehensive to 18 (N=77)	53.2	64.9	57.1	64.9
Sixth Form College (N=6)	0.0	33.3	50.0	16.6
Secondary Modern (N=13)	53.8	53.8	61.5	53.8
Grammar (N=10)	40.0	70.0	20.0	70.0
Independent (N=27)	33.3	29.6	55.6	22.2
Total (N=179)	**44.7**	**62.0**	**41.3**	**53.1**

1. Reponses of 179 Heads of Science.

6.2 The statements from the schools themselves are supported by the independent observations of HM Inspectorate. In their *Survey of Balanced Science Courses in Some Secondary Schools*, carried out between September 1988 and June 1989, they found 30 per cent of schools were short of laboratory accommodation and in another 35 per cent the conditions were described as "cramped". Significant shortages of apparatus and materials were found in a quarter of the schools visited and the level of technician support was considered inadequate in 40 per cent.

6.3 But the picture only emerges partly through the numbers. The heads of science and science advisers spoke vividly of their circumstances:

> *Were it to be '20% for all' some schools would have insufficient labs. The other point is that most of the labs are in appalling condition. Between you and me there aren't many labs in the authority that I would want to teach in; because of our climate here buildings decay rather rapidly. Although the government would claim that we've done rather well in terms of capital spending, the backlog is phenomenal. We have a lot of schools to maintain and the resources are spread very thinly. And we are trying to address some of the problems but they are immense. To give you an example, going into one of our largest secondary schools we were trying to put gas and*

electric cut-offs in all the labs plus water cut-offs. You start to do something and you uncover a rat's nest. The school took in excess of £50,000 and, in fact, we've only managed to do two schools in this year's budget and we're still 40% over budget.

(Adviser, North)

And I also know from other colleagues in the authority, they have done this, they have gone for 20 per cent science, so they have had to have an extra teacher, but they can't fill the vacancy. We also know we need another laboratory. We have had an area earmarked for a laboratory, the sixth form common room which is changing, so by next year we will have a room. We have not got the financial funding yet to equip it. The whole school budget has been decreased, especially as the authority has been 'rate capped'. The budget in real terms this year is less than last year. Although I am having to find more staff, I am having to warn or reprimand staff about breakages in lessons, which is awful, we can't afford for things to be broken.

(Head of Science, London)

Because we have to provide the broad balanced science we are going to have to be timetabled together and this will cause problems because equipment will be needed at the same time. Equipment and resources are very, very tight and in some cases we just don't have it at the moment. (Interviewer: Do you think that LMS will have any effect on the ability of your school to teach science?) We are cutting to the bone, they are making a special case for the science department but this won't last, it will just be for this year. We have only got one set of text books which will have to be shared on a rotation basis.

(Head of Science, North)

We only have increased science provision in the fourth year at the moment. We have eight groups coming to us in six labs. One of the groups can move away from options block, they will be the certificate people, less able. That means I have got seven groups for the six labs, so I will have to have a rota for six labs, and the head's not happy with that. Increased funding for equipment has come from TVEI which is a bit unfair as the TVEI was supposed to be there to supplement the things that the school could not provide, and unfortunately schools see it as a way to help supplement the National Curriculum.

(Head of Science to 16, Wales)

We need at least one extra lab. We have negotiated a room from the art department. It's quite a big room but needs to be re-vamped to make it into a laboratory. We contacted the adviser to ask for support and he wasn't much help. He said that it could be five or ten years before we got any funds. If we did it ourselves then we wouldn't get anything. What we have done is a homemade conversion job. One of the schools nearby was being done up so we managed to get all their

work-benches off them, and the governors got them fitted for us. We are waiting now for DES approval for the governors to pay for the electricity and that has taken six months.

(Head of Science, North West)

6.4 Adequate technical back up also emerged as a major problem. Some heads of science said that under Local Management of Schools they were hoping to bid for more technicians to take the pressure off science teaching staff. But some wrote in on the questionnaire to complain they were at present losing support, with the available technicians increasingly being classed as school technicians rather than lab technicians and being used for reprographic work and audio-visual support throughout the school.

VII. Balanced Science

7.1 Balanced Science is an idea whose time has come. Since a double O-level subject in 'combined science' was mooted, in 1975, by John Cook[14], headmaster of Christ College, Brecon, the dual award has won increasing acceptance. In 1985, the DES issued Science 5-16: a statement of policy[15]. In 1987, sixteen national organisations signed a statement of support for the new GCSE double award[16] Twenty per cent science would, it was argued, increase breadth of understanding, keep job opportunities open, increase the pool of students available for science-based occupations, and help create a scientifically literate society. The final push has come from its incorporation into the National Curriculum.

Courses

7.2 At the present, our survey reveals that a wide variety of science courses occupying very different proportions of the timetable are offered by the schools. Among maintained schools at GCSE, 15.1 per cent are offering separate sciences only, 47.5 per cent are offering separate sciences or balanced/modular science, 23.7 per cent are offering single or double-award science (with in two cases the single science being the norm but with an add-on option for the double award) and 12.2 per cent the double award only. But in two cases only 12.5 per cent science is currently available – either biology or science. The great majority of the independent schools are offering separate sciences.

Table 7.1: Expected Arrangements[1] for Implementing Key Stage 4

Type of School	20% Science for All	20% for Some 12.5% for Others	Other/ Undecided
Comprehensive to 16 (N=46)	60.9	28.3	10.9
Comprehensive to 18 (N=77)	66.2	31.2	2.6
Secondary Modern (N=13)	38.5	38.5	23.1
Grammar (N=10)	60.0	10.0	30.0
Total (N=146)	**61.6**	**29.5**	**8.9**

1. Average percentages by school types expecting to offer 20% science for all, 20% for some, and those still undecided.

7.3 With the introduction of the National Curriculum to Key Stage 4, Table 7.1 shows that nearly two-thirds of the maintained schools expect to offer 20 per cent science for all and most of the rest, the option of 20 or 12.5 per cent. Very few expect to continue with the separate sciences except in the case of the grammar schools and the sixth form colleges (which will offer the GCSE post-16). Implementation of the National Curriculum can therefore be expected to lead to more science in many maintained schools and of a different kind.

7.4 Table 7.2 shows that independent schools (and to a lesser extent the grammar schools) are the most likely to take advantage of the Secretary of State's[17] decision (stated in a letter to the School Examinations and Assessment Council on 20 July 1990) that schools could continue to offer pupils the option of taking biology, chemistry and physics as three separate sciences at GCSE provided all three were taken.

Table 7.2: Separate Sciences to GCSE

Type of School	Yes	No	Undecided
Comprehensive to 16 (N=46)	4.3	82.6	10.9
Comprehensive to 18 (N=77)	6.5	89.6	3.9
Sixth Form College (N=6)	66.7	16.7	16.7
Secondary Modern (N=13)	0.0	92.3	7.7
Grammar (N=10)	50.0	30.0	20.0
Independent (N=27)	66.7	14.8	18.5
Total (N=179)	**19.0**	**70.9**	**18.5**

7.5 The teaching of 'science' rather than biology, chemistry and physics represents a profound change to many staff whose identification is with their subject specialism and it has implications for practice in schools, in-service and initial training which only now are coming to be fully realised.

Experience, Skills and Qualifications

7.6 Specialists in one science teaching general science is our second kind of mismatch. In our survey we asked teachers if they were teaching any courses where they felt they lacked the necessary experience, skills or qualifications. About a quarter mentioned 'experience' and a fifth 'skills' and 'qualifications'. Table 7.3 shows that there were some interesting differences with subject of qualification, with perhaps not surprisingly non-scientists teaching science expressing most concern.

Table 7.3: Teachers[1] Expressing Lack of Confidence by Subject

Subject of Qualification	Experience	Skills	Qualifications
Biology (N=268)	32.8	23.8	18.8
Chemistry (N=192)	18.8	13.6	14.7
Physics (N=145)	23.4	15.2	19.0
General Science (N=50)	30.0	20.0	18.4
Other Science (N=112)	27.7	25.0	25.9
Non-Science (N=27)	33.3	22.2	32.1
Total (N=794)	**26.8**	**19.6**	**19.3**

1. Full-time only.

7.7 There were even greater differences between schools, as we can see in Table 7.4, with over half the teachers in secondary moderns lacking confidence in their experience and skills and a high proportion of teachers in comprehensives to age 16 expressing doubts. In contrast, teachers in sixth form colleges and independent schools (neither of which are currently subject to the National Curriculum), and grammar schools, mainly felt they had the experience, skills and qualifications.

Table 7.4: Teachers[1] Expressing Lack of Confidence by School Type

School Type	Experience	Skills	Qualifications
Comprehensive to 16 (N=152)	31.6	27.4	24.5
Comprehensive to 18 (N=393)	31.6	22.7	22.0
Sixth Form College (N=48)	16.3	4.9	9.3
Secondary Modern (N=17)	52.9	58.8	35.3
Grammar (N=41)	12.2	7.3	14.3
Independent (N=143)	13.6	5.6	9.1
Total (N=794)	**26.8**	**19.6**	**19.3**

1. Full-time only

7.8 As we can see with the non-scientists teaching science and 'other scientists', some of these doubts may refer to mismatch.

> *I trained as a CDT teacher and have more science than CDT on my timetable in my probationary year.*
>
> **(BSc 2.2 Aero Engineering)**

> *The chemistry which I teach to GCSE has been taught to me on a weekly basis prior to the lesson.*
>
> **(BSc 2.2 Physics with maths subsid.)**

> *As a biology specialist I find it frustrating that I am expected to teach aspects of physics/chemistry that require me to spend more time updating my knowledge. Is the same asked of a geographer? Historian? Teaching staff have so little time at present all are under extreme pressure. Unfortunately I have decided to resign this year due to the above.*
>
> **(BSc 2.2 Botany)**

> *Although not a science specialist I have moved across to teach all sciences using my A-level background, on the whole this has been adequate.*
>
> **(Teachers' Cert. Home Economics)**

In-Service Training

7.9 But, as we found in the teachers' responses to a question about what in-service training they would find most useful, most had concerns about their ability to teach balanced science. Table 7.5 shows that more than a quarter of the teachers mentioned the need for some in-service training in this area:

> *Being a subject specialist (physics) and bearing in mind the trend towards more general (balanced) science, which I agree with, I'd like to take the opportunity to learn more about teaching Biology and Chemistry.*
>
> **(BSc 2.2 Engineering Science)**

TABLE 7.5: Teachers' Perceived In-Service Needs

Subject	Per Cent[1]
Balanced Science/Updating Knowledge	26.5
Assessment in the National Curriculum	17.3
Information Technology	9.8
Curriculum Development	6.9
Management Skills/Admin/Planning	6.5
Use of Apparatus/Experiments	4.2
Resources	1.6
Industry Links	1.2
No Response	26.1

1. Of 1004 teachers

If the move to balanced science continues I will need both physics and biology INSET – both theory and practical work with classes in schools.

(BSc 2.2 Chemistry)

With the trend towards science up to 16 there is a real need for training in areas that staff have to teach but have no real background. Falling rolls have compelled most schools to have non-specialists teaching in some subjects.

(BSc 2.1 Botany)

Physics for science teachers. Trying to get O.U. course but no funds to provide it. Help with earth sciences.

(BSc 2.1 Zoology, Head of Science)

As long as I am teaching chemistry, my specialism, then I feel happy, if and when I have to move out then I'll need help.

(BSc 2.1 Biochemistry)

Something about biology that is actually interesting, and a good, simple book on earth science components.

(BSc Physics)

If I have to teach 'science' I need a thorough preparation for 4th and 5th year work in Biology and Chemistry aspects. Alternatively I could retire early.

(BSc Physics)

Although I feel I can cope with the physics at junior level I would like guidance on different types of experimental work that could be used.

(BSc 2.2 Zoology)

7.10 There is clearly a need, if 'science' is to be a success in the National Curriculum, for a major effort with in-service education. Many of the teachers expressed the desire for content based courses:

> *Too often I feel that LEA INSET courses in science spend too much time on talking about how to teach rather than adding to understanding of the subject.*
>
> **(Biology Teacher South East)**

> *They, the people in the post, even more, have come from a separate sciences background. They're learning to become general scientists but some are obviously finding it very difficult. Some find it relatively easy. A solution would be supportive re-training in disciplines other than their own, like physics for biologists. There I can say that the quality of in-service training I've seen for that is not of a satisfactory standard.*
>
> **(Science Adviser, Yorks and Humber.)**

But the problem may be more fundamental:

> *A course I attended last year required teachers to scrutinize pupils' answers to problems on particles and their misconceptions. It was very obvious that the majority of teachers had misconceptions. Discussion and analysis of experience meant everyone left with more knowledge.*
>
> **(Teacher's Certificate, Physical Science and Maths)**

7.11 Table 7.5 shows that the only topic to receive anything like the mentions of balanced science for INSET was assessment in the National Curriculum. Information Technology, curriculum development, use of apparatus which are related to 'balanced science' came up quite often as well. Management skills, resources and industry links were also put forward. About a quarter (26.1%) made no suggestions.

7.12 As well as providing the courses, there is also the problem of making it possible for teachers to go on them:

> *The problem is cover, science requires practical work, if I am away for longer than a day or two I feel my students suffer. If I could have science cover then I would like to participate in university courses in biotechnology and new developments.*
>
> **(BSc 2.2 Zoology)**

> *You can't have staff going out of school too much if you have to provide supply cover. We have a certain amount of INSET money which is allocated and then after that its goodwill. It's really the financial aspect, plus the problem is really caused by N.C. If you are teaching a high content course with a lot of assessment you can't really afford to be out of the classroom too much.*
>
> **(Head of Science, London)**

The biggest problem for us is providing cover; the cost is astronomical. The fees and travelling allowances are another problem. We have been able to get supply but they are not scientists.

(Head of Science, North)

What is science supply? It is unobtainable. If we need science supply we get baby minders.

(Adviser, North West)

Initial Teacher Training

7.13 Balanced science also has implications for initial teacher training which many in the profession feel the training institutions haven't really woken up to.

Training departments must get away from teaching chemistry, physics and biology and ensure that they are turning out people who have plenty of classroom experience, a clear view of the wider re-match of science education, and that they" have a 'variety' of practice in the classroom. A lot of the training departments haven't got their act together. They are still living in a fool's paradise of twenty years ago. They have got to do a serious re-think on how they operate and how they turn out the end product. They have got to recognise what it is that schools want and need. I would like to see all training departments to be truly training departments and not based on reputation of educational research.

(Science Adviser, North West)

If we're looking at PGCE people, they're still coming to me as separate specialists, and I would want them to have a science emphasis but with their specialism at sixth form level. And in terms of training for GCSE, again, I don't think the training colleges are in a position to deliver, because none of them have actually experienced this.

(Science Adviser, Yorks and Humber.)

Feel very strongly that initial training is poor. PGCE year is a poor experience and doesn't teach them enough about the subjects they will have to deliver: (i) still producing PGCE trainees who are subject orientated – the declining BEds were far better prepared – and (ii) anybody with science degrees should have sufficient science to deliver the N.C. except patches where help is needed i.e. Electrostatics, aspects of electronics, mole concept and in microbiology the skills and rituals needed to avoid contamination.

(Science Adviser, North West)

I was surprised recently to find a biology graduate – here for some weeks as part of her PGCE – was not being given any training in the other two main sciences as part of her course, despite the fact she was unlikely to find a job as a biology-only teacher.

(Physics Teacher, North)

7.14 The change to 'balanced science' is a major one – greater than perhaps has been appreciated. We look at the implications in detail in the next chapter.

VIII. Conclusions and Recommendations

8.1 Our survey reveals two kinds of mismatch. The old, which still persists, stems mainly from the failure to attract and retain sufficient physical scientists, particularly physicists, to meet our teaching needs. The new comes with balanced science in the National Curriculum so that science teachers whatever their specialism may find themselves teaching outside it.

Qualifications/Teaching Mismatch

8.2 The first kind of mismatch is concerned with the appropriateness of qualifications in one subject for teaching another. Our study shows a marked lack of balance in the qualifications of science teachers in Years 7-11 (ages 11-16), with there being about twice as many qualified in biology as physics. In schools without sixth forms the ratio rose to four, with only ten per cent of the teachers qualified in physics (degree or teachers' certificate). Does this matter? It could be argued that all science graduates can teach all science to age 16. Moreover, as we have seen, since the biology entrants to PGCE courses, have, on the whole, a higher class of degree then perhaps the children are better off with brighter biologists than the 'also-rans' among the physicists.

8.3 But this fails to recognise that a number of studies have shown that physical and biological scientists differ profoundly in intellectual and personality profiles[18]. (One of the reasons why hitherto it has not been too difficult to attract biologists into teaching is that they, both male and female, tend to be more people-oriented[19]). Different kinds of people are attracted to different specialisms, and inherent in the present situation is the danger that young people will not be taught from an early age by those with an enthusiasm and real feeling for physics and chemistry; and may never reach the experts available to them at A-level or in higher education.

8.4 There is a tendency for schools to reserve their scarce physical science teachers for A-level, but even here, on a strict definition, 30 per cent of physics courses and 20 per cent of chemistry courses are taught by those whose degree or teachers' certificate is not in the subject. But most of those teachers had degrees bearing some relation to physics (material science, metallurgy, various branches of engineering) or chemistry (biochemistry, physiology and pharmaceutical science), and again the question of appropriateness arises. Does it matter that physics A-level is being taught by someone with a degree in naval architecture, or chemistry by someone with a degree in meteorology? Other things being equal we would have thought it did. It seems preferable to have someone with a breadth of understanding in, and a feeling for, the subject itself rather than having just met it only on a service course.

8.5 There are clearly some horror stories, particularly when a school's only physicist resigns and cannot be replaced, but mismatch at A-level may be less of a problem than the bald figures seem to imply. A number of those without a degree in physics had, in fact, taken a PGCE in the subject, indicating that mismatch, such as it is, often occurs at the training stage. Places on physical science PGCE courses are difficult to fill, and they draw very widely.

Differences Between Schools

8.6 The survey also reveals major differences between schools. With not enough physical scientists (even on a wide definition) to go round, some schools are much better placed than others. The sixth form colleges, independent schools and grammar schools tended to have the better balance of staff, and schools without sixth forms to have the most difficulty in attracting physical scientists. This brings to the surface a major management problem which has not been properly faced in the re-organisation of secondary education into comprehensives to 16 and sixth form colleges.

- ***We recommend that ways be found to ensure that high quality staff in subjects in short supply are available to foster the enthusiasm of the young in 11-16 schools, and are not mainly drawn off into sixth form teaching or away from the maintained sector.***

8.7 There were also big differences in the levels of qualification across the schools, with again the sixth form colleges, independent schools and grammar schools coming out top, and schools to age 16 lagging behind. The differences are striking: nearly half (49.1%) of science teachers in independent schools have a good or higher degree compared with less than a quarter (22.7%) in maintained schools to 16. Qualifications in terms of either the appropriateness of the subject or the class of degree do not guarantee quality" of teaching (or' quality' of learning which is the ultimate criterion), but neither is "the reverse true; they are not irrelevant. The well-qualified have a better basis for becoming good teachers and it is a matter of concern that they should be so unevenly distributed. Our national shortage of physical scientists may not be unrelated to the fact that we are not giving enough young people a good start in the subjects.

Attracting Physicists into Teaching

8.8 Many of the problems of subject-subject mismatch stem from the difficulty of attracting sufficient physical scientists, particularly physicists, into teaching. This sorry story was told in some detail in Chapter III. Why is it so difficult? To some extent it is part of the general problem of teaching recruitment. There is a widespread feeling at present that teaching is not a good profession to be in, and it is becoming increasingly more difficult to attract young people into it. The DES is sufficiently concerned to have embarked on a £2.2 million publicity campaign to try to improve the image of teaching, but not always with the intended effect:

> *I remember having to work very late one evening, and I switched on the television at half past two in the morning, and saw a teacher recruitment advertisement. I felt it was a total waste of money, as if they were trying to recruit insomniacs. The government has given a budget of £2 million very recently and let it be squandered. They are pushing out T.V. adverts, not at prime time but at ridiculous times of the day so people don't even know that they're happening – it's a non-event.*
>
> **(Science Adviser, London)**

8.9 Physics is at the sharp end for at least four reasons: (a) physics graduates generally are in short supply; (b) they are in great demand elsewhere; and (c) only about one in five is female but it is females who are far more attracted to teaching and (d) physicists do not necessarily want to work with children[20]. The latter two may well be connected. On average there are personality differences between people attracted to the different subjects and personality differences between males and females. These differences could be inherited or learned. Whatever the truth it reduces the size of the pool of physics teachers. The numbers of English and physics graduates is similar, but the former are much more inclined to go into teaching and moreover two-thirds of the pool there is female in contrast to the preponderance of males among the physicists.

- ***We recommend that further research be conducted to discover why so few physics graduates are attracted to teaching, and why so few females are attracted to physics.***

8.10 The difficulty of recruiting physics teachers has been recognised through the introduction in 1986 of a bursary for those in training (which seems to have given only a temporary boost), and there is talk of differential salaries. To some extent these already exist, as we have seen, with graduates in physics and chemistry holding an above average number of incentive allowances. But this also provides them with a springboard for early promotion out of the classroom.

- ***We recommend that research be undertaken to discover to what extent there are teachers in schools with qualifications in the physical sciences not actually teaching these subjects – and what they are they doing?***

8.11 However, recognising that there is a particular problem with the physical sciences does not sit easily with the idea that now the subject to be taught is 'science'. Teaching training in biology is not supported by a bursary, nor are biology teachers likely to receive the same differential awards as their physical science colleagues, so that in teams of science teachers there are some who could receive higher salaries simply because of the subject categories they are in – rather than anything to do with the quality of their teaching.

Specialism/Balanced Science Mismatch

8.12 This brings us to the second kind of mismatch: that arising from the introduction of 'balanced science'. Treating 'science' as the subject category up to age 16 rather than biology, chemistry or physics is a major change taking place for very good reasons, but it has to contend with the fact that subjects are not just subjects but social systems. They are givers of status and identity. At present, our schools are staffed mainly by teachers 'who see themselves as teachers of biology, or chemistry, or physics, and many, as we saw in Chapter VII, are finding the adjustment to 'teacher of science' painful.

8.13 To make 'science' in the National Curriculum work has major implications for in-service and initial teacher training which do not seem to have been fully faced.

INSET

8.14 As we saw in Chapter VII, there are strong feelings among teachers, heads of department and science advisers that (a) there are not enough opportunities for in-service education, (b) that it is not of the right kind, and (c) that it is not properly funded.

8.15 The teachers in our survey expressed the wish that INSET should be more concerned with the subject matter of the sciences. This is particularly important now that staff have to be helped to make the transition from one identity to another, and given the opportunity of learning about aspects of science with which they are unfamiliar and do not necessarily feel comfortable. But since science is continually developing it is always important to have the opportunity for renewal and refreshment. Universities are well placed to offer such opportunities and we would like to see them involved to a greater extent in the in-service education of teachers, (which up to now' has rather been. the territory of education departments and can lead to "too much talk about teaching"). The .Association for Science Education has given a strong lead in bringing science to the science teacher and a number of our respondents spoke warmly of its work.

- ***We recommend that the subject departments in higher education (rather than just the education departments) be involved to a greater extent in science INSET for teachers.***

8.16 A major difficulty with INSET is that, even if appropriate provision is available, teachers are finding themselves constrained by lack of money, time and supply cover.

- ***We would urge that a more generous programme of support be made available for INSET to underpin the introduction and implementation of balanced science in the National Curriculum, and current provision be fully evaluated to identify what improvements can be made.***

Initial Teacher Training

8.17 The transition to 'science' as the school subject to age 16 depends crucially on the new teacher by whom it will come to be seen as the normal way of doing things. One might have expected that a major effort would have been made in the training institutions to prepare new teachers for teaching 'science' in the National Curriculum, but a number of our heads of science spoke of the new teachers still being specialists wanting to teach only their specialism. In our analysis of entries to PGCE courses we were expecting to find some increase in combined science courses, but this does not seem to have happened. There is a feeling among teachers that PGCE courses are old fashioned and out-of-touch.

- ***We recommend that the impression of teachers that initial teacher training is out-of-touch with the needs of the National Curriculum Science be investigated.***

8.18 We would also suggest that more precise targets for teacher training be set. At present that for science is global and it is usually divided by three to give notional targets for biology, chemistry and physics. This takes no account of developments in the National Curriculum which would seem to require courses in balanced science, and makes it difficult to see whether we are ensuring a good mix of scientists from the different specialisms in our schools.

- ***We recommend that the DES gives careful attention to the targets it sets for science and is clear about how many teacher training places it wants to see offered in balanced science and in biology, chemistry, physics, and other sciences.***

8.19 The present structure of PGCE courses recognizes that it is a deep-seated tradition in this country that ability in science is associated with specialisation. Our most able young people go on to take BSc degrees in physics, chemistry and the other sciences, while the 'second of the cream', as it is sometimes called, takes BEd degrees in general science. One of the reasons why heads may be so dissatisfied with the quality of applicants is that when they advertise general science posts they are entering a different market and one which hardly exists at present (Table 3.3 shows that DES targets allocated only 13.8 per cent of science places to the BEd route in 1989). A. major problem to be faced is: from where are the able teachers of science in the National Curriculum to come? It is a chicken-and-egg situation: once the students who have followed the National Curriculum come through there should be no problem but in the meantime there is a hiatus to be bridged.

Projections

8.20 A major difficulty in stating targets is that the DES, as yet, has no good basis for projecting future needs. We would re-iterate here a plea we made in our earlier report[21] and to the Commons Select Committee[22] for a computerised database to be established.

- ***We recommend that a computerised database be set up which would follow all teachers from the start of training to leaving or retirement.***

8.21 In its evidence[23] to the Commons Select Committee on Education, Science and Arts, the DES estimated that by 1995 we could be short of 2000 chemistry teachers, and 1500 physics teachers, out of an expected demand of 11,000 in each case. The physics figure is in line with the optimistic projection we made in a report on *The Shortage of Mathematics and Physics Teachers* (1988), but we could also envisage circumstances in which the situation would be a lot worse.

8.22 The education scene is changing rapidly. Our 1995 projection for 1985 took into account what was known about the National Curriculum in 1988 and we suggested, along with the Institute of Physics, that 20 per cent science for all would increase the requirement for physics staff by only a relatively modest amount – some 5 to 6 per cent – over 1988 levels. But since that time the

National Curriculum has been amended: (1) to introduce a 12.5% science option and (2) to allow three separate sciences to be taken together. The extent of the take up of these options could appreciably alter staff requirements, or indeed be in 66 response to the staff available. The switch from teaching three separate sciences to a dual-ward course could even lead to some reduction in requirement.

8.23 Local Management of Schools is another reform which could dramatically alter the requirement for science staff since it changes the criterion of what is needed. Up to now projections have been based on calculations involving such things as pupil numbers, the number of science periods per week, and staff contact time – an ideal requirement in fact. But LMS changes the criterion to how many staff can be afforded, and also makes the school system more responsive to changing pupil numbers.

8.24 During the eighties when the secondary-school-age population was falling, the number of staff employed by local authorities did not reduce to the same extent, so that the pupil/teacher ratio in secondary schools improved from 16.6 to 15.3[24]. This was not, however, a planned improvement, but came about through the inelasticity of the system and no-redundancy agreements. LMS is designed to make the educational system more responsive to pupil numbers and, as it is phased in, it is likely that some existing staff will be found to be superfluous to requirements. It is not known if any science staff will be shed in this way, but LMS could also drive up teacher ratios, again affecting staff requirements.

8.25 It is hard therefore to look into the future and say with any certainty what the needs will be. But it is clear that, at present, teacher provision in the sciences falls far short of the optimum the supply of physics teachers is deteriorating. The shortages affect schools in various ways. We have already considered the two kinds of mismatch. But there are also courses being tailored to the capabilities of existing staff, courses being withdrawn, and courses not being put on.

AS Exams

8.26 A major casualty of teacher shortages in science is the government's planned introduction of AS courses. Less than one in five of our schools were offering them in science and very few (1 in chemistry and 2 in physics) were offering them as separate courses. As we have argued before[25] there is a case for a broad A-level Diploma based on the expectation that all students at this level will continue with some mathematics and/or science after sixteen. This would help the nation to become more scientifically literate and should also help provide us with more scientists and science teachers.

- ***We recommend that a broad A-level Diploma be established based on the expectation that all students at this level will continue with some mathematics and/or science after sixteen. In time this should mean more people coming through into the sciences, and to science teaching.***

8.27 AS exams could be a step towards achieving this. But, at the moment, it looks as though any growth in AS exams can only be at the expense of A-levels. We say again that there is an urgent need to get in place a clear policy backed by adequate funding for education 16-18.

Resources

8.28 Our survey reveals that schools are very concerned at the lack of resources for science teaching. Over half reported inadequate equipment and not enough technicians (the ones there are, are increasingly being used on general school duties like reprographic work). Nearly a half (45%) reported. not enough laboratories. 'Well they would, wouldn't they?' is the likely response of the government, but the findings are in line with the independent observations of HM Inspectorate[26].

8.29 The Royal Society[27] has recently published a careful analysis of what it costs to run school science laboratories, and it is to be hoped that this will be accepted by the government as a basis for increasing investment in our schools.

8.30 The main reason for a shortage of science teachers is a shortage of scientists. What to do about this is a report in itself. But we seem to have got ourselves into a downward spiral: not enough physical science graduates> not enough teachers > not enough young people coming forward> not enough physical science graduates. Ways must be found of breaking into it. How do we attract more bright young physicists and chemists into teaching? Do we in fact want our brightest graduates there or are they needed more elsewhere in the economy? If teaching, how are we to attract them, and what are they to teach - their specialism, or general science? And crucially, how can we generate and foster the enthusiasm of the young for the sciences? The British Association, the Association for Science Education, and the Royal Society have already come forward with a number of imaginative ideas, but more are needed.

8.31 We concluded our earlier report, *The Shortage of Mathematics and Physics Teachers*, with the hope that it provided "a useful sketch map of a territory where much remains to be charted". Some of what was then tentative now stands out sharply.

- ***Our conclusion and overarching recommendation is that teacher provision in the sciences is inadequate and demands attention.***

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22. Appendix 9. House of Commons, Education, Science and Arts Committee (1990), *Vol. II*, 248-50.

23. Education, Science and Arts Committee (1990), *Vol. II*, page 7.

24. DES, private communication, July 1990.

25. See ref 21.

26. A report by HM Inspectorate, *A Survey of Balanced Science Courses in Some Secondary Schools*, September 1988-June 1989. London: DES.

27. *The Equipment Resources Required to Teach Balanced Science*, The Royal Society, 1990.

Appendix A: Methods

Sampling

A.1 A five per cent sample of all maintained secondary schools (excluding middle schools deemed secondary) and independent schools (in membership of the Headmasters' Conference and approved by the DES, teaching at the secondary level) in England and Wales was drawn from The Education Authorities Directory and Annual 1989. The sample was stratified by type of school, and was drawn by the random interval method within each subgroup.

Response Rate

A.2 The target sample was 225. In March 1990 a letter, together with a reply form and prepaid envelope, was sent to the headteachers of all sample schools requesting their participation in the survey. Two hundred and three agreed to take part (one later withdrew because the staff had not been consulted) and two had closed.

A.3 Each school agreeing to take part was sent a package containing (1) a headteacher questionnaire, (2) a head of science questionnaire and (3) enough questionnaires for all teachers of science in the school (this had been given on the form agreeing to participate), with prepaid envelopes to enable the replies to be sent individually. In the event, no replies at all were received from seven of the schools, in spite of three follow-up telephone calls, so the effective sample was 195, a response rate of 87.4 per cent.

Table A1: Sample by School Type

School Type	Target	Took Part	Head[3] Teachers	Responses Heads of Science	Teachers
Comprehensive to 16	59	49	47	46	48
Comprehensive to 18[1]	99	84	79	77	84
Sixth Form College	7	6	6	6	6
Secondary Modern[2]	14	13	12	13	13
Grammar[1]	10	10	10	10	10
Independent[2]	36	33	33	27	33
Total	**225**	**195**	**187**	**179**	**194**

1. One school in each case in process of 'opting out'.
2. One school in each case closed.
3. 188 replies but one without identification.

A.4 The distribution of the sample by school type and location is shown in Tables Al and A2. In grossing up to provide estimates for England and Wales the national statistics given in Table A3 were used. Questionnaires were passed on to individual teachers by headteachers and, while we were able to chase heads and heads of science, we had no direct contact with the teachers themselves.

Table A2: Sample by Region

Region	Target	Took Part	Head[1] Teacher	Responses Heads of Science	Teachers
North	12	9	8	8	8
Yorks & Humber	20	20	19	8	20
North West	27	24	22	23	24
West Midlands	20	19	18	15	19
East Midlands	19	18	17	17	18
East Anglia	9	9	9	6	9
Greater London	26	23	23	21	23
South East	54	42	41	40	42
South West	23	18	17	18	18
Wales	15	13	13	13	13
Total	**225**	**195**	**187**	**179**	**194**

1. 188 replies but one without identification.

Table A3: Pupils and Teachers in Maintained Schools, England and Wales, 1989

School Type[2]	Schools (England and Wales)	Pupils (England and Wales)	Full-time Equivalent Teachers (England only)[1]
Comprehensive to 16	1,234	857,786	54,122.75
Comprehensive to 18	1,999	1,763,353	107,437.72
Sixth Form College	112	73,812	6,351.70
Secondary Modern	215	116,388	7,518.03
Grammar	151	99,602	6,307.46
Other	19	14,530	1,064.50
Wales			**12,454.00**
Total England and Wales	**3,730**	**2,925,471**	**195,256.16**

1. Teacher information for Wales not disaggregated by school type.
2. 690 independent schools listed in The Education Authorities Directory and Annual 1989. Redhill: The School Government Publishing Company Ltd. No information available for numbers of pupils and teacher ftes.

Sources: Statistics of Education, Schools, 1989 DES, and Private Communication; Statistics of Education, Wales, Welsh Office, 1989.

Table A4: Pupils and Teachers in Sample Schools[1]

School Type	N	Pupils	Teachers	Science Teachers
Comprehensive to 16	47	34,653	2,069.2	333.5
Comprehensive to 18	79	75,835	4,806.5	821.5
Sixth Form College	6	4,868	392.2	77.0
Secondary Modern	12	7,183	358.7	68.1
Grammar	10	5,894	388.7	77.5
Independent	33	17,059	1,397.5	326.0
Total	**187**	**145,492**	**9,479.8**	**1,703.6**

1. Based on headteachers' replies.

A.5 The response rate given in Table A5 is for all teachers of science whether they be full-time or part-time, teaching all science or part science, or a head or deputy head. Among full-time teachers the response was higher at 62 per cent. However, given the low return from secondary modern schools and the relatively high return from sixth form colleges and grammar schools there could be some over-representation of the more highly qualified. However, in a report given to the problems of teacher provision in the sciences, perhaps this is no bad thing.

Table A5: Teachers' Responses by School Type

School Type	Science Teachers	Teachers Responding	Per Cent
Comprehensive to 16 (N=48)	342	187	54.7
Comprehensive to 18 (N=84)	864	487	56.4
Sixth Form College (N=6)	77	54	70.1
Secondary Modern (N=13)	76	27	35.5
Grammar (N=10)	77	56	72.7
Independent (N=33)	326	193	59.2
Total (N=194)	**1762**	**1004**	**57.0**

Data Collection and Analysis

A.6 Questionnaires were completed by: (1) headteachers (2) head of science and (3) individual teachers as shown in Tables A1 and A5. The questionnaires were constructed with the advice of an ex-headteacher (with a science background), employed on a consultancy-basis, and pilot-tested in local schools before being sent out. Copies of the questionnaire are available on request from the authors. Data from the 1004 teacher replies were coded and processed by computer. The 188 headteachers and 179 head of science responses were counted by hand.

A.7 In-depth interviews were conducted with 19 heads of science and 13 local authority advisers. Interview schedules were drawn up and piloted before being used. Copies are available on request. The interviews were taped and transcribed, with verbatim extracts used in the report.

Appendix B: Characteristics of Teacher Sample

B.1 Table B.1 shows the composition of the sample and B.2 makes some gender comparisons. Being' science teachers the sample was mainly male, but with major differences across the subjects. Three-fifths of the biology teachers were female compared with only a quarter of the physics teachers. Since women go preferentially into teaching one of the reasons why it may be so hard to get physics teachers is the subject's 'maleness', and more female students could mean more teachers.

Table B1: Composition of Teacher Sample

Characteristic	Category	N	Per Cent[1]
Gender:	Male	610	60.8
	Female	392	39.0
Subject of Highest Qualification:	Biology	326	32.5
	Chemistry	154	15.3
	Physics	130	12.9
	General and Combined Science	29	2.9
	Other Science	120	12.0
	Non-Science	57	5.7
	Education	44	4.4
Age:	Under 25	24	2.4
	25-34	236	23.5
	35-44	426	42.4
	45-54	264	26.3
	55 and over	51	5.1
Employment 1:	Full-time	931	92.7
	Part-time	71	7.1
Employment 2	Permanent	939	93.5
	Temporary	57	5.7
	Supply	7	0.7
Post:	Head	17	1.7
	Deputy Head	43	4.3
	Head of Science	183	18.2
	Deputy Head of Science	201	20.0
	Teacher	504	50.2
	Instructor	32	3.2
School:	Maintained	811	80.8
	Independent	193	19.2

1. Of 1004 replies, percentage may not add to 100 because of missing cases.

B.2 In Chapter IV we saw that science teachers held more incentive allowances than teachers generally, but in Table B.2 we can see that there is a big gender difference.

Table B2: Gender Differences

Characteristic	Category	%Male	%Female
Subject of Highest Qualification[#]:	Biology	42.6	57.4
	Chemistry	67.0	33.0
	Physics	76.5	23.5
	General and Combined Science	65.5	34.5
	Other Science	71.7	28.3
	Non-Science	54.4	45.6
Age[2]:	Under 25	1.0	4.6
	25-34	22.1	26.2
	35-44	44.0	40.6
	45-54	27.5	23.9
	55 and over	5.4	4.6
Highest Level of Qualification[2]:	PhD	7.6	2.3
	MSc	10.5	5.4
	BSc (1 or 2i)	12.8	27.6
	BSc (Other)	53.5	44.2
	BEd	7.7	7.7
	Graduate Equivalent	1.6	1.3
	Teachers' Certificate	6.2	11.5
Incentive Allowance[2]:	E	9.2	2.0
	D	27.1	10.8
	C	9.0	7.2
	B	23.7	21.6
	A	7.4	18.4
	MPG	23.7	40.0

1. For subject of qualification, percentages are row percentages.
2. For Age, Highest Qualification and Incentive Allowance, percentages are row percentages.

B.3 Very few young men appear to be entering science teaching. Table B2 shows that only 1.0 per cent of male science teachers are under 25 compared with 4.6 of the female. There were also proportionately more female teachers under 30, but fewer remain in the profession. This could be part of the explanation for the difference in incentive allowances.

B.4 The men teachers held more higher-degrees than the women but proportionately more of the women teachers had taken 'firsts' or '2.1s'.