Science subject uptake for year 11 pupils (1974-1997)

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(Interim Report)

Introduction

Since 1975, there have been many changes that have transformed the science education of year 11 school children in England. These changes have included the move from CSE and O-level examinations to the GCSE, and the introduction of the National Curriculum. In the early 1980s, a major concern was the Biology/Physics polarisation in the option choices of girls and boys and the resulting limitation of later career opportunities (Royal Society and Institute of Physics, 1982; Johnson and Murphy, 1986). For example, Frazer (1986) stated that:

> Each year that goes by without all boys and girls from 5-16 receiving a balanced science curriculum is a shame. A shame on the country for depriving itself of much needed talent, and a shame for depriving young people from learning about part of the culture and about knowledge which will so much affect their lives.

By 1995 this situation had changed. Almost all pupils in state schools were required to take science and the differences in gender had apparently disappeared. Elwood (1995) reviewed the performance in GCSE and noted that:

> ...the patterns of performance in the GCSE are not unique, but are part of wider trends that support the assumption that the old stereotypes of girls' and boys' performance in examinations and assessment systems no longer hold firm.

This paper will consider gender related changes in uptake from the 1970s to 1997. It will draw data from a variety of sources:

- the HMI Aspects of Secondary Education Report which surveyed schools over the period 1975-78,
- the Assessment of Performance Unit's Science Surveys 1980-1984,
- an Assessment of Performance Unit Questionnaire from 1988,
- and the 1997 16+ database.

At the time of the APU surveys, two of the major issues in science education were the dangers of early specialisation resulting from candidates choosing to study an incomplete set of sciences at 14 and the lower performance of girls in physics (Johnson and Murphy, 1987). The former has been prevented in maintained schools by the introduction of the National Curriculum. Candidates who are subject to the requirements of the National Curriculum for Science at Key Stage 4 must be entered for either Science: Single Award or Science: Double Award or one of the linked sets of Biology, Chemistry and Physics. Candidates attending independent schools are not subject to this requirement but are included in these analyses. Other science subjects can be entered but they cannot be used as a substitute for National Curriculum science. Students can also take the science course but not enter the examination. Both Science: Double Award and Science: Single Award include material from the three separate sciences of Biology, Chemistry and Physics but differ in the range of coverage.

Number of science courses followed

The first feature of the science curriculum that will be considered is the number of GCSE science examinations taken (double and dual awards were counted as two examinations). This is a measure of the amount of science studied. This can be compared with the results of the APU surveys with a major proviso. The APU surveys counted the number of science subjects studied and the 16+ database counts the number of GCSE examinations taken. For example, this means that in the 16+ database some of the pupils listed as taking no science will include those who are studying science but not sitting any examinations in the relevant period.

The number of science subjects studied for 1975-84 (from HMI survey (DES, 1979) and the APU surveys) and the number of examinations sat for 1997 are given in Table 1.

Table 1: Number of science subjects studied 1975-84 and number of GCSE examinations taken in 1997

No. of	1975/8			1980			1984			1997		
Subjects	M	F	A	M	F	A	M	F	A	M	F	A
3 or more	10	4	7	16	8	12	15	8	12	8	5	6
2	31	18	25	32	22	27	34	25	30	78	81	79
1	50	60	55	47	59	53	48	60	54	9	10	10
0	9	18	13	5	11	8	3	6	4	4*	4*	4*
Pupils (1000s)	19.2	16.9	36.1	5.8	5.9	11.8	3.6	3.6	7.2	281	276	557

* many of these candidates may have been taking science but not entered for examinations.

Before the introduction of GCSE and the National Curriculum, many schools had policies that influenced the number of science courses taken. In the 1983 survey (Welford et al., 1986), schools were asked a series of questions about school policy for 15-year-olds with respect to science. 13% of schools did not have a school policy that every pupil must study at least one science. 13% of schools had a policy that no pupil might take more than two sciences (which in most cases meant that the pupils would not be able to follow a balanced science curriculum including elements of Biology, Physics and Chemistry). In 31% of schools, only those pupils entered for more than six O-levels were allowed to take three sciences.

The GCSE had an influence on the science curriculum before the introduction of the National Curriculum. In 1988, a significant number of schools did not allow or discouraged pupils from taking all three major sciences (Daniels and Bell, 1989). In other schools, the GCSE courses had been introduced to replace general science courses but only for the less able and average pupils while the more able pupils were still offered a choice of separate subjects, i.e. the pattern that existed before the introduction of the GCSE. Several schools explicitly stated that their pupils had to choose between Biology and Physics.

Individual courses followed

The number of science courses followed does not reveal the full picture. It is necessary to consider the percentages of individual courses followed and examinations taken, and also how they are combined together. In the APU surveys, the following subjects were identified: Biology, Chemistry, Physics, 'General Science', Human Biology, Technology, Rural Science, Electronics, Physics with Chemistry and SCISP, the Schools Council Integrated Science Project. The term 'General Science' was used to indicate a variety of science courses (many of which would be called simply science) and was obsolescent at the time of the APU. It was used then to distinguish between the course, General Science, and the subject area, science. Technology in 1984 was restricted to science-based technology courses and not design and technology.

The percentages of boys and girls following individual science courses in 1984 and taking science examinations in 1997 are given in Table 2.

Table 2: Science courses followed by sixteen-year-olds by sex in 1984 and examinations taken in 1997
(percentages of candidates taking course or examination)

	1984 courses		1997 examinations	
Subject	Boys	Girls	Boys	Girls
Biology	34	57	8	5
Physics	56	21	8	5
Chemistry	36	28	8	5
General Science	12	11	-	-
Human Biology	4	11	<1	<1
Technology	3	<1	0	0
Rural Science	4	1	<1	<1
Electronics	2	<1	<1	<1
Physics with chemistry	2	<1	0	0
SCISP	3	<1	-	-
Double GCSE	-	-	77	80
Single GCSE	-	-	10	10

- not applicable

One notable change is the decline in the amount of time spent on the separate elements of science as a result of introducing a balanced science curriculum. For example, 56% of boys were studying physics as a separate course and in 1997 only 8% were taking physics as a GCSE examination. The majority of pupils were studying Science: Double Award. The Physical Processes attainment target is only one quarter of the total examination, which is the equivalent of two GCSEs.

In the 1984 study, the survey schools were asked to indicate both the number and level of external examinations each sample was likely to be entered for in the following year, i.e. towards the end of the fifth year, now year 11. This information has always served as a useful indicator of the pupil's general level of academic ability. The distributions of the examination entry plans for the 1984 sample are presented in Table 3. There is a problem with the category 8+ O-levels because, in some schools, there was a policy not to allow candidates to sit that number of examinations. This information was used to investigate the ability related differences in subject take-up rates.

Table 3: Pupil sample composition in 1984 in terms of examination entry plans
(Percentage of pupils in each 'examination entry' group)

Examination Intentions*	Boys	Girls	All
8+ O-levels	21	19	20
6-7 O-levels	11	13	12
3-5 O-levels	15	17	16
1-2 O-levels	13	15	14
4 or more CSEs	26	25	25
0-3 CSEs	15	12	13
Number of Pupils	3378	3297	6675

*Those pupils in the first four groups might also be taking CSEs; those pupils in the two 'CSE' groups would *not* be taking O-levels.

In the 16+ database, there are the GCSE examination results for candidates. By assigning marks to the GCSE scores (U=0, G=1, etc.) and taking the mean scores, it is possible to arrive at an achievement distribution. By taking the GCSE mean scores at the percentiles given in Table 3, it is possible to arrive at broadly similar categories for the purposes of comparison. For the purposes of subsequent analyses, three categories of examination intentions will be considered:

High attainers	Six or more O-levels	32% of candidates	5.20<mean GCSE
Medium attainers	One to five O-levels	30% of candidates,	3.70<mean GCSE ≤ 5.20
Low attainers	CSEs only	38% of candidates,	mean GCSE ≤ 3.70

It should be recognised that these categories are not completely comparable. Although 32% of pupils in 1984 were entered for 6 or more O-levels this does not mean that all the pupils attained better results than those in

lower categories because it is derived from examination intentions which were determined by school policies. Independent and grammar schools tended not to enter candidates for CSE examinations.

Table 4 shows that the uptake of science subjects by pupils in 1984 was strongly related to predicted attainment.

Table 4: Science courses followed by sixteen-year-olds by ability in 1984 and 1997
(percentage of candidates in each ability band following course)

	1984			1997		
Subject	High	Medium	Low	High	Medium	Low
Biology	63	51	38	16	3	<1
Chemistry	57	32	16	16	3	<1
Physics	58	40	28	16	3	<1
General Science	2	6	33	-	-	-
Human Biology	4	7	15	<1	<1	<1
Rural Science	1	2	6	<1	<1	<1
Double GCSE	-	-	-	77	86	75
Single GCSE	-	-	-	3	8	17

- not applicable

The combinations of subject by sex are given in Table 5. The information on combinations of subjects has been taken from the report of the 1983 survey (Welford et al., 1986). In 1983, only 22% of boys and 17% of girls were studying balanced science either as all three traditional sciences or as a general science course. 54% of boys and 57% of girls were studying an incomplete combination of only one or two of the three traditional sciences. In 1997, the percentages of boys and girls taking examinations in the three traditional sciences had fallen to 7% and 4% respectively. The percentages of pupils taking incomplete combinations of only the traditional sciences were negligible in 1997 and would, almost certainly, be attending independent schools. 95% of boys and 96% of girls were taking balanced combinations of science examinations in the form of either all three traditional sciences, double award GCSE or single award GCSE.

Table 5: Combinations of science subjects in 1983 and science examinations in 1992

	1983		1997	
Course Combination	Boys	Girls	Boys	Girls
Biology, Chemistry, Physics	12	10	7	4
Biology, Chemistry	3	11	<1	<1
Biology, Physics	7	4	<1	<1
Chemistry, Physics	16	4	<1	<1
Biology only	7	30	<1	<1
Chemistry only	3	4	<1	<1
Physics only	18	4	<1	<1
General Science only	10	7	-	-
Human Biology only	2	9	<1	<1
Science: Double Award	-	-	77	80
Science: Single Award	-	-	9	10
Other combinations	19	13	2	1
No science course/examination	4	6	4	4

* no science means no examination taken in 1997, not no science course followed

The introduction of the National Curriculum has seen a major change in the provision of science in secondary school. In the early 1980s, science uptake tended to be taking combinations of the three traditional science subjects: Biology, Chemistry and Physics, or a Single Subject (General) Science course. With the introduction of GCSE examinations and the National Curriculum, there has been a move away from the traditional science subjects to Double Award Science GCSEs. From 1992, all children in maintained schools in England have to follow a balanced science curriculum to satisfy the requirements of the National Curriculum. Of the three approaches to satisfying the requirements of the National Curriculum, the most common is to enter a double award GCSE.

There has been a decline in the amount of science studied by candidates in the highest attaining group. The percentage of candidates taking all three traditional science courses has approximately halved since 1980. For pupils taking two subjects, in 1992 the majority are now taking double science GCSEs instead of selecting two of the three traditional sciences as was the common practice in 1984. This leads to arguments that depth of scientific knowledge may have been sacrificed for width and balance.

In 1984, the polarisation of girls and boys into the biological sciences at 13+ could be expected to result in the emergence of sex-related performance differences in the subcategories used in the age 15 APU survey which would not be found in the age 13 surveys. The survey evidence was that this was the case. Performance differences in the subcategories *Using graphs, tables and charts; Interpreting presented information* and *Applying chemistry concepts,* present at age 15 but not at age 13, were attributable to different subject take-up patterns among boys and girls. This explanation, however, did not work for the subcategory *Applying physics concepts.* Significant sex differences in performance in favour of boys consistently appeared at every age in the APU surveys and this gap in performance persisted even among those able pupils continuing to study physics at age 15. It was hypothesised that this gap might be attributed to the very different leisure activities of young boys and girls out of school (Johnson and Murphy, 1986; Johnson, 1987a and b). The activities preferred by boys were of a kind offering greater opportunities to develop practical skills and acquire an appropriate grounding for later conceptual learning in physics.

In 1997 the group mean of the total science GCSE scores for boys was 8.47 compared to 8.25 for the girls. This difference is related to the fact that boys tend to take more science GCSEs than girls. It is not possible to investigate the sex differences in the component parts of science using the 16+ database because so many pupils take combined courses. To investigate this, a more detailed study of performance on the component examination papers and the individual questions in GCSE is necessary. The stereotypical patterns of performance still occur at both the component and the question level in GCSE science (Bell, 1997a and b).

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