CAMBRIDGE ASSESSMENT

Science: A valid overview of entries in schools and colleges

Including a commentary on
the Policy Exchange Report *Science Fiction?*

Cambridge Assessment – Research Division
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University of Cambridge
Local Examinations Syndicate

Commentary on Policy Exchange Report: Science Fiction? Uncovering the real level of science skills at school and university

Cambridge Assessment – Research Division

Executive Summary

- We concur with the overall drift of the argument in the Policy Exchange paper – namely that there has not been a dramatic increase in attainment and participation in Science education in the period 1997 – 2008. However, there are some key gaps in the data used, and some significant problems in the interpretation of the data. These affect the specific policy recommendations deriving from the analysis.

- The data on science qualifications are complex. One issue is the confusion between the number of exam entries and the number of candidates. This problem is evident in the Policy Exchange report. One candidate may take more than one qualification. While the number of entries gives an idea of the total volume of science education which is occurring, it is possible for there to be an increasing number of entries, but a decreasing number of people taking science, or vice versa.

- The report presents misleading data on candidates taking Additional Science. They are mentioned in the report but not represented correctly in the graphs. The continuous lines in the graphs (p.6) imply that Double Award and Single Award continued after 2007. This was not the case as they were replaced by GCSE Science and Additional Science. Also, in the Policy Exchange Report it is stated that '…in September 2006 when Double Award science was scrapped and pupils were shifted into a new single GCSE Science qualification under the new '21st Century Science' curriculum….' In fact, most of the pupils who would previously have taken Double Award took both Science and Additional Science in 2008.

- It is not the case that all pupils took all three science subjects under the O-level system. Most studied one or two of the separate sciences only, not three.

- The analysis goes back to 1997, an apparent test of Labour policy commitments. A comprehensive analysis must go back to 1991 at least, due to major changes which occurred then and should clarify the pattern of exam taking prior to the introduction of GCSE in 1986. Three phases can be identified from 1991 to 2008 (see full Cambridge Assessment commentary).

- Major shifts within science education derive from events and policy decisions taken in the early 1990s. Actions taken during the late 1990s and early 2000s have not significantly disturbed the situation, despite successive Government revisions to the structure of qualifications. This latter period has been characterised by neither catastrophic decline in overall volumes nor substantial increase.

- It is important to link exam entries to the population of 16 year olds as a whole since simply looking at trends in entries is misleading. Entries can decline

simply because the population reduces (see Cambridge Assessment full commentary for details).

- Overall A-level volumes from 2002 to 2008 are basically static – but Physics is declining. The A-level cohort has decreased slightly. However, per head of the increasing 18-year-old population, the number of science entries has remained constant since 2003.

- A misleading set of percentages is presented in the Policy Exchange report. In their Figure 3, (p.11) the figures presented as the numbers of students entering A-level sciences are, in fact, the percentages of the entire age cohort (showing A-level Physics at 3%). Only around a third of the A-level population are studying A-levels (of these 10% take A-level Physics). For the accurate figures see the full Cambridge Assessment commentary.

- The Policy Exchange report presents over-simplistic comparisons of independent and state schools. Many independent schools do not offer separate sciences and if they do, they do not necessarily offer them to all of their pupils. At A-level, provision by comprehensive schools and independent schools tends to be similar.

- The report has not taken into account the prior attainment of students in independent schools, which tend to have a higher proportion of higher attaining pupils at GCSE, who naturally have a greater tendency to progress to A-level in any subject.

Commentary on the Policy Exchange Report: Science Fiction? Uncovering the real level of science skills at school and university

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We concur with the overall drift of the argument in the Policy Exchange paper – namely that there has not been a dramatic increase in attainment and participation in Science education in the period 1997-2008. However, there are some key gaps in the data used, and some significant problems in the interpretation of the data. These affect the specific policy recommendations deriving from the analysis.

1
Confusion between the number of exam entries and the number of candidates
One key complexity of the data on science qualifications must be appreciated: that most reports (and the Policy Exchange paper is no exception) are based on entries to qualifications. One candidate may take more than one qualification. While the number of entries gives an idea of the total volume of science education which is occurring, it is entirely possible for there to be an increasing number of entries, but a decreasing number of people taking science, or vice versa. The paper presents misleading data on candidates taking Additional Science – some 470,000 entries in 2008. The report mentions Additional Science but the graphs (p.6) have continuous lines between pre-2008 and 2008 for Double Award and Single Award. This implies that these qualifications continued after 2007. This was not the case as they were replaced by GCSE Science and Additional Science qualifications. The data are correctly represented in our commentary here.

On this issue, the report also has the following very misleading sentence in the third paragraph on p.6: “This was intensified in September 2006 when the old Double Award science was scrapped and pupils were shifted into a new single GCSE Science qualification under the new ‘21st Century Science’ curriculum…”. In reality most of the pupils who would have previously studied Double Award took both Science and Additional Science in 2008.

2
Misunderstanding history: three sciences as a mainstream diet
The Policy Exchange paper does tend towards a gilded view of the past. It is simply not the case that all pupils took all three science subjects under the O-level system. Prior to the introduction of GCSE most 15 and 16 year olds studied one or two of the separate sciences only, not three (Bell, J 2001). Entry to subjects was heavily gendered. Double Science GCSE was introduced as a remedy to the heavily gendered nature of entry at O-level (a trend which continues to this day at A-level) and to ensure that a far greater number of candidates had a wider diet of science. Its introduction may have spawned unintended consequences, but the reasons for its introduction need to be understood.

3
The time window used for the analysis
How far back is far enough? The analysis goes back to 1997, an apparent test of Labour policy commitments. But any comprehensive analysis of the recent history of key trends in science education must go back to 1991 at least, and in addition should make clear the pattern of exam-taking prior to the introduction of GCSE in 1986. Although statistical analysis across the timeframe 1991 to the present day is hampered by the lack of a consistent body of data, it is clear that there was a substantial decline of Physics from 1991, associated with a dramatic rise in double science from that date. GCSE attainment also needs to be examined in the light of

the changes in A-level entry and attainment. The period 1991-2008 is in fact characterised by three phases:

From 1991 to 1997: dramatic decline in all single science GCSE due to systemic switch to Double Science. Dramatic decline in Physics A-level, slight decline in Chemistry and a significant increase in Biology.
From 1997 to 2003: gradual decline in the proportion of the age group taking science subjects at A-level.
From 2003 to the present day: general stability.

We suggest that the major shifts within science education derive from events and policy decisions taken in the early 1990s. What is clear is that actions taken during the late 1990s and early 2000s have not significantly disturbed the situation. Despite successive Government-led revisions to the structure of qualifications – revisions which are costly, threaten standards maintenance, and have led to complex routes through GCSE science – the period 1997-2008 has seen neither dramatic improvement in participation, nor has it seen a catastrophic collapse. We would argue that constant change in the structure and content of the qualifications has not resulted in any substantial changes in participation and provision – the period is, in fact, characterised by stability. Although the structural switch to double science was indeed a watershed, later changes in qualifications structure have been overshadowed by far more significant factors. These drive patterns of provision in a more potent way: incentives and drivers deriving from league (performance) tables; signals from the labour market; learning preferences; advice and guidance.

The following tables give a more comprehensive picture of enduring trends – compare the 1991 figures and 2008, in terms of the overall volume of science qualification entries:

Table 1: GCSE
*note that Double Science counts as two GCSEs so the total entries are twice the number of candidates

Subject	***1991***	***1997***	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Single Science	*27,406*	*43,468*	54,686	56,930	59,418	74,834	81,703	84,036	
Double Science*	*392,830*	*929,523*	944,888	958,964	972,754	910,762	883,218	879,846	
Science								55,149	501,235
Additional Science									406,933
Biology	*160,953*	*59,029*	43,672	45,504	47,739	50,917	54,427	57,138	77,817
Chemistry	*122,986*	*45,486*	41,761	43,329	45,816	47,979	51,382	53,527	70,064
Physics	*132,095*	*44,978*	41,171	42,439	44,941	47,175	50,669	52,697	69,097
Other Sciences			10,406	9,570	9,274	8,672	8,814	8,515	10,552
Total GCSE science entries	***836,270***	***1,122,484***	**1,136,584**	**1,156,736**	**1,179,942**	**1,140,339**	**1,130,213**	**1,190,908**	**1,135,698**

A-level

Subject	***1991***	***1997***	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
GCE Biology	*46,607*	*56,706*	46,480	46,192	46,320	47,925	48,813	48,659	50,148
GCE Chemistry	*44,440*	*42,262*	32,995	32,544	33,492	34,935	36,123	36,458	37,711
GCE Physics	*43,416*	*33,243*	28,607	27,580	25,820	25,418	24,730	24,854	25,544

Source 1991 and 1997 data: QCA Stats and Information Management Team – Inter-examination Board Final Results – England Wales and Northern Ireland
Source 2002-2008 data: JCQ England

4

Stability in participation appears to be the order of the day

As a result of the changes in qualifications (particularly the introduction, in 2008, of Science and Additional Science) it is very difficult to use graphs to present information on the volume of science learning; they simply look confusing. For the sake of completeness, we have included new graphs at the end of this paper which make good the Policy Exchange omission of Additional Science. But they are not really that clear or helpful. Far more helpful are the following tables.

In table 2, look at the bottom row. This includes a measure of the number of science GCSE entries per head of population. This gives a good idea of the volume of science education. It is important to link exam entries to the population of 16 year olds since simply looking at trends in entries is misleading. Entries can decline simply because the population of 16 year olds reduces. There are instances during population fluctuation cycles when overall entries decline but increased numbers of candidates are taking particular exams (and vice versa).

The figures in the bottom row in table 2 (GCSE) show very slow decline, from 1.81 to 1.72. Interestingly, the figures in the bottom row of table 5 (A level) are incredibly stable. Tables 3 and 4 display this in more detail for GCSE, and tables 6 and 7 do this for A-level.

These data suggest that the general thrust of the Policy Exchange paper is correct: policy initiatives in the late 1990s onwards have not led to increased volume of science learning.

Table 2: Entries for science GCSEs for 2002-2008 (England only)

Subject	2002	2003	2004	2005	2006	2007	2008
Single Science	54,686	56,930	59,418	74,834	81,703	84,036	
Double Science	944,888	958,964	972,754	910,762	883,218	879,846	
Science						55,149	501,235
Additional Science							406,933
Biology	43,672	45,504	47,739	50,917	54,427	57,138	77,817
Chemistry	41,761	43,329	45,816	47,979	51,382	53,527	70,064
Physics	41,171	42,439	44,941	47,175	50,669	52,697	69,097
Other Sciences	10,406	9,570	9,274	8,672	8,814	8,515	10,552
Total GCSE science entries	**1,136,584**	**1,156,736**	**1,179,942**	**1,140,339**	**1,130,213**	**1,190,908**	**1,135,698**
GCSE cohort	**606,554**	**622,165**	**643,574**	**633,464**	**628,700**	**637,000**	**636,700**
Science GCSE Entries per candidate	**1.87**	**1.86**	**1.83**	**1.80**	**1.80**	**1.87**	**1.78**
Population aged 16	**629,300**	**641,500**	**661,100**	**655,300**	**661,400**	**671,900**	**661,100**
Science GCSE entries per head of population	**1.81**	**1.80**	**1.78**	**1.74**	**1.71**	**1.77**	**1.72**

The losses and gains in this period require careful tracking. We look at key trends here.

Entries for GCSE sciences for the period 2002 to 2008 can be seen in Table 2 above. The number of Double Science entries fell from 944,888 in 2002 to 879,846 in 2007. There was also a fall in Double Science entries over this period as a percentage of the GCSE cohort, from 77.9 to 69.1 - see Table 4 below.

Double Science and Single Science were replaced in 2008 by Science and Additional Science. The sum of the Science and Additional Science entries in 2008 (908,168) was less than the sum of the Double and Single Science entries in 2002 (999,574).

However, there were increases in the entries for all three of the separate sciences over the period 2002 to 2008, both in terms of raw numbers and cohort percentages. Biology increased from 43,672 entries (7.2% of the GCSE cohort) to 77,817 (12.2%), Chemistry from 41,761 (6.9%) to 70,064 (11.0%) and Physics from 41,171 (6.8%) to 69,097 (10.9%).

But the telling figures are in table 2 above: the bottom row (science GCSE entries per head of the population of 16 year olds) and the third row from the bottom (science GCSE entries per candidate). Both show a downwards trajectory; a reduced volume of science learning.

Table 3: Percentage of 16-year-old population studying each category of science subject at GCSE

Subject	2002	2003	2004	2005	2006	2007	2008
Single Science	8.7	8.9	9.0	11.4	12.4	12.5	-
Double Science	75.1	74.7	73.6	69.5	66.8	65.5	-
Science	-	-	-	-	-	8.2	75.8
Additional Science	-	-	-	-	-	-	61.6
Biology	6.9	7.1	7.2	7.8	8.2	8.5	11.8
Chemistry	6.6	6.8	6.9	7.3	7.8	8.0	10.6
Physics	6.5	6.6	6.8	7.2	7.7	7.8	10.5
Other Sciences	1.7	1.5	1.4	1.3	1.3	1.3	1.6

Table 4: Percentage of GCSE cohort studying each category of science subject

Subject	2002	2003	2004	2005	2006	2007	2008
Single Science	9.0	9.2	9.2	11.8	13.0	13.2	-
Double Science	77.9	77.1	75.6	71.9	70.2	69.1	-
Science	-	-	-	-	-	8.7	78.7
Additional Science	-	-	-	-	-	-	63.9
Biology	7.2	7.3	7.4	8.0	8.7	9.0	12.2
Chemistry	6.9	7.0	7.1	7.6	8.2	8.4	11.0
Physics	6.8	6.8	7.0	7.4	8.1	8.3	10.9
Other Sciences	1.7	1.5	1.4	1.4	1.4	1.3	1.7

Table 5: Entries for science A-levels for 2002-2008 (England only)

Subject	2002	2003	2004	2005	2006	2007	2008
GCE Biology	46,480	46,192	46,320	47,925	48,813	48,659	50,148
GCE Chemistry	32,995	32,544	33,492	34,935	36,123	36,458	37,711
GCE Physics	28,607	27,580	25,820	25,418	24,730	24,854	25,544
Other GCE science subjects	3,887	4,243	3,974	3,948	3,729	4,032	4,118
Total A-level science entries	**111,969**	**110,559**	**109,606**	**112,226**	**113,395**	**114,003**	**117,521**
A-level cohort	**257,922**	**268,671**	**265,257**	**263,635**	**258,285**	**249,547**	**256,622**
Science A-level entries per candidate	**0.43**	**0.41**	**0.41**	**0.43**	**0.44**	**0.46**	**0.46**
Population aged 18	**614,100**	**643,300**	**645,300**	**657,700**	**675,800**	**669,900**	**675,100**
Science A-level entries per head of pop	**0.18**	**0.17**	**0.17**	**0.17**	**0.17**	**0.17**	**0.17**

Table 6: Percentage of 18-year-old population studying each category of science subject at A-level

Subject	2002	2003	2004	2005	2006	2007	2008
GCE Biology	7.6	7.2	7.2	7.3	7.2	7.3	7.4
GCE Chemistry	5.4	5.1	5.2	5.3	5.3	5.4	5.6
GCE Physics	4.7	4.3	4.0	3.9	3.7	3.7	3.8
Other GCE science subjects	0.6	0.7	0.6	0.6	0.6	0.6	0.6

Table 7: Percentage of A-level cohort studying each category of science subject

Subject	2002	2003	2004	2005	2006	2007	2008
GCE Biology	18.0	17.2	17.5	18.2	18.9	19.5	19.5
GCE Chemistry	12.8	12.1	12.6	13.3	14.0	14.6	14.7
GCE Physics	11.1	10.3	9.7	9.6	9.6	10.0	10.0
Other GCE science subjects	1.5	1.6	1.5	1.5	1.4	1.6	1.6

5

Overall A-level volumes are basically static – but Physics is declining

Table 5 shows the number of GCE A-level science entries for the period 2002 to 2008. Entries for Biology have risen from 46,480 in 2002 to 50,148 in 2008. Entries for Chemistry have risen from 32,995 in 2002 to 37,711 in 2008. Entries for Physics have fallen from 28,607 in 2002 to 25,544 in 2008. Entries for other GCE A-level science subjects have fluctuated at around 4,000 over these years. The total volume of GCE A-level science (in terms of the total number of entries) has risen from 111,969 in 2002 to 117,521 in 2008 despite the total A-level cohort decreasing slightly between these years. However, per head of the increasing 18 year old population, the number of science entries has remained constant at 0.17 since 2003, see bottom row of table 5. The number of science entries per A-level candidate has risen from 0.43 in 2002 to 0.46 in 2008.

6

Be very careful when you generate percentages

One misleading set of percentages in the Policy Exchange report is presented in their figure 3, page 11, which suggest that, in 2008, around 6.5% of students enter Biology, 5% enter Chemistry and 3% enter Physics. However, these are not the proportion of A-level students entered for these subjects, which in reality are 19.5% (Biology), 14.7% (Chemistry) and 10% (Physics).

This part of the report is misleading in stating that these seemingly low percentages refer to the percentages of A-level students choosing to study science subjects. They do not: they are the percentages of the entire age cohort. Only around a third of the 18-year-old population are studying A-levels.

The accurate trend figures are as follows: from 2002 to 2008, the percentage of the A-level cohort studying Biology has risen from 18% to 19.5% and from 12.8% to 14.7% for Chemistry; Physics shows a decline from 11.1% to 10%.

7

The contribution of qualifications other than GCSEs and A-levels

The Policy Exchange report is right to include 'other' qualifications in its reckoning. It is difficult to count these accurately. We have compiled the following table from disparate data sources. For ease of comparison with GCSE and GCE volumes, we have separated out these 'other qualifications' into entry level, level 2 (equating to GCSE) and level 3 (equating to A-level).

What this reckoning shows is that these qualifications account for a small percentage of the volume of science offered in schools, sixth forms and further education colleges. However, they present an alternative route to the more academic courses. These provide students with the technical knowledge, skills and understanding needed in the workplace, in further education or in training.

Entries for other science qualifications at Levels 1 to 3 have increased from 2002 to 2008.

Table 8: Entries for other science qualifications 2002-2008 at Entry Level (England, Wales and Northern Ireland)

Subject	2002	2003	2004	2005	2006	2007	2008
Science Single Award	18,780	16,931	16,561	15,871	15,690	16,211	14,053
Science Double Award	1,136	1,714	1,530	1,382	1,498	1,430	516
Total	**19,916**	**18,645**	**18,091**	**17,253**	**17,188**	**17,641**	**14,569**

Table 9: Entries for other science qualifications 2002-2008 at Levels 1 and 2 (England, Wales and Northern Ireland unless otherwise stated)

Subject	2002	2003	2004	2005	2006	2007	2008
GNVQ Foundation Science	288	669	448	581	808	592	
Applied Science GCSE*			8,694	17,394	25,808	29,564	19,996
GNVQ Intermediate Science	1,887	5,210	6,951	10,995	13,161	12,485	
BTEC First Certificate in Applied Science*						1,329	11,406
BTEC First Diploma in Applied Science*						72	4,541
OCR National Award in Science					1	140	2,970
OCR National Certificate in Science						63	2,101
Total**	**2,175**	**5,879**	**16,093**	**28,970**	**39,778**	**44,245**	**41,014**

*England only

**For each year, entry figures had been added together. It should be noted that for some subjects, these figures are for England, Wales and Northern Ireland and for others, they are for England only. The entries for Northern Ireland and Wales are very small and should not make a difference to the trends.

Table 10: Entries for other science qualifications 2002-2008 at Level 3 (England, Wales and Northern Ireland unless otherwise stated)

Subject	2002	2003	2004	2005	2006	2007	2008
Advanced Double VCE Science	1,187	1,141	958	952	998		
Applied GCE Double Science						742	841
Advanced Single VCE Science	645	605	659	956	764		
Applied GCE Single Science						1,125	1,544
BTEC National Award in Applied Science*					49	197	389
BTEC National Certificate in Applied Science*					110	380	450
BTEC National Diploma in Applied Science*					24	682	766
Total	**1,832**	**1,746**	**1,617**	**1,908**	**1,945**	**3,126**	**3,990**

* England only

8

Over-simplistic comparisons of independent and state schools should be avoided

The Policy Exchange report states that '…only 46% of England's state schools entered at least one pupil last year for the traditional science GCSEs…' (p.5). It is important to recognise that many independent schools also do not offer separate sciences (Claessen, M 2005). If they do, they do not necessarily offer it to all their pupils (four out of five independent schools entered pupils for the Double Award). At A-level the provision of A-levels by comprehensive schools and independent schools tend to be similar. For each of the sciences, a course is not offered by between 15% and 10% of independent schools (Vidal Rodeiro, C 2005). In a similar vein, the report states '…as with GCSEs, independent schools continue to produce a disproportionate number of entries for science A-levels…' (p.15). What is vital here is that the report has not taken into account prior attainment levels. Independent schools tend to have a higher proportion of higher attaining pupils at GCSE, who naturally have a greater tendency to progress to A-level in any subject.

Data

The examination entry figures for schools and colleges in England quoted in this report were obtained from the website of the Joint Council for Qualifications (JCQ) http://www.jcq.org.uk/national_results/index.cfm and are available for GCSE and A-level from 2002 onwards. Population estimates were obtained from the website of the Office for National Statistics (ONS) http://www.statistics.gov.uk/statbase/Product.asp?vlnk=15106. GCSE and A-level cohort figures were obtained from the website of the Department for Children, Schools and Families (DCSF) http://www.dcsf.gov.uk/cgi-bin/rsgateway/search.pl?keyw=001&q2=Search.

References

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Appendix

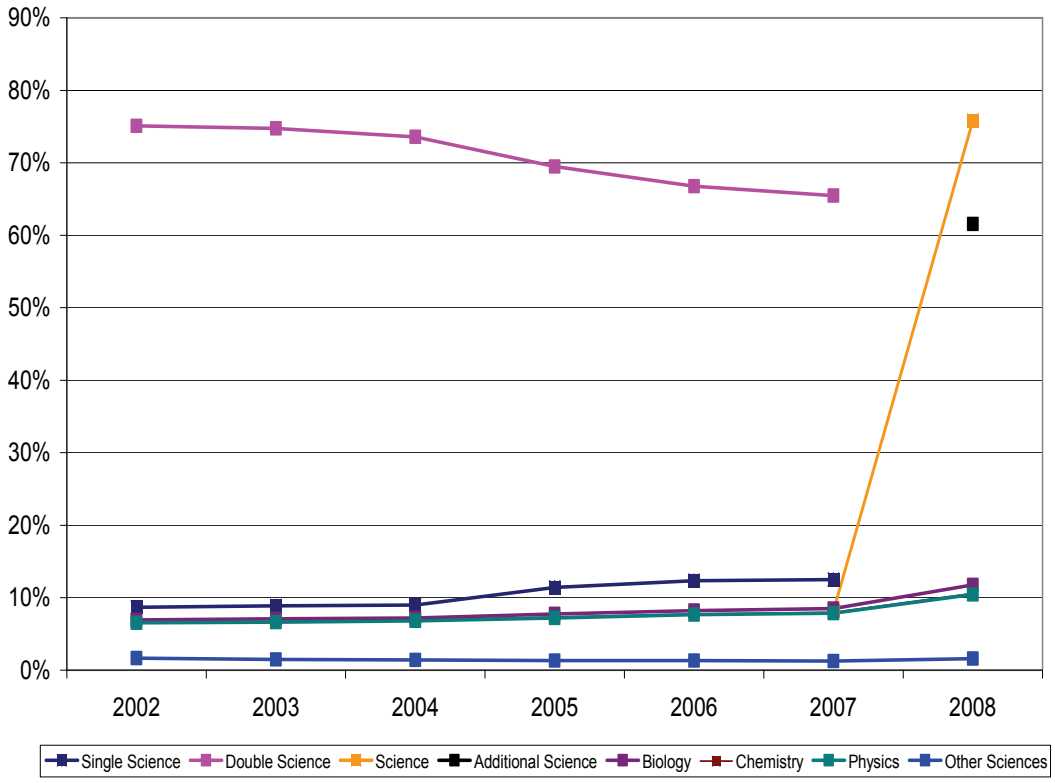

Figure 1: Percentage of 16-year-old population studying science subjects at GCSE

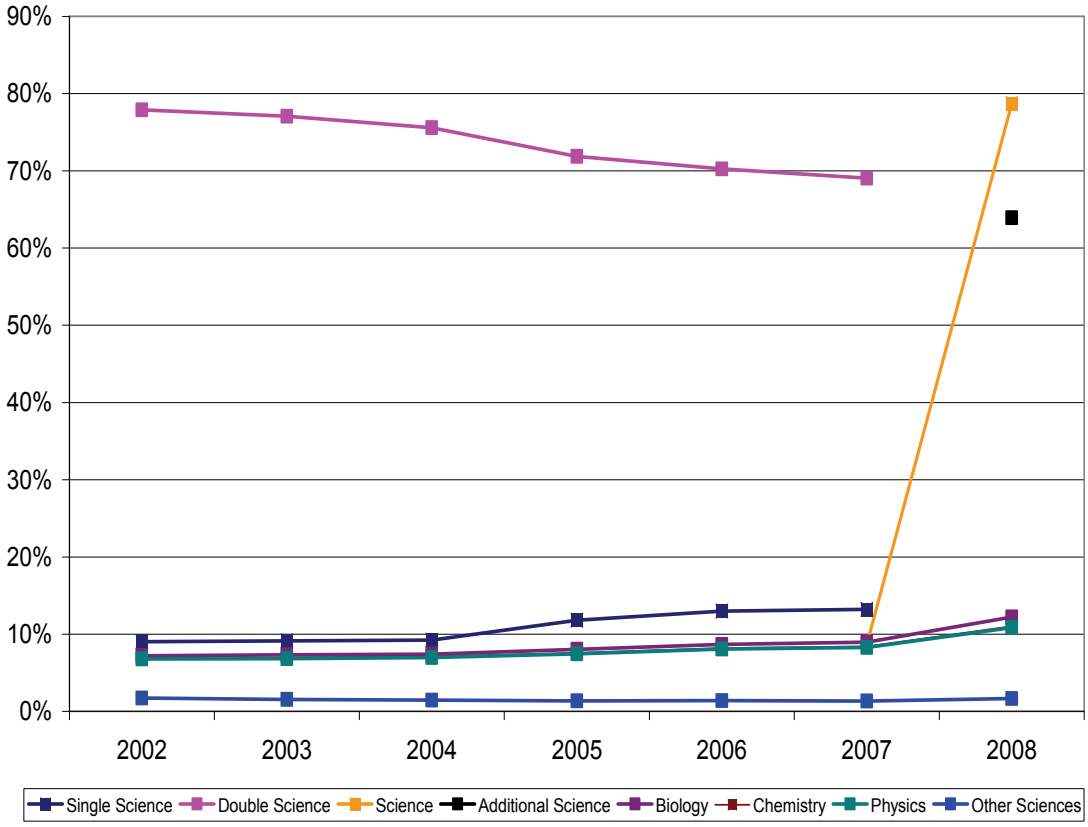

Figure 2: Percentage of GCSE cohort studying science subjects

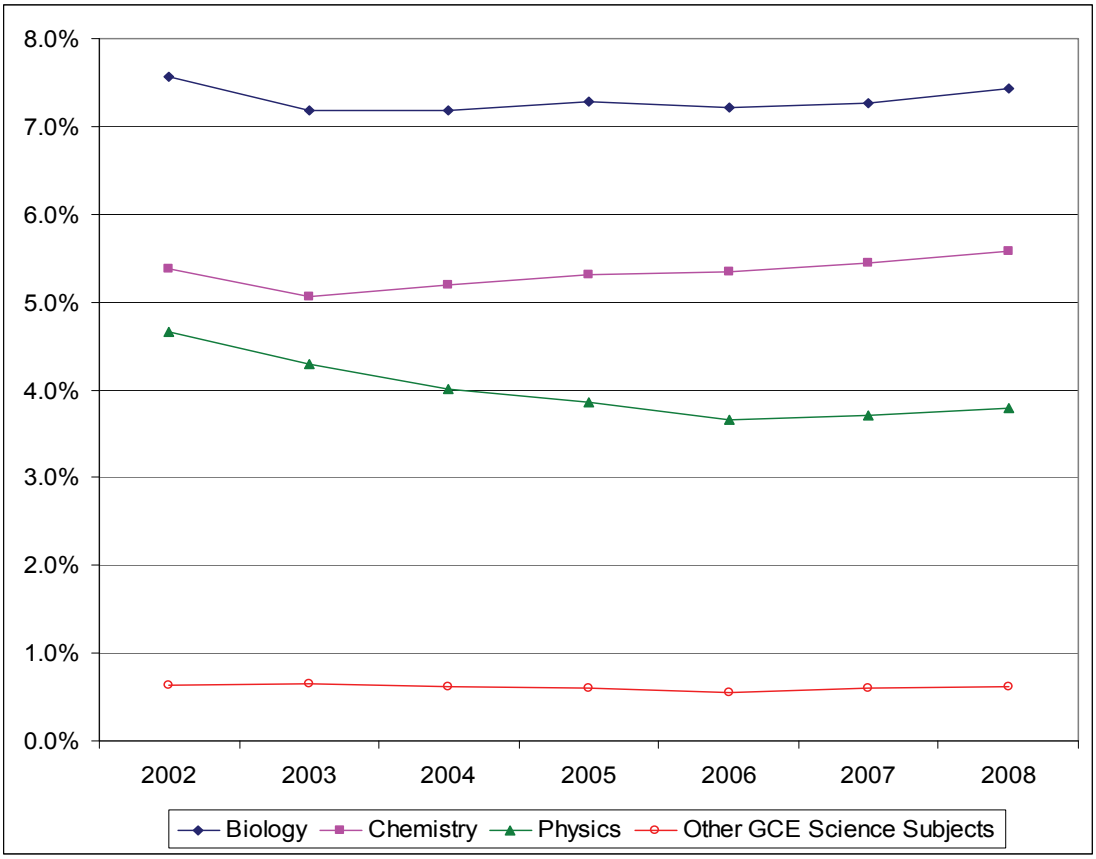

Figure 3: Percentage of 18 year old population studying science subjects at A-level

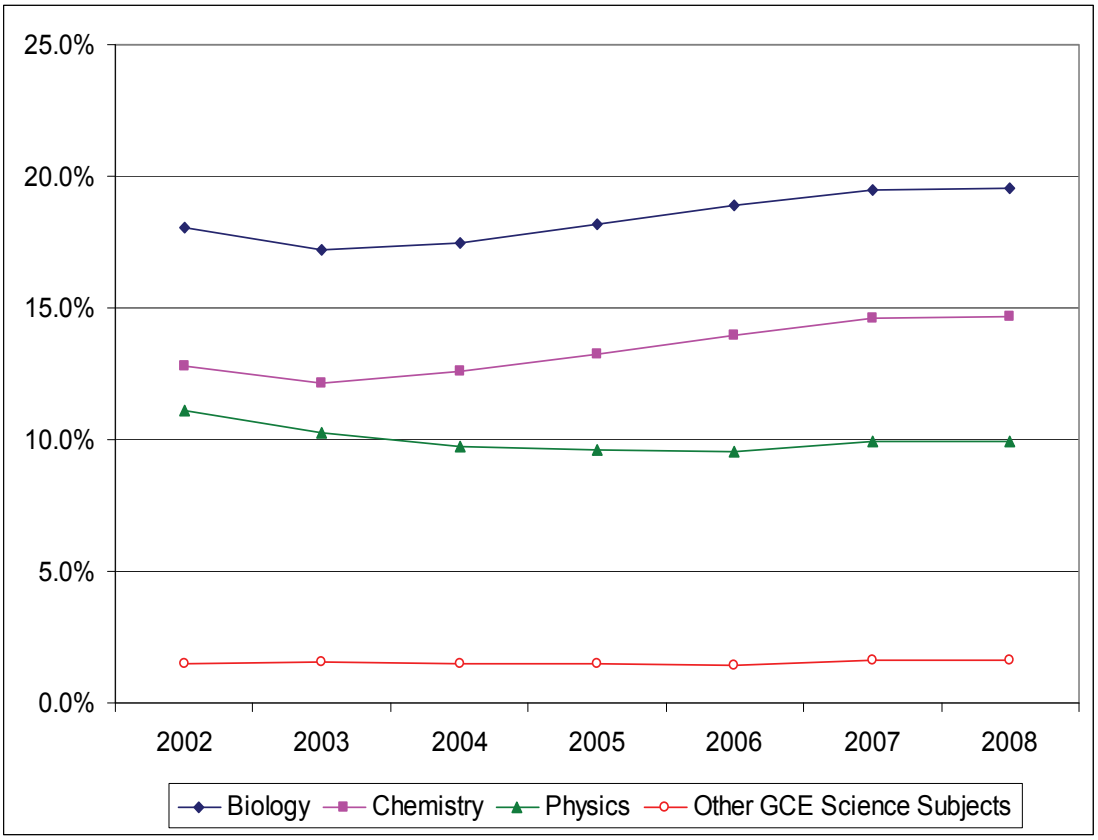

Figure 4
Percentage of A-level cohort studying science subjects