THE ENGINEERING COUNCIL

THE IMPACT OF DOUBLE SCIENCE

Alan Smithers and Pamela Robinson

Foreword

In 1987 The Engineering Council and the Secondary Science Curriculum Review published a statement of support for double award balanced science. The statement was endorsed by a further 14 key organisations that also supported the new dual award and argued that it would increase the breadth of understanding, keep career options open and help create a scientifically literate society.

The evidence presented here suggests that national curriculum science and the double GCSE should be celebrated for their part in ensuring that more pupils study science to age 16, but this increased uptake has not yet fed through into A Levels.

In the light of the report's findings The Engineering Council 's clear preference is still for a norm of double award balanced science at GCSE in schools. During the last few years this development has been one of the major areas of success in the education system and should be further encouraged and supported.

Our thanks go to the authors, Professor Alan Smithers and Dr Pamela Robinson of the Centre for Education and Employment Research, University of Manchester, for producing this report which illuminates and informs on the changes taking place in the science curriculum. This report complements the recent trilogy of reports on school technology produced by the same authors for The Engineering Council.

I strongly commend this report to Government, the School Curriculum and Assessment Authority, examination boards and schools. It is an important contribution to the national debate on school science.

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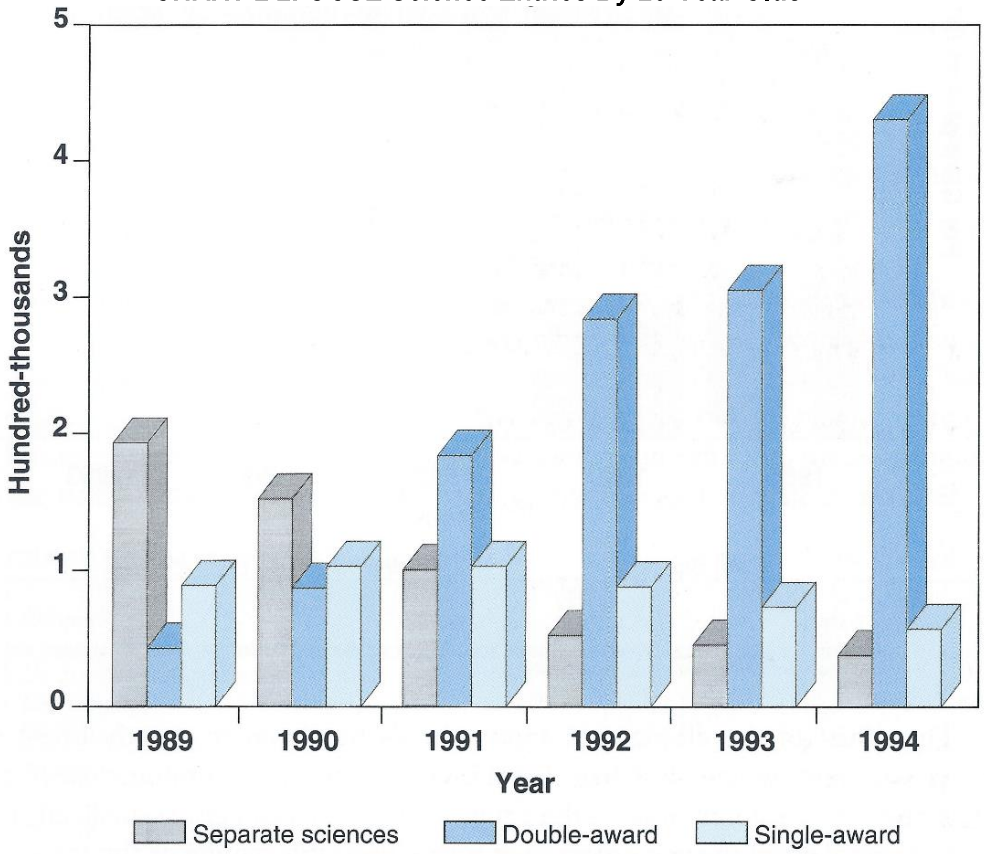
1. Science to 16

1.1 There have been many recent changes in the administration, organisation and curriculum of British education, but perhaps the most important affecting science has been to make it, in maintained schools, compulsory to age 16. Along with English and mathematics it is now recognised as one of the core subjects which no child should miss out on throughout the whole period of statutory schooling. Unlike the old laissez-faire approach when many pupils, particularly girls, wrote themselves off from some or all of the sciences at the age of 13 or 14, it is intended that all should continue with it to at least the minimum school leaving age. It is hoped that requiring science to be studied to age 16 will improve scientific literacy, help to correct the gender stereotyping of subjects and increase participation beyond 16.

1.2 Accommodating science as a core subject in an already crowded curriculum has led to a major change in the way it is organised for 14-16 year-olds. The subject category adopted for the national curriculum has been ‘science’ - not biology, chemistry and physics - and to retain breadth across disciplines it could only really be afforded the time of two subjects. This has led to the establishment of a double-science GCSE. Its dramatic growth is shown in Chart 1.1. From only 22.3 per cent of science GCSE entries in 1989, it is now 82.0 per cent.

CHART 1.1: GCSE Science Entries By 16-Year-Olds[1]

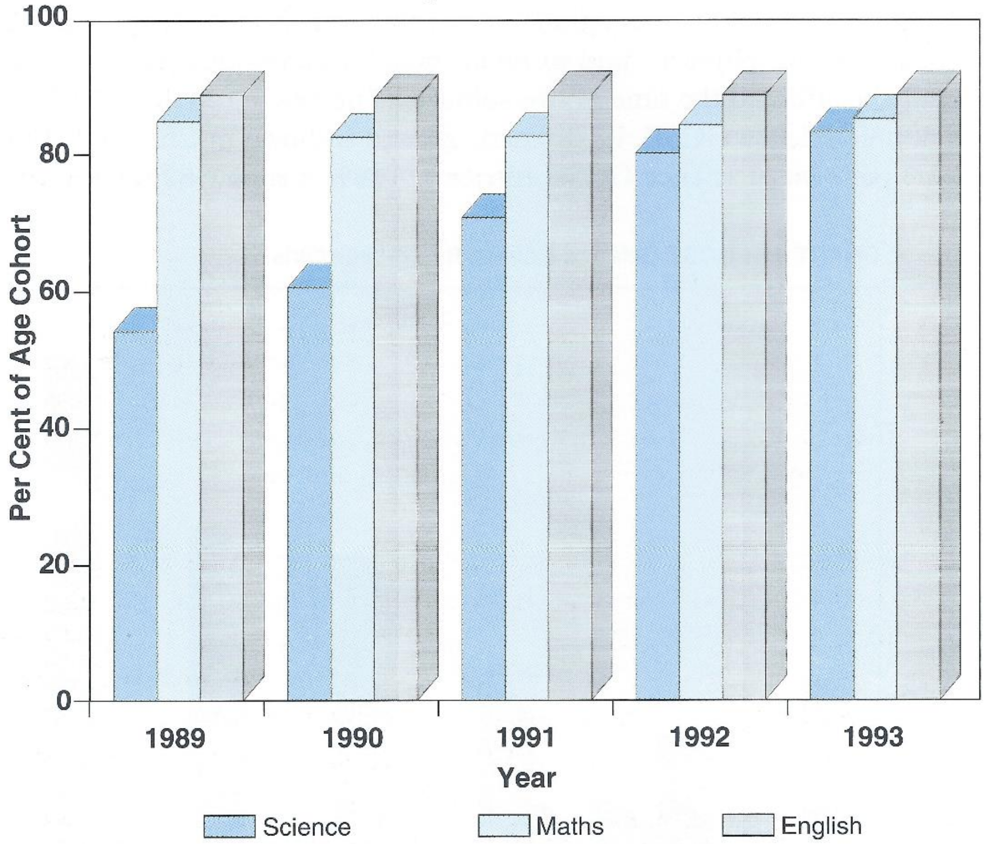


1. England.
Sources: *Statistical Bulletins 1/91, 22/91, 15/92, 15/93 and 7/94*. London: DFE; *GCSE Provisional Results Statistics*, 1994. Bristol: Joint Council for the GCSE.

1.3 National curriculum science can also lead to taking two other types of GCSE – single-award, or all three of biology, chemistry and physics. Under current arrangements, it is possible for a school to offer a course in 12.5 per cent curriculum time, and from September 1996 this will be reduced to ten per cent. Minimum time leads to the single-award GCSE. This initially proved popular but it has now fallen back from 30.1 per cent of the entries in 1990 to 10.9 per cent in 1994.

1.4 It is also possible to offer the three separate sciences provided it is all three, but their take-up has fallen progressively from an average of 59.4 per cent of science entries in 1989 to 7.2 per cent in 1994. Many of these separate science entries will have been from independent schools, which are not bound by the national curriculum and are free to offer one or two separate sciences, just biology, or chemistry and physics for example, or even none at all.

CHART 1.2: GCSE Entries By 16-Year-Olds[1]



1. England.
Sources: For GCSE entries as Chart 1; age cohort from *Science and Maths: A Consultation Paper on the Supply and Demand of Newly Qualified Young People*, 1994. London: DFE.

1.5 The effect of the changes in state schools has been to greatly boost science participation to age 16. Chart 1.2 shows that science is coming close to rivalling English and mathematics in the proportion of the age cohort involved. In 1993, 83.0 per cent of the age group took science (double, single or the three separate subjects) as compared with 89.4 per cent English and 84.9 per cent mathematics. (It might be thought that even so too many are still being 'lost' from all three subjects.)

1.6 The objective of equally involving boys and girls has also nearly been achieved. Chart 1.3 shows that in 1980 only 10.9 per cent of girls were taking physics to O-level but, by 1993, 65.2 per cent were taking substantial physics to GCSE (counting both the separate science and double-award science), with the gender ratio reducing to almost one. Conversely, the proportion of boys taking biology in the 16+ examination has risen from 20.4 per cent in 1980 to 68.6 per cent in 1993, with this time the gender ratio almost rising to one.

CHART 1.3: O-Level/GCSE Entries[1]

Subject	Entries		% Age Group		Ratio
	m	f	m	f	m:f
Physics					
1980	126,914	42,108	31.1	10.9	2.85
1993[2]	193,810	168,644	70.3	65.2	1.07
Chemistry					
1980	86,528	47,611	21.2	12.4	1.71
1993[2]	187,147	173,331	67.9	67.0	1.01
Biology					
1980	83,469	144,506	20.4	37.5	0.54
1993[2]	189,075	195,573	68.6	75.6	0.91

1. All ages, England.
2. Includes double-award science.
Sources: *Statistics of Education, School Leavers, CSE and GCE*, 1980. London: DES; *Statistical Bulletin 16/93*. London: DFE; *Inter-Group Statistics, 1993*. Guildford: Joint Council tor the GCSE.

1.7 Not only have the girls' participation levels in the physical sciences increased but they are also doing well. Chart 1.4 shows that in 1993 the proportion of girls obtaining grades A-C in double-award science was slightly above that of boys, and in mathematics they have all but eliminated the deficit since 1980. On the other hand, the performance of both sexes in science and mathematics was below that in English where girls are now streets ahead.

1.8 The proportions awarded A-C in the separate sciences are considerably above those in double-award science, suggesting they attracted those of higher ability. The pattern of scores between the sexes is similar to that in 1980 with the minority in each subject (girls in physics, boys in biology) tending to do the better suggesting that, where gender stereotyping remains, those going against the tide for their sex tend to be particularly able and sure of themselves.

CHART 1.4: O-Level/GCSE Results[1] *Per Cent Grades A-C*

Subject	1980		1993	
	m	f	m	m:f
Double-Award Science	-	-	48.0	49.3
Mathematics	60.3	52.1	41.8	41.7
English	50.7	57.1	50.2	65.1
Physics	60.0	61.8	66.8	71.7
Chemistry	62.9	59.1	69.9	68.0
Biology	59.9	52.0	66.9	56.8

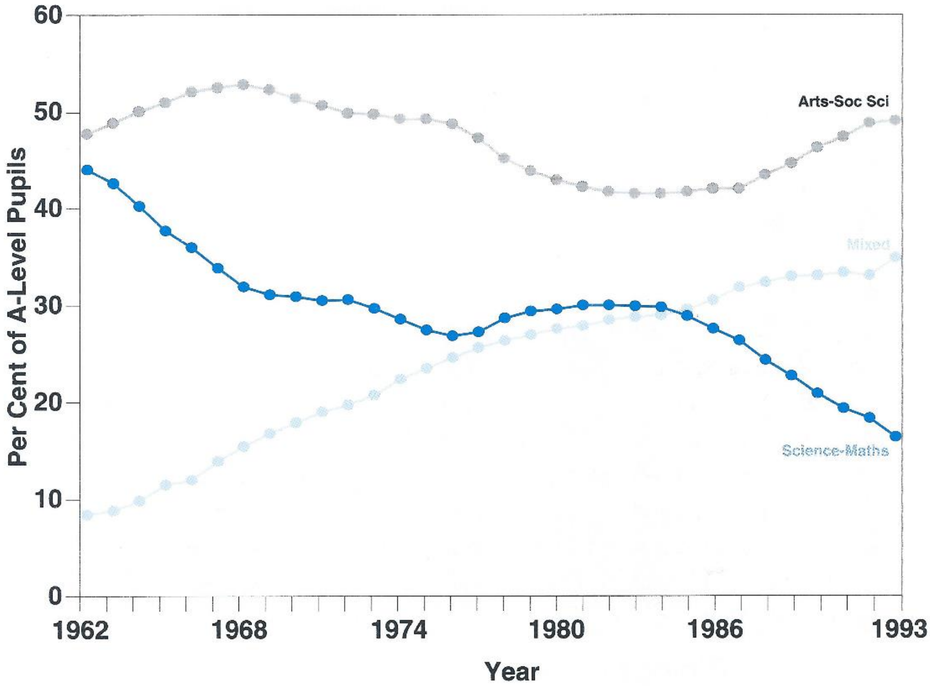
1. All ages, England.
Sources: *Statistics of Education, School Leavers, CSE and GCE*, 1980. London: DES; *Statistical Bulletin 16/93*. London: DFE; *Inter-Group Statistics*, 1993. Guildtord: Joint Council for the GCSE.

1.9 The introduction of national curriculum science and the double GCSE have been successful in increasing involvement and performance in the sciences to age 16, particularly of girls in physics and chemistry, and boys in biology. It looks as if the first two objectives - of improving scientific literacy and of helping to correct gender imbalances - are being met. It was also hoped that there would be greater take up of science A-levels.

2. Progress to A-level

2.1 In fact, the sciences have continued to decline relative to other A-levels. Chart 2.1 shows that, in 1962, 43.0 per cent of A-level entries were in science combinations, but by 1993 the proportion had dropped to only 16.6 per cent. In contrast, although fluctuating, the proportion taking arts and social sciences has remained at about 48.0 per cent (of a much increased entry). The major growth has been in mixed courses (sciences combined with non-sciences) which have gone up from nine per cent in 1962 to 34.8 per cent now.

CHART 2.1: A-Level Combinations[1]



1. Students on courses in schools (including the sixth form colleges), England. In addition, a few other 17- and 18-year-olds (2.4% in 1993) would be taking A-levels in the FE Sector.

Sources: *Annual Statistics of Education, Schools*. London: DES and DFE.

2.2 In terms of actual numbers, Chart 2.2, shows that since 1983 there has been a 31 per cent increase in those taking mixed courses and 28 per cent increase in arts and social sciences, but a drop of 40 per cent in the specialist science grouping. This is against a background of a fall of about 30 per cent in the number of 18-year-olds.

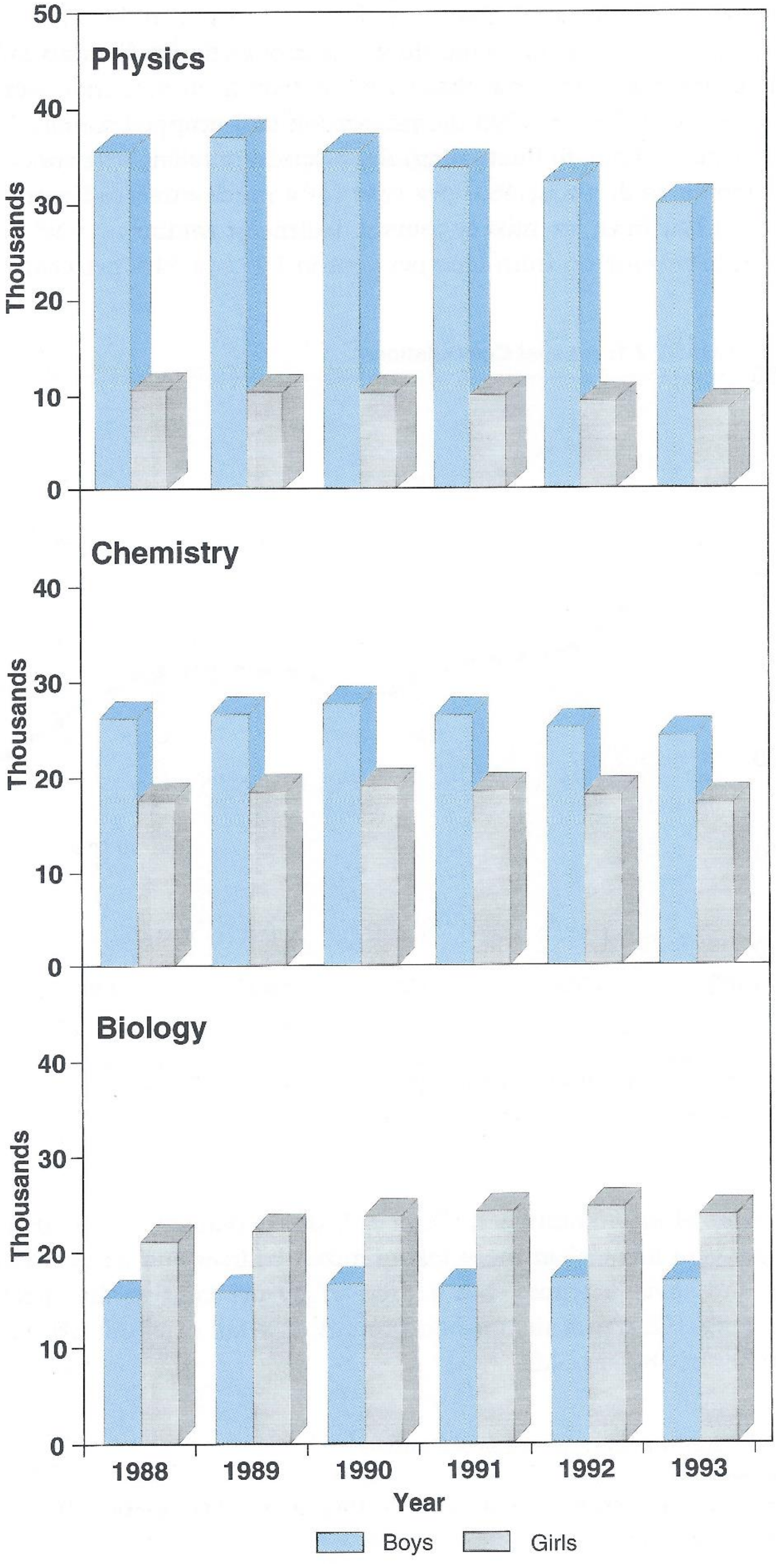
CHART 2.2: Numbers on A-Level Courses[1]

Combination	1983	1993	% Change
Science-Maths	97,214	58,288	-40.0
Arts-Soc Sci	134,361	171,396	+27.6
Mixed	93,788	122,463	+30.6

1. Schools, England.

Sources: *Annual Statistics of Education, Schools*. London: DES and DFE.

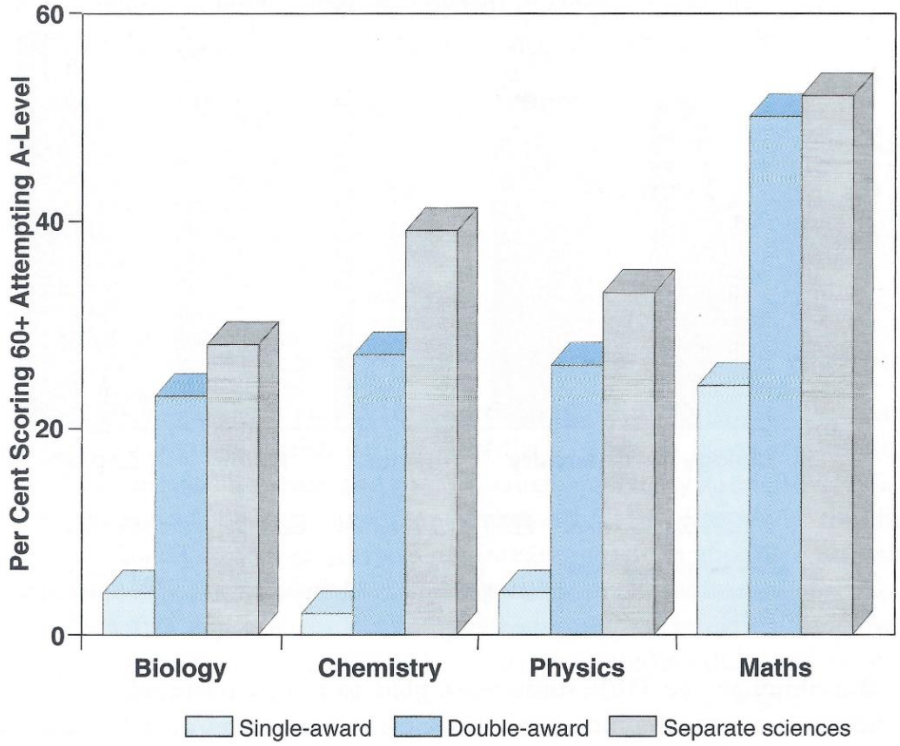
Chart 2.3: A-Level Entries[1]



1. Numbers sitting the examination in England, Wales and Northern Ireland.
Sources: *Inter-Board Statistics*, Guildford: AEB.

2.3 The impression of relative decline in science entries is confirmed by looking at the individual subjects. Chart 2.3 shows that since 1988 physics entries have fallen by 21.3 per cent, while the ratio of boys to girls has actually got bigger again - from 3.41 to 3.54. Since 1990 entries have been falling faster than the number of 18-year-olds. This is in spite of the recent doubling of the numbers taking physics to GCSE standard and the now near parity between the sexes. In chemistry too A-level entries have fallen but not as much as in physics (-4.8 per cent). In contrast, biology has enjoyed some growth though with the sex ratio remaining at 0.71.

CHART 2.4: GCSE Science and A-Level Choice[1]

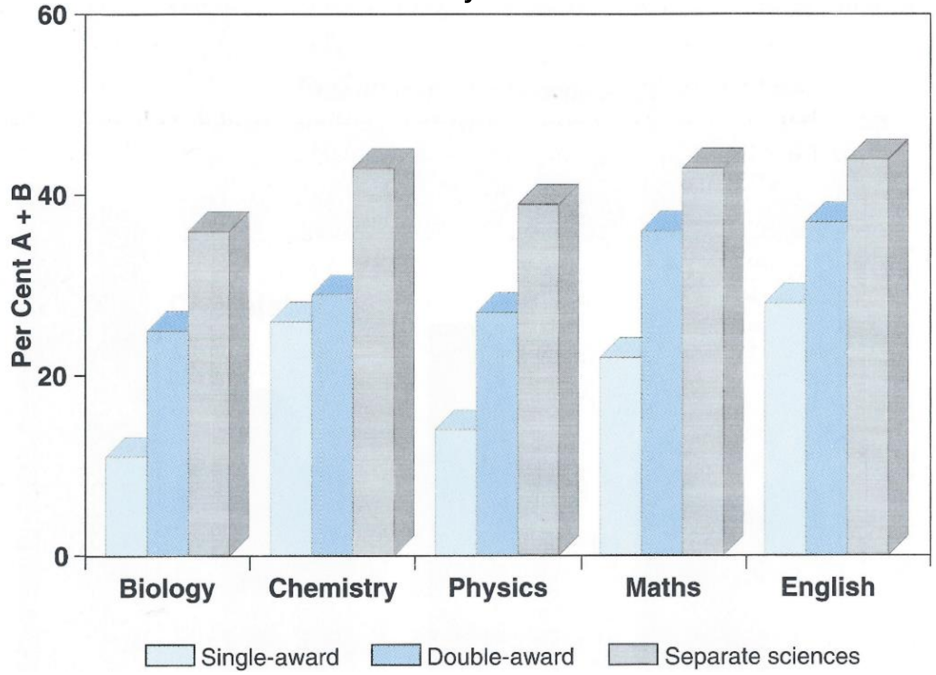


1. Schools and FE colleges, England.
Source: *Science and Maths: A Consultation Paper on the Supply and Demand of Newly Qualified Young People*, 1994. London' DFE.

2.4 It could be that increased participation at the GCSE stage has not had time to make much impact at A-level, but the double-award was prominent in 1992 and in 1994 A-level physics was still falling. The apparent failure of increased numbers 14-16 to feed through into A-level take-up as yet has put the double-award under scrutiny. Sears[1], in a series of studies marred by poor sampling, found "no evidence that the introduction of double-award syllabuses has affected the uptake to A-level science". But he did not address the more interesting question of why greatly increased participation to age 16 has not boosted participation post-16.

2.5 A recent DFE[2] review of statistics relating to science and mathematics supply has provided data suggesting students are more likely to progress to science A-levels from GCSE separate sciences than the double-award. Chart 2.4 shows that this held true for each of biology, chemistry and physics - and also to some extent mathematics. The data also make it clear that very few progressed from the single-award to science A-levels.

CHART 2.5: A-Level Grades by Science GCSE1



1. Schools and FE colleges, England.
Source: *Science and Maths: A Consultation Paper on the Supply and Demand of Newly Qualified Young People*, 1994. London: DFE.

2.6 But although the DFE study attempted to match those taking the separate sciences and the double-award on GCSE performance, with the different rules for independent and maintained schools, it was difficult to compare like with like. Chart 2.5 shows that those taking the separate sciences at GCSE were not only more likely to do well in biology, chemistry and physics at A-level, but also remarkably in English and mathematics as well. This suggests that those taking the separate sciences may have been the more generally able, or have been the better taught, or have been influenced by some factor other than the difference per se between the separate science GCSEs and the double-award.

2.7 Why science for all to age 16 has not yet fed through to A-level is a puzzle. This makes it important to discover exactly what is happening in schools.

3. Key Stage 4 in Transition

3.1 Science for all to age 16 is now a requirement of the national curriculum. It is however provided in a great variety of ways. Our ten per cent sample of maintained and independent schools (see Appendix A for details) shows - Chart 3.1 - that in 1994 double-award science was offered in all but one of the maintained schools and nearly three-quarters of the independent schools. In many schools however it was not the only science course. Three-quarters of independent schools also continued to offer all three separate sciences, but this was true of only a fifth of the maintained schools. The single-award science GCSE was available in nearly half the maintained schools but only just over a third of independent schools. Nearly half the independent schools continued to enter students for just one or two out of biology, chemistry and physics.

CHART 3.1: Science 14-16 by School

Type of Science	Maintained		Independent	
Physics, Chemistry and Biology	19.4		73.4	
Double-Science GCSE	99.7		73.4	
Co-ordinated		53.6		88.6
Integrated		10.8		4.5
Modular		48.5		9.1
Single-Science GCSE	47.5		36.3	
One or Two Separate Sciences	-		45.3	

3.2 Chart 3.1 also shows that double-award science is not uniform but comes in a number of versions which can be broadly grouped as co-ordinated (separate areas of biology, chemistry and physics usually taught by specialists), integrated (themes are arranged to stress inter-relationships) and modular (modules of varying degrees of co-ordination or integration, with modular assessment). Independent schools overwhelmingly favoured the co-ordinated approach with less than five and ten per cent respectively offering integrated and modular courses. In maintained schools nearly as many offered modular as co-ordinated, with again only a small proportion, this time 11 per cent, going for integrated.

CHART 3.2: Per Cent Pupils

Type of Science	C to 16 (N=138)	C to 18 (N=172)	SM (N=15)	Grammar (N=16)	Ind[1] (N=64)
3 Separate Sciences	2.5	3.3	0.0	32.5	35.8
Double-Award Science	95.4	94.8	97.2	66.1	45.2
Single-Award Science	2.1	1.9	2.8	1.3	6.3
2 Separate Sciences	-	-	-	-	8.6
1 Separate Science	-	-	-	-	4.1

1. In three schools, a small proportion of pupils were taking no science but overall this amounted to less than 0.05 per cent.

3.3 In terms of the numbers of pupils taking the different options, Chart 3.2 shows there is a sharp contrast between the comprehensive schools and secondary moderns on the one hand, and the grammars on the other. In most state schools the vast majority of pupils in the year prior to GCSE now take double-award science (though some are only entered for the single-award exam). Only a handful take the separate sciences. The few remaining grammar schools, however, are much more like the independents. In the grammar schools about a third take the separate sciences and two-thirds the double-award. In the independents, again about a third take all three separate sciences, but the proportion on double-award courses is less since about 13 per cent of pupils sit one or two out of biology, chemistry and physics.

3.4 The great variety of approaches which this implies is borne out by the 1993 GCSE examination returns in *Inter-Group Statistics*[3]. Chart 3.3 shows that across the GCSE Boards no less than 44 single-award and 82 double-award syllabuses were on offer. In the double-award there is literally double counting since the two papers contributing to the award are treated separately in the statistics and the number of candidates is about half the number of entries. Taking the Northern Examinations and Assessment Board[4] as an example we find there were 107,280 candidates altogether spread between Science Modular (44,637, 41.6 per cent), 'The Sciences' Modular (29,723, 27.7 per cent), Integrated (3504, 3.3 per cent) and Co-ordinated (29,416, 27.4 per cent).

CHART 3.3: GCSE Exams[1], 1993

Examination Board	Single-Award		Double-Award	
	Syllabus	Entries	Syllabus	Entries
Midlands Examining Group	8	14,755	28	334,280
Northern Examinations and Assessment Board	4	49,421	20	214,520
Southern Examining Group	10	8,189	8	36,142
University of London Examinations and Assessment Council	7	18,025	12	65,671
Northern Ireland Schools Examination and Assessment Council	3	1,011	2	2,936
Welsh Joint Education Committee	12	6,521	12	14,746
All	44	97,922	82	668,295[2]

1. All entries, England, Wales and Northern Ireland.
2. Approximately double the number of candidates since the two papers of the double-award are each counted.

Source: *Inter-Group Statistics*, 1993. Guildford; Joint Council for the GCSE.

3.5 In 1994 it was all change as the syllabuses came into line with the national curriculum programmes of study and statements of attainment. The examinations also had to comply with regulations governing coursework and terminal assessment. Double-award science was however still available in co-ordinated, integrated and modular forms though in the case of the latter with the module tests now being set externally.

3.6 In trying to describe what is happening in schools with regard to science for 14-16 year-olds we are therefore seeking to capture a rapidly changing scene. This emerges clearly in Boxes A and B where the heads of science themselves explain why they have chosen to offer the particular forms of science that they do, and if they are considering changing why.

3.7 Box A shows that not all the forms of science, double-science even, are regarded as equivalent. In fact, they fall into a distinct hierarchy. Where the full range is on offer the brighter and more science-inclined students tend to go on to the separate sciences and those who found difficulty or were quite clear they wanted to do something else at A-level tended to take single-award science (or in the case of the independent schools, two sciences, one science or none even). There was also differentiation within the double-award with the teachers saying that the co-ordinated schemes were for the more able and the modular for the weaker

BOX A: Reasons for Different Kinds of Science

Double-award science is offered as part of our 'core' curriculum, which ensures breadth and balance. It also allows pupils to choose any of our A-level sciences post-16 so is part of our equal opportunities policy. A modular course was chosen for the benefits it brings in pupil motivation and involvement, although these are less effective under current GCSE regulations. Lower ability pupils follow single-award as we feel this is more appropriate. The time gained is used to broaden their vocational programme.

Maintained, Co-ed, Comp to 18, West Midlands

We were given TVEI money to set up double-award modular science about five years ago. The immediate feedback from tests was a terrific motivation for pupils.

Maintained, SS Boys, GM, Sec Mod, South East

We feel (the whole Science Dept), strongly supported by the Head, parents and governors, that those pupils who have ability in science should be given the opportunity to study the separate sciences. This has to be done in the time allocated for 2 subjects but it has proved very successful. The majority, it is felt, will be able to cope with the double-award co-ordinated science. There are a few pupils each year with learning difficulties who take the single-award science course because that is all they can cope with.

Maintained, SS Boys, GM, Comp to 18, South East

The school follows a modular course (single-award, double-award) because it is appropriate to the children's academic abilities. It was also a logical progression from TVEI modular science. We do recognise that between 5-10% of pupils could succeed with separate sciences but it would not be cost/staff effective. The staff would dearly love to return to the separate sciences.

Maintained, Co-ed, GM, Comp to 16, North West

Single-award science for those who wish for a broader range of options. Double-award science (co-ordinated) as the provider of the most broadly-based and relevant science education. Separate sciences for a small group of particularly able scientists in 20% curriculum time and supported self-study.

Maintained, Co-ed, Comp to 16, North

The school policy is that all students take the same double-award course. This allows all entry to A-levels if they reach a required standard in all 3 sciences. Co-ordinated science was chosen to allow staff a chance to maintain their own subject specialism.

Maintained, Co-ed, Comp to 18, Greater London

The inspectorate and the LEA have been promoting the balanced science approach in recent years. This school was the last state school in the borough to continue with separate sciences at GCSE. However we had to change because of the pressure involved.

Maintained, Co-ed, Comp to 18, Greater London

Insufficient time to allow for 3 separate sciences. We find the Nuffield co-ordinated sciences at least retain the separate identities of the sciences and can be taught by specialists as far as staffing allows. Ideally we would prefer the previous system of allowing pupils to choose double-award or 2 separate sciences or 3 separate sciences.

Maintained, SS Girls, Grammar, East Midlands

Introducing Nuffield co-ordinated science in 1990 improved the balance of many students' timetables, in that prior to 1990 they could take either 1, 2 or 3 separate sciences. I believe that it has also strengthened the science department within the school and provided more unity within the department. Against this it does make transition to A-level science less smooth, particularly in chemistry, but these difficulties are not insurmountable.

Independent to 18, Co-ed, East Anglia

Separate sciences are considered better for their intrinsic depth and for their usefulness as preparation for A-level sciences.

Independent to 18, SS Boys, North

We encourage girls who want to study A-level sciences to take 3 separate sciences at GCSE because we consider this to be the only suitable preparation. We feel the double-award at the higher levels is appropriate for academic girls who know that they want to study 'arts' A-levels.

Independent to 18, SS Girls, North West

BOX B: Changing Science

The option offered in year 11 is double-award Suffolk co-ordinated science. Up to the present year this course motivated students and examination results improved dramatically. The present Suffolk course is unsatisfactory and we have changed to a modular double-award course in year 10, and are looking at the separate sciences.

Maintained, Co-ed, Comp to 16, North West

We chose Nuffield co-ordinated sciences 4 to 5 years ago because we thought it would challenge our brighter pupils. We have not found this to be particularly so and are intending to start all year 10 students in September on 3 separate sciences, allowing the weaker ones to drop back to double-award during the course of year 11. We are doing separate sciences on 3 x 3 periods per week.

Maintained, Vol-Aided, SS Boys, Grammar, West Midlands

With the advent of TVEI and the necessity for balanced science, the demand for all 3 separate sciences diminished and we did not have enough pupils to make a viable group. We are now re-introducing separate sciences into the options. However if pupils could choose just 2 of the 3 separate sciences we feel there would be greater demand.

Maintained, SS Girls, Comp to 18, Wales

A policy of double-award science for all has been implemented as far as year 10 this year, the present year 11 have single-award and double-award. We would have liked to have continued with modular science – it was our most successful course ever, but the new modular course with all its restrictions - fixed test dates, no resits and a final exam is just hopeless. We have therefore switched to co-ordinated.

Maintained, Co-ed, Comp to 18, North

1% changed from 3 separate sciences and single-award science to 20% balanced science for all due to LEA pressure, followed by change in options and giving more time to other subjects. Now there is a lack of science staff to teach 3 separate sciences.

Maintained, Co-ed, Comp to 16, East Midlands

Double-award seems the only way of offering the required 'broad and balanced science' in the time available. We chose modular (taught as 3 separate sciences) because we wanted the pupils to have the benefits of some continuous assessment; but we do not care for it and we are likely to change to a co-ordinated syllabus.

Maintained, Co-ed, Comp to 18, Wales

Our pupil intake reflects the area in which the school is situated - a high percentage of ethnic minority groups; little concern for education; poor parental support and a high proportion of below average pupils. We decided that (a) separate science provision was going to be too demanding for the majority of pupils (b) double science would provide a broad science education. We settled on the co-ordinated science (Suffolk Development) because of the manner of the examination - end of unit tests, internal assessment of practical skills and broad practical work. We have been overtaken by events and the thing we initially avoided - final exams, has now been introduced. We will look again at the course once changes arising from the Dearing Review are implemented and then reassess its suitability for our pupils.

Maintained, Vol-Aided, Co-ed, Comp to 16, West Midlands

We have been appalled by the single-award syllabuses and lack of interest in it shown by our students so we are discontinuing it. We are allowing (from 1994) students to pick one science in which they feel most competent/interest, on the understanding that they are unlikely to be able to go into A-level sciences. Double science keeps their options open for further study. All 3 separate sciences are offered for those able students who are sure they want to do A-level sciences and want the best foundation for these. There is no evidence yet that forcing all 3 sciences in some form into pupils increases interest and the desire to study science further. It seems that girls don't like physics, it's not that they cannot manage it.

Independent to 16, SS Girls, South East

We used to do double and single award modular science but found this to be inadequate for A-level preparation, particularly in physics and chemistry. (We offered this to satisfy the national curriculum). We have changed from next year since we no longer follow the national curriculum to the letter of the law. We now offer single-award science, and physics, chemistry and biology - as one, two or three separate sciences.

Independent to 18, Co-ed, South West

since it was thought easier to get them through a course in small bites, particularly with teacher assessment.

3.8 Many heads of science are contemplating change (Box B). Some feel they were forced by their LEA, or TVEI-money, or the integrated approach of the first national curriculum Statutory Order into adopting 'science' as their category and they are increasingly wanting to offer the separate sciences for those intending to go on to science A-levels. There is also a feeling that modular schemes are now less attractive since they have to conform to the examination boards assessment timetables, which could lead to some switching to co-ordinated schemes.

3.9 In the new national curriculum to be effective from September 1996 the minimum requirement for science at Key Stage 4 has been reduced *de facto* to ten per cent of curriculum time[5] Even though this is just a safety net below which no child should fall, there are fears that this single-science option will be taken mainly by girls leading to a re-emergence of gender stereotyping within national curriculum science.

CHART 3.4: GCSE Entries By Sex

Subject	1992				1993			
	Boys		Girls		Boys		Girls	
	N	%[1]	N	%[1]	N	%[1]	N	%[1]
Separate Sciences[2]	30.6	10.8	22.7	8.4	27.2	9.9	18.8	7.2
Single-Award	46.3	16.3	51.2	19.0	39.6	14.4	43.3	16.7
Double-Award	147.3	51.9	144.2	53.6	158.2	57.6	156.2	60.1
Science (Total)	224.2	78.9	218.1	81.1	225.0	81.9	218.3	84.0
Maths	233.9	82.4	230.8	85.8	229.1	83.4	224.5	86.4
English	245.3	86.4	243.7	90.6	240.7	87.6	237.4	91.4

1. 16-year-olds as percentage of age cohort.
2. Average of physics. chemistry, biology.
Source: *Statistical Bulletins 15/93 and 7/94*. London: DFE.

3.10 These fears are probably unfounded. Although the national figures for 1992 and 1993, shown in Chart 3.4, indicate a somewhat higher proportion of girls taking the single-award, they were also, as a percentage of the age cohort, more likely to be taking the double-award. More boys than girls were taking the separate sciences, but overall the proportion of girls' entries in science was the higher, as it was in mathematics and English.

CHART 3.5: More Single-Award Science *Per Cent (N in bracket)*

Type of School	C to 16		C to 18		Sec Mod		Grammar		Total[1]	
Mixed	18.9	(127)	24.8	(153)	33.3	(12)	25.0	(4)	22.7	(300)
Boys	20.0	(5)	33.3	(9)	50.0	(2)	0.0	(5)	23.8	(21)
Girls	16.7	(6)	40.0	(10)	0.0	(1)	14.3	(7)	25.0	(24)
Total	18.8	(138)	26.3	(172)	33.3	(15)	12.5	(16)	23.5	(345)

1. N's in this column contain 4 schools from 'other' category shown separately.

3.11 In our survey we asked heads of science in maintained schools whether greater flexibility at Key Stage 4 was likely to lead to more pupils taking single-award science (remember the current trend, Chart 1.1, is downwards). Chart 3.5 shows that only just under a quarter (23.5 per cent) thought it would. On present trends therefore it does not look as though the minimum requirement of ten per cent will lead to a wholesale movement out of the double-award. The schools after all have already geared themselves up for double science. There was however some variation in the views of schools, with the remaining secondary moderns and the girls' comprehensives to age 18 looking most likely to exercise the single-science option.

CHART 3.6: Attitudes to Double-Award Science *Per Cent 'Strongly Agree' or 'Agree'*

Statement	Maintained				Independent
	C 16	C 18	SM	Gr	
Lacks sufficient depth for smooth progression to science A-levels	57.8	52.0	60.0	75.0	73.0
Inadequately prepares students for studying the separate sciences at A-level	52.6	43.0	60.0	73.4	68.3
Not sufficiently challenging for able students	22.2	25.2	20.0	56.3	62.5
Keeps subject choices open at A-level	70.3	85.9	66.7	75.0	67.2
Adversely affects take-up of science A-levels	32.9	26.3	20.0	37.6	31.8
Improves flow of young people into the sciences and science-based occupations	24.8	21.2	20.0	6.3	11.1
Is appropriate because the process of science identifies one subject	47.7	38.8	60.0	21.4	16.1
Helps counteract the gender bias of physics and biology	78.8	61.5	60.0	20.0	50.0
Is taught by a disproportionate number of biologists	25.9	19.3	33.3	14.2	19.4
Is necessary to fit three subjects into curriculum time for two	71.4	73.5	77.0	53.9	52.5

3.12 Across the schools there was nevertheless considerable commitment to reducing gender bias. Chart 3.6 shows the heads-of-science' attitudes to the introduction of the double-award. Again there was a division between the comprehensives and secondary moderns on the one hand, and the grammars and independents on the other. Broadly the comprehensives and secondary moderns thought double-award science would help to counter gender bias, keep choices open and was, in any case, a pragmatic necessity for fitting three into two. They did not agree that it was inadequate preparation for A-level or insufficiently challenging. By contrast, the grammars and independents thought it lacked sufficient depth and was not sufficiently challenging, and they were less concerned about fitting three into two, or any gender link.

3.13 The comprehensives and secondary moderns were also more inclined to agree that 'science' as the category was appropriate because 'the process of science identifies one subject'. This is a clue to why perhaps the introduction of science in the national curriculum leading to a double-award GCSE has been so difficult and emotional. It has not just been about re-organising what is taught, but has been something of an ideological struggle between those who wanted to emphasize 'process' and those who wanted to emphasize 'content'.

4. Process or Content?

4.1 The reorganisation of three sciences into a two-subject slot for 14-16 year-olds has been more than just slimming down; it has been an ideological battleground.

4.2 The heart of the conflict goes back to the late 1950s when the Americans shocked by the launching of the first Russian Sputnik on 4th October, 1957, began a major effort to re-vitalise their science curricula. The mood was caught this side of the Atlantic, and the Nuffield Foundation[6] initiated a number of major curriculum development projects which led to new courses at A-level, O-level and 11-16. They were based on the view that students should learn as practising scientists do, by discovery, and that since no one person could possibly acquire all the knowledge in any field, the emphasis should be on the *processes* or *patterns* of science. When first introduced there was considerable excitement and the approach put new life into science teaching but, taken to extremes, it could be interpreted to mean that knowledge itself is unimportant. Although the Nuffield projects have exerted a powerful influence, their take-up in the pure form of guided-discovery has never been very great.

4.3 The Nuffield approach influenced a Schools Council's (a forerunner of the School Curriculum and Assessment Authority) project set up in 1970 to develop a double O-level in science. The Schools Council Integrated Science Project (SCISP)[7] produced a series of books published by Longmans called Patterns based on the central idea that science is "finding patterns and using patterns to solve problems". It was essentially about process. The double O-level was also mooted from another direction. John Cook[8], headmaster of Christ College, Brecon, in 1975, proposed a combination of biology, chemistry and physics to fit into a two-subject slot. It was essentially about content. The seeds of confusion had been sown.

4.4 In 1985, the DES[9] (as it then was) issued Science 5-16: A Statement of Policy setting out the government's views on the central place of science in the curriculum for all pupils 5-16. It introduced the notion of balanced science which became coupled with the idea of a double-award GCSE. In 1987, sixteen national bodies[10] (including The Engineering Council) signed a statement of support for the new award based on 20.0 per cent curriculum time. It was argued that the new dual award would increase breadth of understanding, keep career opportunities open, increase the pool of students available for science-based occupations, and help create a scientifically literate society. Balance was however never clarified and for some it meant an appropriate mix of biology, chemistry and physics, and for others it meant an integrated process-based approach.

4.5 The 1988 National Curriculum established science as one of the three 'core' subjects. Those holding the process view of balance were in the majority on the working party set up to advise the Secretary of State, and the Science Order emerged with 17 attainment targets deliberately designed to break the links with biology, chemistry and physics[11]. This led to considerable confusion and disquiet among many science teachers who felt they were going to have to teach outside their subject which they regarded as biology, chemistry or physics.

4.6 In the event the 17 attainment target science curriculum soon proved unworkable and a much changed National Curriculum Council under David Pascall revised it to four attainment targets, essentially biology, chemistry and physics plus investigation[12]. That curriculum has been further revised in Sir Ron Dearing's review[13]. While there may be disagreements over whether the three sciences are each represented sufficiently strongly there seems widespread acceptance that science in the national curriculum should be a balance between them. This is reflected in the relative popularity of the co-ordinated examination syllabuses described in the previous chapter.

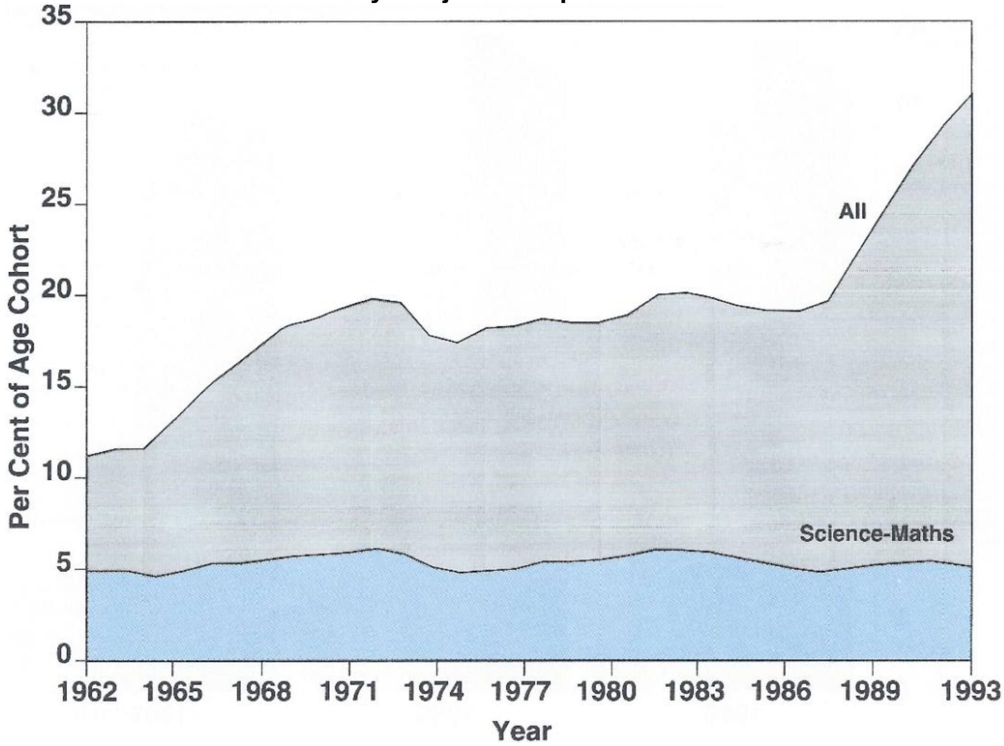
4.7 When doubts are expressed about whether the introduction of the double-award GCSE was a good thing, these are frequently coloured by confusion over what 'science' was intended to be, and the reaction against it has frequently been more against the idea of integration rather than the dual-award *per se*. In thinking about its future contribution we should recognise that it is now bedding down as an appropriate mix of biology, chemistry and physics, with the processes of scientific investigation being taught and examined through the practical work in these three main areas.

5. Necessary But Not Sufficient

5.1 The introduction of national curriculum science and the double GCSE have been a great success in increasing participation in science to age 16 and in improving the gender balance, but the apparent failure to lift A-level entries is a mystery. Many more in science to age l6 could reasonably be expected to lead to higher numbers post-16. But, as we saw in Chapter 2, this has not yet happened; if anything A-level science uptake appears to be falling.

5.2 If, however, we take the long view of A-levels as a proportion of the number of 18-year-olds, as in Chart 5.1, we find that, with minor fluctuations, science uptake has been stuck at about five per cent of the age cohort since at least 1962. This means that through all the changes - not only national curriculum science and the double award, but also the Nuffield projects and other syllabus changes, and the shifts between terminal examinations and coursework - A-level science uptake has remained about the same. It is the other A-levels (including sometimes science or mathematics in a mixed combination) that have taken off, increasing from six to 26 per cent of the age cohort during this period.

CHART 5.1: A-Levels By Subject Group[1]



1. Students on courses in schools, England.
Sources: *Annual Statistics of Education. Schools*. London: DES and DFE.

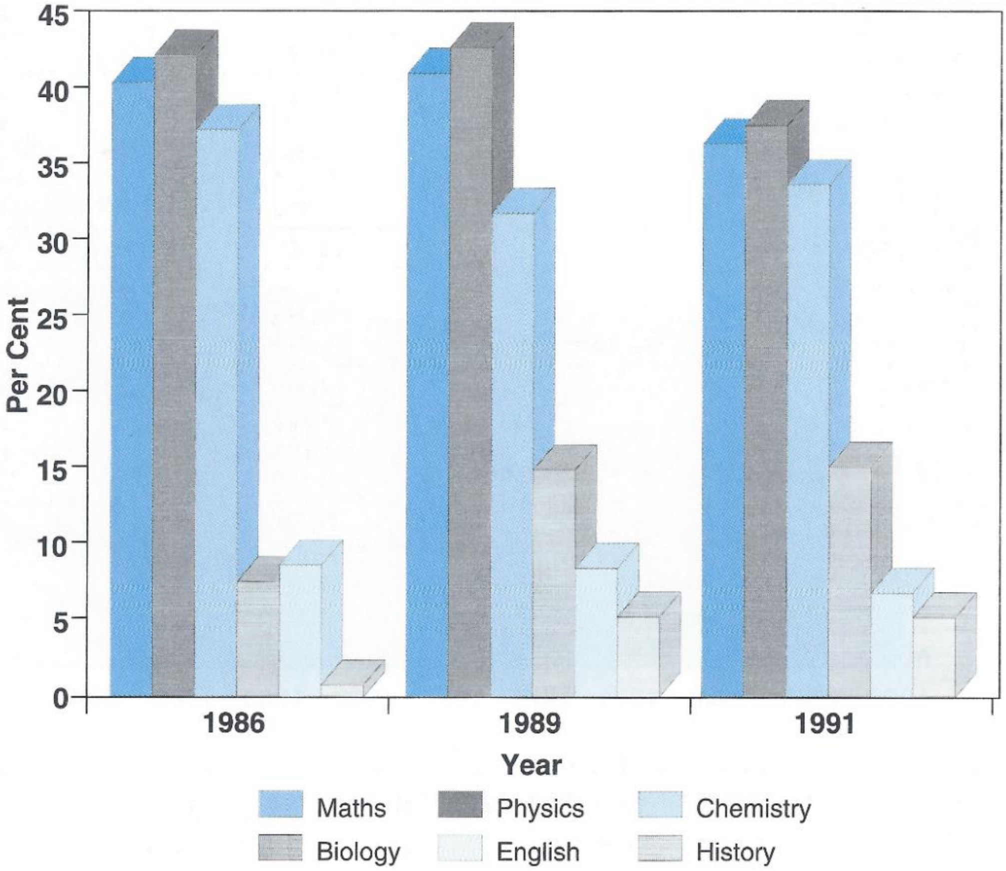
5.3 The relative stability of the proportion specialising in the sciences at A-level over more than thirty years suggests that it could be rooted in something fundamental in the structure of English education and society. A favoured candidate would be the three-subject character of the A-level curriculum, but it has also been suggested that the low take-up of the sciences could be due to a poor foundation in the primary school or the lack of appropriate incentives.

Three Subject A-Level Curriculum

5.4 During the whole time that A-level science uptake has remained at about five per cent we have had an essentially three-subject A-level curriculum. While much else has changed, this has stayed the same. Young people coming up to age 16 have, in effect, to choose for or against the sciences (since, as Smithers and Robinson[14] have shown, a mixed combination does not often contain a sufficient platform of science for progression to the sciences and engineering in higher education).

5.5 Such an abrupt choice may demand a particularly high level of confidence and commitment on the part of the students if they are to specialise in the sciences and mathematics which are generally seen to be more difficult than other A-levels. Other countries, like Japan and South Korea, Canada and Australia, with a broader curriculum in upper secondary schooling seem able to bring two or three times as many students through to their equivalent of A-level standard[15]. It may be that under the conditions we operate only about five per cent of the age group are sufficiently confident to proceed to the sciences at A-level. Changes in education 14-16 may be relatively powerless when confronted with the high threshold of science A-level choice.

CHART 5.2: Teacher supply[1] *Third Class Degree or Lower*



1. PGCE, 'old' universities.
Sources: *First Destination Surveys*. London: UCET.

Primary School Teaching

5.6 The structure of A-levels may not be the only influence. Ofsted[16] has recently considered flows into science and mathematics, and has identified the quality of mathematics teaching in primary schools as a key factor. Certainly, it has proved difficult to attract well-qualified physicists and mathematicians into teaching (Chart 5.2), and interestingly, these are the two subjects where the decline in A-level uptake is most evident.

5.7 The shortage of science and mathematics teachers is particularly acute in primary schools. There the teacher training target is global, not subject-specific, and no special effort is made to attract those in the shortage areas. Our survey of primary schools[17] found very few primary school teachers had good qualifications in science and/or mathematics. Since understanding in science and mathematics is cumulative it may be that we are paying the price in the lack of subsequent interest in those subjects. An implication of the national curriculum is that more attention must be paid to the subject expertise of primary school teachers.

CHART 5.3: University Admissions[1]

Field[2]	1986	1993	% Change
Physical Sciences	8,410	14,304	70.1
Biological Sciences	6,736	12,729	89.4
Mathematical Sciences	6,928	13,925	101.0
Science and Maths	**22,074**	**40,958**	**85.5**
Engineering and Technology	14,222	21,535	49.3
Architecture and Building	3,095	5,844	88.8
Medicine and Dentistry	4,686	5,068	8.2
Medicine Related	2,845	9,843	246.0
Agriculture	1,412	2,350	66.4
Applied Science	**26,460**	**44,640**	**68.7**
Social Sciences	17,101	31,278	82.9
Business and Administration	9,085	21,906	141.1
Mass Communication and Documentation	870	2,866	229.4
Social Science	**27,056**	**56,050**	**107.2**
Humanities	5,568	10,217	83.5
Languages	10,070	16,567	64.5
Creative Arts	1,513	5,124	238.7
Humanities	**17,151**	**31,908**	**86.0**

1. Home, first-year, full-time, first degree, UK.
2. Not including Education or Combined Subjects.

Sources: *Annual Reports*. UCCA and PCAS.

Incentives

5.8 So far we have been looking at the structure of education, but A-level science uptake will also reflect the students' inclination to make use of what is provided. The incentive of available university places has been maintained. Chart 5.3 shows that since 1986 (the first year when data for the 'old' universities and the ex-polytechnics which are now universities were compiled in the same form) science places have been increased by 86.0 per cent, the same proportion as the humanities. However, while as we saw in Chart 5.1 page 21, there have been increases in the A-level students to fill the arts and social science places, A-level science entries have fallen.

5.9 This has made it hard to recruit to science and engineering even in the 'old' universities. Chart 5.4 shows that average A-level entry scores for the physical sciences, mathematical sciences and engineering have all gone down since 1986 while in other fields they have risen. It is in the difficulty of filling university places that the widespread impression of the shortage of scientists and engineers probably resides.

CHART 5.4: Entry Scores to 'Old' Universities *Average A/AS-Level Score*

Field	1986	1993
Physical Sciences	21.6	20.9
Mathematical Sciences	24.0	22.2
Engineering and Technology	22.6	20.2
Biological Sciences	20.2	20.8
Social Sciences	22.6	23.8
Humanities	21.8	23.1
Medicine and Dentistry	26.0	26.0

Sources: *University Statistics, Vol 1, Students and Staff, 1985-6 and 1992-3*. Cheltenham: USR.

5.10 Whether we are also short in employment terms has still to be resolved. The theory of the market is that it should respond to any shortfall by improving incentives and rewards. The Department for Education's consultative document, *Science and Maths*[18], provided evidence that the salaries of scientists and engineers tended to be lower than those in many equivalent occupations. Statistics from the Higher Education Careers Services Unit[19] have shown that new science and engineering graduates are no less likely to be unemployed than those from other fields. It may be that, in fact, there is no real shortage. However, it could also be that the market is not an efficient one since, for example, it is likely to be easier to generate higher salaries in some occupations than others through, say, commissions on financial transactions. At all events, the signals from the labour market may be having a strong influence on the take-up of science A-levels, outweighing any effects from the introduction of the double-award GCSE.

Conclusion

5.11 A good platform of science to age 16 is necessary for A-level science take-up but it is not sufficient to ensure it. Failure to continue could be due more to the three-subject structure of A-levels, poor teaching in the primary school, or to the labour market than to the double-science GCSE. The national curriculum has been successful in increasing science participation to age 16. How can that be extended post-16, particularly to improving the supply of high quality scientists and engineers?

6. Next Steps

6.1 The evidence of this report suggests that national curriculum science and the double GCSE should be celebrated for their part in ensuring more pupils study science to age 16. In 1993 pupils were obtaining an average of 1.56 GCSE passes in science compared with 1.29 in 1989[20]. Greater participation pre-16 has not yet however fed through into greater uptake of science A-levels, or demand for university science and engineering places. The question then arises: what can be done to strengthen the links between science pre-16 and post-16? There are at least five possibilities:

- more consistency in the provision of national curriculum science;
- abandon the separate sciences at GCSE;
- allow maintained schools the same freedom as independent schools to offer separate sciences at GCSE;
- show levels of performance in biology, chemistry and physics separately on the double-award GCSE;
- change A-levels.

More Consistency

6.2 Although all maintained schools now follow the national curriculum in science, they can do so in a great variety of ways. Not only are there the three separate sciences, double-award science and single-award science, but the double-award comes in co-ordinated, integrated or modular forms. In 1993 there were no less than 82 double-award syllabuses assessed by anything from internal teacher assessment of coursework to externally set and marked terminal examinations.

6.3 Great strides have already been made in the direction of greater consistency. In 1994 the GCSE syllabuses came into line with the programmes of study and attainment targets of the national curriculum and now have to meet SCAA's requirements on the balance between course work assessment and terminal examination. The science curriculum has been further revised in the light of Sir Ron Dearing's review and it is hoped the new Statutory Order can remain in place unchanged for five years from September 1996 for Key State 4. The ideological struggle of what is 'science' in the double-award seems to have been resolved in favour of the separate teaching of biology, chemistry and physics in a close contextual framework.

Abandon Separate Sciences at GCSE

6.4 But there are dilemmas still over GCSE examinations. The difficulty with having the three separate sciences alongside double-award science is that students going on to do A-levels have different starting points. This may be within classes when the school offers both routes or when, as in a sixth-form college, the students come from different schools. Or it may be between schools, where A-level science courses recruiting only on the basis of specialist study pre-16 might be thought to be at an advantage.

6.5 If we accept that the scientific way of establishing truth about the world leads to different subjects defined by what is studied (living things - biology; substances and reactions - chemistry; properties of matter and energy - physics), then it becomes a question of when is the most appropriate stage at which to treat it not as one category but as several. Is it at age 11, 14, 16, 18 or even 21? There is no one right answer; it has to be a matter of judgement. The most appropriate point for separation may well depend on the interests and abilities of the students and hence the somewhat different outlook of the grammar and independent schools from the others.

6.6 It is a dilemma which every country has to face and, as the International Study of Educational Achievement[21] has shown, the split can come anywhere between Grade 4 as in Finland and Grade 11 as in Japan. In some countries biology, chemistry and physics are taught simultaneously, but in others, notably the United States, the different sciences are taught consecutively. In most countries all three are taught either separately or as science, but in Israel and the Netherlands, for part of the time at least, only two are taught.

6.7 It is easy to see why the separate sciences should appeal more to some schools and students, and double-award science to others, but having two entry points to A-levels poses something of a problem. A tidy solution would be to plump for age 16, the end of compulsory schooling, as the point of transition and have everyone taking science to age 16 and the separate sciences at A-level. This would ensure much greater consistency of provision and guard against knock-on effects such as reducing the capacity of schools to offer other subjects like technology at Key Stage 4. But it is an arrangement which has been rejected in the past as a straitjacket. The options of offering all three separate sciences or the single-award have been added to cater for the differing demands and aspirations.

Remove Restrictions

6.8 There are some who would go even further. They suggest there is quite a jump from double-award science to all three separate sciences which maintained schools are required to offer if they choose that alternative, and maintained schools like independent schools should be free to enter their students for just two. The national curriculum would continue to ensure that the entitlement to balanced science was being met, but the students could, unlike now, be entered for just physics and chemistry, or chemistry and biology, or biology and physics.

6.9 In our survey we asked heads of science if this is what they wanted and the results are shown by school type in Chart 6.1. Overall 39.1 per cent said they would like the opportunity of entering GCSE students in just two of the sciences. This feeling was particularly strong in the grammar schools and boys' schools. Those favouring such a move tended to argue that it provided a better basis for A-level, that there were substantial differences between physics and biology, and that young people had developed clear preferences by the age of 14.

CHART 6.1: Two Separate Sciences *Per Cent (N in bracket)*

Type of School	C to 16		C to 18		Sec Mod		Grammar		Total[1]	
Mixed	40.9	(127)	33.3	(153)	50.0	(12)	100.0	(4)	37.7	(300)
Boys	40.0	(5)	44.4	(9)	0.0	(2)	80.0	(5)	47.6	(21)
Girls	16.7	(6)	50.0	(10)	0.0	(1)	42.9	(7)	37.5	(24)
Total	39.9	(138)	34.9	(172)	40.0	(15)	68.8	(16)	39.1	(345)

1. Includes 4 'other' schools not shown separately.

6.10 There was, however, also a widespread feeling that such a move would be retrogressive. That the gains identified in this report of increased scientific literacy and diminished gender stereotyping would be lost and we would soon be back with girls taking biology and chemistry, and boys chemistry and physics.

6.11 A variant, consistent with the new national curriculum minimum of ten per cent science, which seeks to meet these objections, would be for all students to have to be entered for at least single-award science at GCSE but, in addition, be able to take one or more separate sciences. This has some appeal in underwriting balanced science to 16, but it is untidy in that students would be drawing on the same material for two examinations, for example, physics for the science GCSE as well as for the physics GCSE. It would also tend to reinforce the view of the single-science GCSE as the poor relation.

Separate Recording

6.12 An alternative way forward would be for separate reporting within the double award. If it is now accepted that GCSE science is a combination of biology, physics and chemistry it would be helpful if performance in these three areas could be separately identified on the GCSE certificate instead of as now as just one double grade. Amalgamating the marks as at present can mean that poor performance in one of the sciences dragging down the other two. It perhaps also gets in the way of pupils seeing a clear bridge to particular science A-levels, particularly if they are in an ll-16 school. Further, it seems sixth-form tutors are increasingly having to rely on other indicators to select their science students, like taking mathematics as a proxy for physics ability. As well as the double grade the certificate could record some indication of what had been achieved in biology, chemistry and physics.

Change A-Levels

6.13 So far we have been considering possible changes at GCSE, but the bridge could also be strengthened by changing A-levels. Our analysis suggests that the relatively low take-up of science A-levels has a lot to do with the norm of three subjects and that participation could be increased to the levels of other countries by moving to a five-subject norm. This was, of course, the recommendation of the Higginson Committee[22] which was summarily rejected by the government.

6.14 The government regards GCE A-levels as 'the gold standard' of our education system, not to be changed. But in considering A-levels it is necessary to distinguish the examining process based on panels of teachers convened by independent examination boards which can fairly be claimed to be 'the gold standard' and the norm of three subjects which is to some extent arbitrary. We could move to a norm of five subjects without too much ‘dilution’ - to refer to the government’s main worry - if we recognised that General Studies would no longer be necessary to give bolt-on breadth and could be abandoned to free up some time[23], and if, perhaps more controversially, we put more into the sixth-form day.

6.15 At present our 17- and 18-year-olds work fewer hours than do their counterparts in Europe[24]. With a careful look at the timetable we could probably move to a norm of five subjects at A-level by slimming existing A-levels by about a fifth without any loss of real quality. In that trimming process there should be explicit regard to the attainment targets of the new Statutory Order, and biology, chemistry and physics at A-level could be devised so as to lead on naturally from the appropriate parts of double-award science.

6.16 A norm of five subjects would have the great advantage of allowing students to continue to choose their subjects freely while causing all to think seriously about breadth. Those who wanted to specialise would still be able to do so, but those seeking a wider range of studies would be able to achieve it while not closing off the sciences. It would be of great advantage to engineering since students would be able to combine GCE A-level technology or GNVQ A-level engineering with physics and mathematics while still leaving room for a modern foreign language and/or other subjects[25]. It would also allow room for the development of a double-science A-level to follow on from the double-science GCSE if there were a demand for it.

6.17 But the main purpose would be to respond to the groundswell of pupil demand for more breadth (see Chart 2.1, page 9) and offer them more choice at A-level. The greater flexibility through allowing more to keep open a platform for progression in the sciences should bring benefits both to the supply of scientists and engineers and in greater public understanding of the sciences.

6.18 Even if changing to five A-levels is still too much to swallow there remains a good case for reviewing existing A-levels in the light of the recent revision of the national curriculum. There is a tendency for A-level science courses to become overloaded because while there is always enthusiasm for adding new things there is also reluctance to take anything out. What young people are expected to achieve by age 16 is now made explicit through GCSE examinations directly based on the national curriculum programmes of study and attainment targets. As well as setting an end-point for compulsory schooling they also, in effect, identify a starting-point for A-levels. Existing A-levels should be revised – while maintaining standards - to ensure that they lead on directly from double-award science based on the new Statutory Order.

Conclusion

6.19 Our preference would be to move towards a norm of double-award science at GCSE (with separate identification of performance in biology, chemistry and physics) and a five-subject A-level curriculum as part of an option array post-16. The separate sciences at GCSE introduce a necessary element of flexibility, but care must be taken that this is not at the expense of a broad and balanced education for all 14-16 year-olds.

6.20 The arrangements which emerge must provide for science both as education and vocation, fun and trade. It is important to provide for both the public understanding of science and the supply of high quality scientists and engineers. It is especially important that the key decision-makers - government, employers, and others in power - who affect the quality of all our lives should have received a good science education so that they can take wise decisions. There can be a tension between providing for those with particular interests and abilities and providing for everyone. Striking the right balance is the challenge of science education 14-16, indeed the whole of education 14-19.

Appendix: Sample and Methods

A.1 A questionnaire was sent to heads of science departments in a random one-in-five sample of maintained and independent schools in England and Wales. Maintained secondary schools were taken from the listing in the *Education Year Book, 1995*, and independent schools from the *ISIS Official Guide, 1993-4*.

CHART A.1: School Type

School Type	Sample N	Sample %	England & Wales N	England & Wales %
Comp to 16	138	40.0	1,367	39.6
Comp to 18	172	49.9	1,721	49.9
Grammar	16	4.6	155	4.5
Secondary Modern	15	4.3	169	4.9
Other	4	1.2	38	1.1
Maintained	345	100.0	3,450	100.0
Ind to 16	7	10.9	75	11.7
Ind to 18	57	89.1	565	88.3
Independent	64	100.0	640	100.0

A.2 The response rate was very good, 72.8 per cent of the maintained schools and 82.8 per cent of the independent schools. For ease of handling and understanding, the returns were reduced to an exact one-in-ten quota sample using school type, regional distribution and sex of school as the organising variables. Within these parameters, inclusion of schools in the final sample was random. The success in achieving the quotas can be seen in Charts A1, A2 and A3. Furthermore, of the maintained schools, 61 (17.7%) were grant maintained compared with the national figure of 605 (17.5%) at the time.

CHART A.2: Regional Distribution

Region	Maintained				Independent			
	Sample		England & Wales		Sample		England & Wales	
	N	%	N	%	N	%	N	%
East Anglia	14	4.1	133	3.9	3	4.7	32	5.0
East Midlands	31	9.0	310	9.0	4	6.3	32	5.0
Greater London	40	11.6	406	11.8	8	12.5	87	13.6
North	22	6.4	212	6.1	3	4.7	25	3.9
North West	45	13.0	453	13.1	5	7.8	53	8.3
South East	70	20.3	696	20.2	22	34.3	212	33.1
South West	30	8.7	305	8.8	8	12.5	84	13.1
West Midlands	38	11.0	384	11.1	5	7.8	55	8.6
Wales	22	6.4	224	6.5	2	3.6	21	3.3
Yorks & Humb	33	9.6	327	9.5	4	6.3	39	6.1
Total	345	100.1	3,450	100.1	64	100.0	640	100.0

A.3 Separate questionnaires were piloted and prepared for the maintained and independent schools taking into account the differences between them. Both versions (copies available on request from the authors) were kept as brief as possible. Apart from details such as school type, age range and sex of school, information was requested on what science options were available from age 14 and what the current take-up was.

CHART A.3: Single Sex or Co-educational

Region	Maintained				Independent			
	Sample		England & Wales		Sample		England & Wales	
	N	%	N	%	N	%	N	%
Mixed	300	87.0	3,004	87.0	24	37.5	236	36.9
Boys	21	6.0	206	6.0	14	21.9	139	21.7
Girls	24	7.0	240	7.0	26	40.6	265	41.4
Total	345	100.0	3,450	100.0	64	100.0	640	100.0

A.4 The heads of science departments were asked for their views. Attitudes to double-award science were also elicited through agreement or disagreement with ten separate statements on five-point scales. Additionally, heads of department in maintained schools were asked whether they would like to offer two separate sciences instead of three and whether a reduction in single-award science to ten per cent of curriculum time would have any effect.

A.5 The questionnaires went out to schools in June 1994 and were completed and returned within two or three weeks, by mid-July 1994. The large and rapid response is indicative of the level of interest and concern about the nature of science provision in schools as it currently is and might be.

Notes

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