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Abstract

There has been much concern recently in the UK about the decline in the number of students studying physics beyond age 16. To investigate why this might be we used data from a national database of student qualifications and a multilevel modelling technique to investigate which factors had the greatest impact on the uptake of physics at Advanced Level (A-level) in a particular year. Each factor of interest was entered into a separate model, whilst accounting for prior attainment and gender (both well known predictors of A-level uptake). We found that factors associated with greater probability of uptake included better attainment in physics (or combined science) and maths qualifications at age 16 in comparison to other subjects, and (for girls only) attending an independent or grammar school. Whilst it is difficult to address these factors directly, the results imply that more needs to be done to improve relative performance at GCSE, perhaps by increasing the supply of specialist physics teachers at this level and to overcome the perception (especially amongst girls) that physics is a particularly difficult subject.

Introduction

The study of science is compulsory up to age 16 in the UK, after which students can choose to leave school and go into employment or training or can stay on in full-time education to study (usually) three Advanced Level (A-level) subjects. Pupils have a free choice when selecting A-levels (subject to timetabling) and thus are not required to study any sciences. Concern has been expressed in several quarters (Research Councils UK, 2008; Sharp, Hutchinson, Davis & Keys, 1996; Smithers & Robinson, 2006) about the decline in the number of students studying physics in post-compulsory education in the UK. Other countries have similar concerns (Angell, Guttersrud, Henriksen & Isnes, 2004; Committee for the Review of Teaching and Teacher Education, 2003; Santiago, 2002;) Having a large number of physics graduates is seen as crucial to the economy of the country, not just in the physics and engineering sectors, but also in the financial

1 sector. According to the Research Councils UK Review of Physics (2008) the economic activity of physics
2 based sectors made up 6.4% of all UK economic activity in 2005.
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7 Several reasons have been put forward to explain the decline in the UK. The introduction in 1988 of the
8 General Certificate of Secondary Education (GCSE) and the National Curriculum may have had an impact.
9 Before the advent of GCSEs the most usual way to study physics as a preparation for A-level was to take
10 an O-level in the subject (Archenhold, Bell, Donnelly, Johnson, & Welford., 1988), and the numbers taking
11 this had increased steadily since 1950 (Smithers & Robinson, 2006). However, the introduction of a
12 combined science GCSE (initially either a single award or a double award, worth two GCSEs, with content
13 equally split between biology, chemistry and physics) led to a sharp fall in those taking a separate physics
14 qualification at 16 (Bell, 2000b), although this decline has reversed somewhat in the last few years (Vidal
15 Rodeiro, 2007a). Currently, the majority of pupils in secondary schools take one or both of the combined
16 science GCSEs¹ and so the numbers studying some physics to age 16 is much higher than in the O-level
17 days. However, this is as part of a combined science and therefore the depth or breadth to which physics is
18 studied is less. The alternative to the combined science is to take separate GCSEs in all three of biology,
19 chemistry and physics. However, this is generally seen as a difficult option, more suited to high achievers.
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34 Several authors (Research Councils UK, 2008; Smithers & Robinson, 2006; Wright, 2006) point to a lack of
35 teachers with a physics degree teaching these GCSEs as another reason for declining uptake in the UK.
36 The in-depth understanding of and enthusiasm for their subject that specialist teachers can impart is almost
37 certain to be an encouragement for pupils to study it further. Smithers and Robinson (2007) also looked at
38 the characteristics of comprehensive schools that 'bucked the trend' of decline in physics A-level. They
39 found that these schools tended to have an enthusiastic specialist physics teacher. This issue is not
40 confined to the UK. Research in other countries has noted a shortage of specialist teachers in physics, and
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50 ¹ In 2007 the double science GCSE was replaced by two combined science GCSEs (Science and Additional Science) which can be
51 taken separately.
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1 the importance of having a specialist for encouraging further study (Angell et al, 2004; Committee for the
2 Review of Teaching and Teacher Education, 2003; Santiago, 2002)
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7 Another reason for the decline may be perceptions that pupils have of particular subjects when making their
8 A-level choices (see Osborne *et al.* (2003) for a review of literature on attitudes to science). In particular,
9 physics is perceived as a difficult, less relevant and boring subject (and more so than other sciences).
10
11 Davies, Davies, Hutton, Adnett and Coe (2009) found that an important predictor of A-level choice was
12 something they called 'relative advantage', a measure of how well a pupil is likely to do in a particular
13 subject at A-level based on their GCSE results. Vidal Rodeiro (2007b) asked pupils the reasons for their A-
14 level choices. Common reasons given for choosing science subjects included that they would be interesting
15 and enjoyable and that students thought they would do well in them.
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25 Murphy and Whitelegg's (2006) review of research into girls and physics in the UK concluded that teacher
26 perceptions of girls' abilities (or lack of) in physics also had a significant impact on uptake. Furthermore,
27 teachers' perceptions of girls' low confidence in maths may also impact on physics uptake because of the
28 importance of maths to the study of physics. This issue of perceptions of physics (and science in general)
29 as a 'male' subject and its impact on female participation rates has generated a vast amount of research
30 internationally (see Scantlebury & Baker, 2007 for a review).
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38 The well established gender gap in A-level physics in the UK may be partly explained by the idea that
39 students choose subjects they enjoy or believe they are likely to do well in. In a small sample of A-level
40 physics students Stewart (1998) found that 40% of the girls considered physics to be their favourite GCSE
41 subject, against only 21% of boys, suggesting that girls are more likely to be influenced by their enjoyment
42 of the subject when considering choice at A-level. Bell (2001) reported that girls performed less well than
43 boys on the physics items of a combined science GCSE, despite their overall grades being very similar.
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50 This may lead to fewer girls than boys believing they have the necessary skills to study physics at A-level.
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3 School type is another factor that is generally acknowledged to have an impact on the uptake of science
4 subjects. Uptake of physics A-level (as a percentage) is much higher in independent and grammar schools
5 than it is in comprehensives², and is higher in single sex schools than mixed sex (Vidal Rodeiro, 2007a).
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7 However, these differences can be explained to a large degree by prior attainment in the subject. After
8
9 controlling for this Cheng, Payne and Witherspoon (1995) found that in England and Wales girls in single
10 sex schools were marginally less likely than girls in mixed sex schools to take physical sciences. Boys in
11 mixed sex schools were also more likely to take physical sciences than those in single sex schools. The
12 issue of uptake of male-dominated subjects in single and co-educational schools and colleges has been
13 explored in depth in an international context (e.g. Billger, 2002; Brutsaert, 1999; Haag, 1998; Solnick, 1995)
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22 Cheng et al (1995) included a large number of other factors as well as school type in a multi-level model
23 investigating uptake of physical sciences: they found that the science taken at GCSE was important, with
24 those taking separate sciences having a higher probability of uptake than those taking combined science;
25 the grades achieved in GCSE physics and chemistry were also important as was the maths grade; however,
26 parental education and occupation had little effect on likelihood of uptake.
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34 From the literature it is clear that the issue is complex and multi-faceted. The focus of this paper is on
35 investigating factors that may have an impact on uptake of A-level physics in England in one particular year.
36 It starts by looking at gender differences in uptake, and patterns of progression from GCSE to A-level. Then
37 the results of a multilevel model are presented in an attempt to determine which individual and school level
38 characteristics impact most on uptake.
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50 ² Independent schools are private, fee-paying schools. Grammar schools are not fee-paying but are selective. Thus, both these types of
51 schools are able to select the best candidates and therefore achieve better results on average than comprehensive schools.
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Gender effects

A common observation made in the literature with regard to physics uptake at A-level is that substantial differences exist between genders (see Murphy & Whitelegg, 2006). Girls are known to take physics in far smaller numbers than boys. The following section investigates some aspects of gender differences.

At what stage do the gender differences in uptake occur?

It is interesting to consider at what point in the education system the gender difference in physics uptake occurs. Figure 1 shows the number of candidates of each gender at the following stages (in the year in parentheses): all GCSE candidates (2006), all candidates taking double, applied or physics GCSE (2006), those achieving grade B or above³ at GCSE (2006), candidates entering for AS level⁴ physics (2007), candidates passing AS level physics (2007), candidates entering A-level physics (2008) and candidates passing A-level physics (2008). The data for this graph are taken from the National Pupil Database (NPD) for the year in question. The NPD contains all the qualifications gained in a given year by candidates in English schools at different key stages.

[Insert Figure 1 about here]

We can see from Figure 1 that the main difference occurred after GCSE. The number of candidates getting a grade B or above at GCSE was very similar for both genders, but females did not go on to AS and A-level in anything like the same numbers (there were 24,778 AS level entries among males compared with 7,304 among females). The other difference of note was between AS and A-level: just under 70% of female students who passed AS level physics went on to do it at A-level, compared to nearly 81% of male students.

³ Grade B or above was used in this analysis as only a very small proportion of candidates with a grade C or below go on to study physics A-level (see Bell & Emery (2007)).

⁴ Advanced Subsidiary (AS) level qualifications usually make up the first half of an A-level, although they can also be taken as free standing qualifications.

1 We can only speculate on the reason for the differences post GCSE, but it may be due to expectations that
2 physics is more of a boys' subject. It may also be a consequence of girls doing less well on physics items in
3 combined science papers (Bell, 2001). This might imply that part of the difference is really occurring at the
4 'Grade B or above' stage. Female students may be compensating for a below grade B performance on the
5 physics items with an excellent performance on the chemistry and biology items. Further investigation would
6 be necessary to find out how much difference this actually makes. The difference after AS level may again
7 be one of expectation, or it may be that a lack of other female students in their classes during the first year
8 of A-level discouraged some girls from continuing.

19 **Progress between GCSE and A-level**

22 A factor likely to influence choice at A-level is the performance (or expected performance) in the equivalent
23 GCSE. Pupils tend to go on to study subjects in which they have obtained good grades in the past (Davies
24 et al, 2009; Vidal Rodeiro, 2007b). It is therefore of interest to look at the rates of uptake of A-levels in
25 relation to performance on the same (or a related) subject at GCSE.

32 In Figure 2 the percentages of students attaining grades A* to C in a range of different GCSE subjects in
33 2004 who went on to take the A-level in the subject in 2006 are presented. This includes students taking
34 GCSE double science who went on to take each of the sciences at A-level. It also includes those taking
35 GCSE mathematics going on to take A-level physics, since taking A-level physics is generally dependent on
36 a good grade in mathematics GCSE. Again, the data are from the NPD.

44 **[Insert figure 2 about here]**

48 Figure 2 provides evidence that, in comparison to other subjects, fewer of the very best candidates in GCSE
49 physics go on to take it at A-level. A smaller percentage of those getting a grade A* or a grade A in physics

1 GCSE went on to the A-level than the equivalent biology and chemistry candidates. Furthermore, of the
2
3 candidates getting an A* or A in the double science GCSE, a larger percentage went on to take A-levels in
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5 biology and chemistry than in physics. Thus, even the very best candidates in physics or science GCSE are
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7 not taking physics A-level in similar proportions to other subjects.
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11 A further analysis of these data was undertaken to investigate any gender differences. The results are
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13 presented in Table 1. It is notable that the gender gap is larger for students going on to study A-level
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15 physics in comparison to other subjects, and this gap is present amongst the very top performers at GCSE.
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17 This suggests that female students at all levels are taking A-level physics in much smaller numbers than
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19 their male counterparts; it is not that they are achieving less well in physics (or double science) at GCSE.
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21 One of the startling figures is that amongst female candidates getting an A* at GCSE double science, only
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23 just over 10% went on to study A-level physics. However, it should be noted again that these double
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25 science A* candidates may have performed only moderately on the physics components.
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28 **[Insert Table 1 about here]**
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31 32 **Multilevel modelling** 33

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36 The main part of the research used logistic regression analyses to look at the uptake of A-level physics at
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38 one point in time and which of many different variables of interest had the biggest impact on it. A multilevel
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40 model was used, where the probability of a particular student taking A-level physics was predicted based on
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42 some measures of interest. Multilevel models are appropriate when looking at hierarchical data, where
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44 independent variables (*e.g.* school type) are at a higher level than the outcome variable (*e.g.* physics
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46 uptake). In an educational context multilevel models recognise that the 'clustering' of individuals within
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48 schools means that students within a school are likely to have more in common with each other than with
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1 students in different schools. Multilevel models allow us to take account of this hierarchical structure of the
2 data and produce more accurate predictions.
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7 The modelling process was conceived as a two-level model in which students (level 1) were nested in
8 schools (level 2). The effects of explanatory factors (prior achievement, gender, school characteristics, etc.)
9 were entered into the model. The models were fitted using the programme MLwiN (Rasbash *et al.*, 2009).
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13 14 15 **Data**

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18 The data for the multilevel model were mainly taken from the National Pupil Database (NPD) for 2008. For
19 the purpose of this report, the Key Stage 5 database, which records all A-level results in England, was used.
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25 Candidates were categorised by whether or not they had a grade for physics A-level and this was used as
26 the dependent variable in all the models. Many of the independent variables, such as candidates' prior
27 attainment at GCSE, gender, ethnicity and school type were also available in the NPD.
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32 A further set of independent variables was generated from the UK government's Neighbourhood Statistics
33 Service (<http://www.neighbourhood.statistics.gov.uk/dissemination>). These were all measures of deprivation
34 related to the individual students' home address, at ward or lower super output area (LSOA) level. LSOA
35 and ward are both very small geographical areas. An LSOA typically consists of 1,500 households. Wards
36 are more inconsistent in their size, ranging from 100 residents to 30,000. The NPD data were matched to
37 these variables using a code for either the ward or the LSOA.
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46 Only candidates who were aged 17 at the start of the academic year 2007/2008, and who took at least one
47 A-level, were considered in all the following analyses. This meant the total number of candidates was
48 231,982, of which 21,818 (9.4%) had a grade for A-level physics.
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Results

Summary statistics

Table 2 summarises the categorical independent variables used in the models and, in each case, gives the percentage in each category taking A-level physics. This gives some indication of how each variable relates to the likelihood of taking physics (ignoring for the moment any interactions between variables).

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[Insert Table 2 about here]

Modelling probability of taking A-level physics

To begin with we ran several different sets of models where gender was the first variable included, followed by another independent variable, and the interaction between the two. Then prior attainment was added to the model, since this was thought likely to be an important determinant of uptake of physics. The parameter estimates presented here are from the final model in each case. Thus, they estimate the effect of different variables on the probability of taking physics A-level, after accounting for both gender and prior attainment.

The parameter estimates (Est.) refer to the change in the log odds due to a unit increase in the value of the independent variable. Whilst difficult to interpret directly, the important thing to keep in mind is that a positive value means that an increase in the value of the independent variable is associated with an increased probability of 'success' (in this case, taking physics) in the dependent variable. Where the independent variable is categorical (e.g. gender, school type), the estimate refers to the effect of being in that specific category compared to being in the 'base' category. The base category was determined by the authors and will be stated for each categorical variable in each model.

1 The first model included only gender, prior attainment and their interaction. Prior attainment was measured
 2 by taking the best five GCSE grades for each student (see Bell, 2000a for an analysis of different measures
 3 of prior attainment). The grades were converted into numbers, with A*=8, A=7, etc. Thus the range of this
 4 variable was 0 (5 grade Us) to 40 (5 grade A*s). To make the parameter estimates for prior attainment and
 5 any interactions easier to interpret, an adjusted variable was used in the models, centred on the mean value
 6 of the GCSE score. Thus, a student with a value of zero for the adjusted variable had a GCSE score equal
 7 to the mean. A student with a positive value had a GCSE score above the mean and a student with a
 8 negative value had a GCSE score below the mean.

Deleted: It is clear (Figure A1 in the appendix) that prior attainment was related to uptake, with those taking physics performing better at GCSE.

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9 Table 2 shows that, as expected, the percentage of male students (16.5%) taking physics was much higher
 10 than the percentage of female students (3.6%).

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11 The results of the multilevel model are shown in Figure 3. Figures in bold signify statistical significance.

12 Males were the 'base' category for gender so the estimate refers to the effect of being female, as opposed
 13 to male. Thus, the negative value of this estimate (-2.4) means that a female student's probability of taking
 14 physics was significantly less than that of a male student. In all the models the 'constant' term refers to the
 15 log odds when the continuous independent variables are zero and the categorical variables are set to the
 16 base category. Thus, for this model it is the log odds for a male student with a GCSE score equal to the
 17 mean.

18 The prior attainment variable was positively related to the probability of taking physics (0.2), meaning that as
 19 prior attainment increases so does the probability of taking physics. However, there was also a significant
 20 (if small) positive interaction effect (labelled Female*Best 5 GCSEs = 0.1), which changes the interpretation
 21 of the estimates. Thus, the parameter estimate for prior attainment (Best 5 GCSEs) refers to male students,
 22 whilst the effect for females is quantified by the Best 5 GCSEs estimate and the estimate for the Best 5

1 GCSEs-female interaction. Therefore, the effect of prior attainment on probability was greater for females
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3 than for males.
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7 Although the parameter estimates are difficult to interpret they can be used to generate a graph that is
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9 simpler to understand. The graph in Figure 3 shows two probability curves, generated by the fixed
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11 parameters in the model, one for males and one for females. These represent the probability of taking
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13 physics, based on a pupil's best 5 GCSEs (unadjusted). Thus males and females with a best 5 GCSE score
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15 of 15 were extremely unlikely to take physics. For males with a best 5 GCSE score of 40 the probability was
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17 greater than 0.4, whereas for females with the same GCSE score the probability was only about 0.1. This
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19 graph clearly shows the big difference between males and females at all ability levels in their probability of
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21 taking physics.
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25 **[Insert Figure 3 about here]**
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29 The next model (Figure 4) includes a term for whether or not the candidates' grade at GCSE science was
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31 their best GCSE grade. It seems likely that students will be influenced in their choice of A-level physics by
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33 their performance in GCSE science (and perhaps mathematics) and in particular whether or not they
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35 achieved their best grade in one of these. Table 2 shows that 22.2% of students with one of physics, double
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37 science or applied science as their best grade went on to take A-level physics, compared with only 4.6% of
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39 those without science as their best grade. The equivalent figures for maths were 19.3% and 5.2%
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41 respectively.
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45 In this model the base category was males who did not get their best grade in GCSE science. There was a
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47 clear significant effect of the best grade variable, with candidates who did achieve their best grade in
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49 science more likely to go on to take physics, even after accounting for prior attainment (est = 1.2). There
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1 was a small, positive interaction effect with gender (est = 0.2), meaning that the effect of having their best
 2 grade in science was greater for females than males.
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 7 Again, the graphs in Figure 4 show more clearly the change in the probability of taking physics based on
 8 prior attainment. This time there is one graph for females and one for males and separate probability curves
 9 depending on whether the pupil achieved their best grade in science at GCSE or not. Thus, a female pupil
 10 with a best 5 GCSE score of 40 had a probability of taking physics of around 0.15 if she achieved her best
 11 grade in science, but only around 0.05 if she did not. For males the equivalent probabilities were around
 12 0.52 and 0.27 respectively.
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 21 **[Insert figure 4 about here]**
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 25 A further model was run including a term for whether or not maths GCSE was the student's best grade.
 26 However, as the results were very similar they are not shown here.
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30 The next model included school type. We looked at the school type for where the pupils took their A-levels
 31 ('KS5' in Table 2), and where they took their GCSEs ('KS4'). Their choice of A-level subjects might be
 32 influenced both by the school they were at when they made their choice and the school where they took
 33 their A-levels. From Table 2, we can see that, as expected, a higher percentage of pupils in grammar and
 34 independent schools took physics at A-level than those in comprehensive schools or sixth form colleges.
 35 Further education (FE) and tertiary colleges lagged further behind.
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 44 Table 3 presents the results for the multilevel model with the KS5 school. The base category for this model
 45 was male students in comprehensives. No graphs were presented for this model as the effects of school
 46 type were very small, and therefore the differences between the lines were not clear.
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1 In this model there was a significant interaction between gender and school type. This means that each
2 parameter estimate for school type (e.g. Independent, Grammar etc.) refers to male students, whilst the
3 effect for females is quantified by the school type estimate *and* the estimate for the school type-female
4 interaction (e.g. Independent*female, Grammar*female etc). The results suggest that male students were
5 more likely to take physics if they were at comprehensive schools than independent (est = -0.2), FE/Tertiary
6 colleges (est = -0.2) or sixth forms (est = -0.1), after accounting for prior attainment.
7
8 In contrast female students at independent and grammar schools were more likely (than females at
9 comprehensives) to take A-level physics, since the estimates for Independent*Female (0.5) and
10 Grammar*Female (0.4) were both positive and larger than the Independent or Grammar estimates (-0.2 and
11 -0.1 respectively).

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23 [\[Insert Table 3 about here\]](#)
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26 A similar model was run using the centre type where the candidate took their GCSEs and chose their A-
27 levels (KS4) rather than where they took them (KS5). The results are not presented here, but were very
28 similar in that being in a comprehensive school at KS4 had a positive effect for males, whilst being in an
29 independent or grammar school had a positive impact for females.
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36 The next model (Figure 5) looked at the impact of the type of science taken at GCSE. Students were
37 classified by whether they had a GCSE in physics, double science, single science or applied science. From
38 Table 2, it is clear that students who took physics as a separate science GCSE were generally far more
39 likely to take physics at A-level than those taking any other science.
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46 Males taking double science was the base category in the model. From Figure 5 we can see that again
47 there was a significant interaction effect between the type of science and gender, but only for those taking
48 physics at GCSE. Thus, students of either sex who took single (est = -1.1) or applied science (est = -1.3)
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1 were less likely to take physics A-level than those taking double science, after taking account of prior
2 attainment. Conversely, students taking separate physics at GCSE were more likely to go on to take it at A-
3 level (est = 0.8). This effect was greater for female than for male students (the interaction effect was
4 significant and positive, est = 0.5). Again this can be seen more clearly graphically in Figure 5. For
5 example, females with a best 5 GCSE score of 35 who took a separate physics GCSE had a probability of
6 around 0.08 of taking physics A-level, compared with a probability of only 0.03 for those taking double
7 science. The equivalent probabilities for males were around 0.33 and 0.18 respectively. However, it is worth
8 noting that some schools offer both the double science and the separate sciences at GCSE. In these
9 schools, it is likely that the students who had chosen separate sciences were more likely to intend to
10 continue studying science at A-level. Thus the effect of taking a separate physics GCSE is likely to be less
11 than the model implies in these schools.
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25 It is also worth noting that single science tends not to be taken by able candidates and is not really suitable
26 preparation for further study in the sciences, so it is reasonable that the model predicts a very low
27 probability of these students taking A-level physics.
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33 [Insert Figure 5 about here]
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36 Another variable of interest was whether the school attended by the candidate for their A-levels was single
37 sex or mixed. Each school was thus categorised in terms of both its year 11 and its sixth form gender
38 composition. For example, a centre which was single sex girls for GCSE, but had a mixed sixth form was
39 classified as 'Female-Mixed'. This variable is referred to in this report as 'school gender'. Table 2 shows
40 that the uptake was by far the highest in boys only schools with a boys only sixth form. It is also interesting
41 to note that 7.7% of girls in female only schools with a female only sixth form took physics, which compares
42 to only 3.6% of girls in the population. There was also a large difference between schools with mixed sixth
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forms and single sex at KS4, with boys-mixed having higher uptake than girls-mixed. This is likely to be due to the gender mix in the sixth form.

Table 4 presents the results of the multilevel model. Male students in a 'mixed-mixed' school was the base category. Sixth form colleges and FE colleges were defined as 'none-mixed'. Most of the effects of school gender were very small, so, as with the model including school type, no graphs are shown.

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[Insert Figure 7 about here]¶

There was a significant interaction effect, meaning that the effect of the mixed/single sex status of the school was different for male and female students, after accounting for prior attainment. Male students in entirely mixed schools were more likely to take A-level physics than male students in entirely single sex schools (est = -0.3) or schools that are single sex up to sixth form, but then become mixed (est = -0.4). In contrast, female students in entirely single sex schools were more likely to take physics (est = 0.9) than female students in entirely mixed schools. This effect may be due to the presence of gender stereotypes in the mixed schools, which were there to a lesser degree in single sex schools.

[Insert Table 4 about here]

The overall ability of the sixth form was also measured, using the mean GCSE performance of the candidates now in the sixth form. Table 5 presents the results of the multilevel model, with males as the base category. Again there is evidence of differing effects between the sexes. Male students' probability of taking physics (after accounting for prior attainment) was lower in a school with higher ability pupils (although the effect was very small, est = -0.1), whilst female students' probability was higher in a school with higher ability pupils (est = -0.1+0.5 = 0.4).

Deleted: Figure A1 suggests that students attending centres with more able students were more likely to take physics. ¶
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[Insert Table 5 about here]

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1 *Neighbourhood and ethnicity effects*

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5 A further set of models were fitted, including candidates' ethnicity and background variables on the
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7 neighbourhood in which they live. For these models a reduced set of data was used. This was because
8
9 not all students could be matched to the neighbourhood data and the ethnicity data were not available for all
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11 candidates. There were 133,537 candidates in this reduced dataset.
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15 Students were classified by ethnicity. To avoid the problem that using broad categories masks important
16
17 differences between sub-groups within the categories, seventeen different ethnic groups were considered.

18
19 In Table 2, students of Chinese origin were the most likely to take physics A-level, followed by other Asian
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21 and White & Asian. The least likely were those of Caribbean, Bangladeshi and White & Black Caribbean
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23 origin.
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27 Table 6 gives the estimates from the multilevel model for each ethnic group, having already accounted for
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29 prior attainment. White British were the base category. After accounting for prior attainment, Chinese (est =
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31 0.8) and other Asian (est = 0.3) candidates were more likely than white British students to take physics,
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33 whilst Bangladeshi (est = -0.4), Caribbean (est = -0.4), Irish (est = -0.5), white and black African (est = -0.6)
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35 and white and black Caribbean (est = -0.4) were less likely. A further model was also run including an
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37 interaction term between ethnicity and gender. However, there were no significant interaction effects, and
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39 therefore no evidence that the effect of ethnicity was different between sexes.
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42 [Insert Table 6 about here]

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46 The neighbourhood characteristics investigated were six separate measures of deprivation: the Income
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48 Deprivation Affecting Children Index (IDACI), the percent of households without a car at ward level, the
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50 percent of lone parent households at ward level, the percent of adults with no qualifications and the percent
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1 with a level 4/5 qualification at ward level, and the unemployment rate at LSOA level. It should be noted that
 2
 3 all of these measures, except for IDACI score and the unemployment rate, were from the 2001 census.

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 7 In the multilevel models these measures were all significant contributors when considered in isolation.

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 9 However, Table 7 displays the parameter estimates after accounting for prior attainment and gender and
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 11 shows that all of the variables except one (percent of households without a car, est = -0.004) were non-
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 13 significant.

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 17 [Insert Table 7 about here]

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21 **Conclusions**

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 25 The results of the multilevel model confirm what many believe to be the biggest predictors of A-level uptake:
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 27 after accounting for prior attainment, males were much more likely to study A-level physics, as were those
 28
 29 taking a separate physics GCSE and females in independent and grammar schools. However males in
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 31 independent and grammar schools were slightly less likely. Interestingly, the effect of single sex schools
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 33 was also dependent on gender, with males in mixed schools and girls in single sex schools more likely to
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 35 take the A-level. The reason for the differences in school type effects by gender may have to do with
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 37 different expectations. There is a perception amongst both teachers and students that physics is more of a
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 39 boys subject and this perception may be more entrenched in state and mixed-sex schools. This belief may
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 41 be less amongst the higher ability students in independent and grammar schools, or may be less in girls
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 43 only schools.

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 46 Whether or not students achieved their best grade in science or maths at GCSE was also a strong predictor
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 48 of uptake, suggesting that a student's probability of taking the A-level is much greater with higher prior
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 50 attainment in these subjects. This was a slightly more important predictor for females.

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1 The gender gap in A-level uptake is of particular concern. In the multilevel model gender was the largest
2 determinant of the likelihood of uptake. The reasons for this difference in uptake are still uncertain. It may be
3 partly the fact that females find physics a more difficult subject whilst studying it at GCSE. However, this
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6 cannot be the only reason, as the gap persists amongst those getting an A* in their GCSE. It seems most
7 likely that there still exists a perception that it is more of a boy's subject. It is vital that this perception is
8 overcome, so that even if physics continues to be thought of as a difficult subject in general, high-achieving
9 girls (particularly in comprehensive and mixed schools) might be encouraged to take it in greater numbers.
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11 Further research may be worthwhile in this area in order to identify the reasons for the perception, and
12 suggest ways to overcome it.
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21 That physics is perceived as a difficult subject by both genders is of little doubt. Yet even the very best
22 performers at GCSE are not going on to take it at A-level in large numbers. This is particularly the case for
23 those taking double science as opposed to physics at GCSE (see Figure 2). It is not clear how much this is
24 the result of uneven performance across the three sciences in the double award and how much is due to the
25 lesser content. This difference may also be influenced by differences in the provision of specialist teachers
26 for the two ways of providing science at GCSE.
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34 Thus, one strategy likely to increase uptake would be to increase the number of specialist physics teachers
35 teaching the subject at GCSE (whether as a separate subject or as part of a combined science). As others
36 have noted (Smithers & Robinson, 2006; Davies et al., 2009; Lipsett, 2004) a vicious circle has resulted
37 from a lack of specialist physics teachers. Pupils taught by non-specialists are less likely to have a good
38 grounding in the subject, particularly if they study it as part of combined science, and may therefore find it
39 more difficult than the other sciences. This means they will be less likely to study it at A-level and beyond,
40 so reducing the pool of potential physics teachers. Thus, incentives are needed (financial or otherwise) to
41 break this cycle; not just to encourage students to take physics beyond GCSE, but to encourage physics
42 graduates to go into teaching in greater numbers.
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1 The study of separate sciences at GCSE is not currently available in all schools. However, we would argue,
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3 that enabling more pupils with an interest in the subject to take physics as a separate GCSE could
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5 encourage uptake at A-level. It would allow students to study it in more depth and thus be better prepared
6
7 for A-level, or receive more encouragement to study it further from teachers and parents. Of course, there is
8
9 no guarantee that the additional pupils studying the separate sciences would be influenced in this way. In
10
11 the past few years there have been some positive signs, with the numbers of pupils studying for separate
12
13 sciences at GCSE seeing a steady rise (Gill, 2009; Shepherd, 2009). The government has also taken some
14
15 steps towards encouraging uptake of the separate sciences by making it an entitlement for those achieving
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17 level 6 science at Key Stage 3. However, the present lack of qualified physics teachers may make this
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19 pledge difficult to achieve in many schools. Furthermore, an increase in the number of qualified physics
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21 teachers is likely to be beneficial, regardless of the organisation of GCSE science.
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24 Appendix A: Variables included in the
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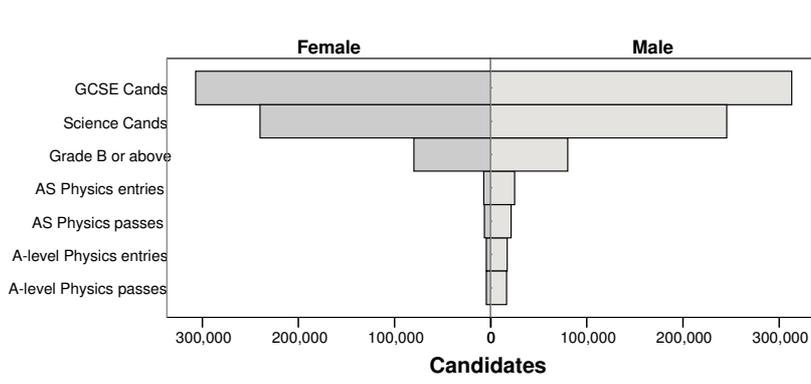


Figure 1: Numbers of students at different stages of education, by gender

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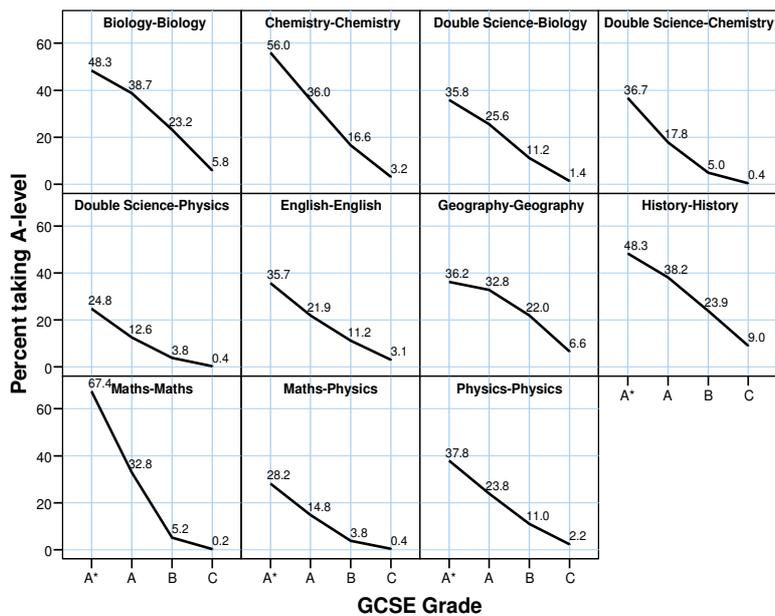


Figure 2: Percentages of candidates taking individual A-level subjects in 2006, by GCSE grade

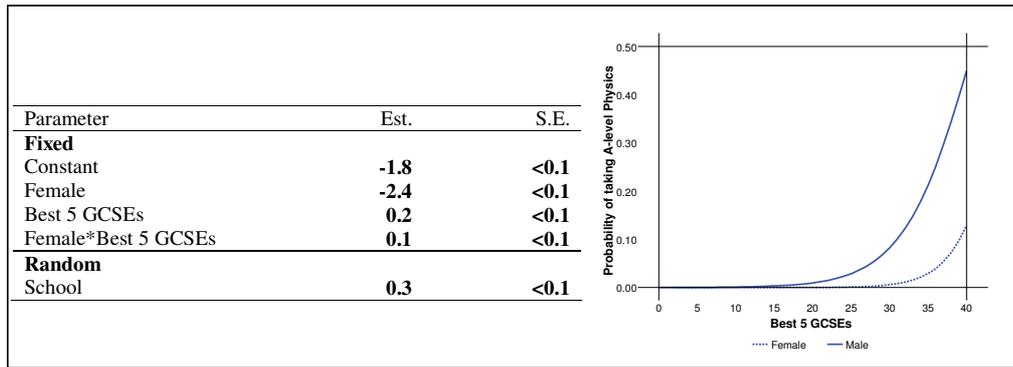


Figure 3: Multilevel model of probability of A-level physics uptake (gender and attainment)

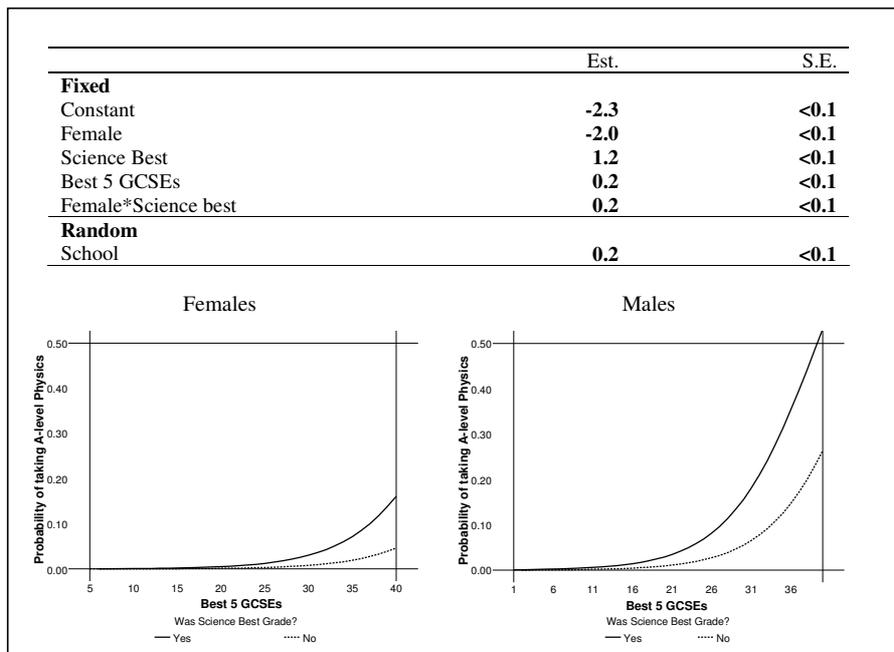
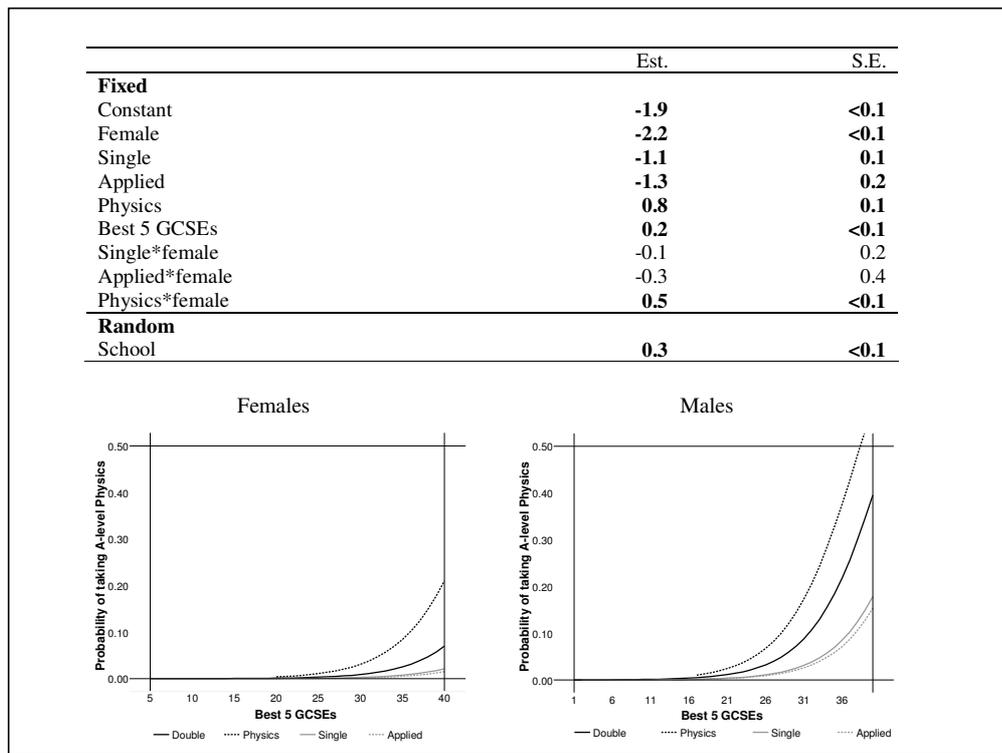


Figure 4: Multilevel model of probability of A-level physics uptake (science best)



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Figure 5: Multilevel model of probability of A-level physics uptake (GCSE science subject)

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Table 1: Percentages of candidates taking individual A-level subjects in 2006, by gender and GCSE grade

GCSE	A-level		GCSE grade					Totals
			A*	A	B	C	Below C	
Biology	Biology	Boys	40.9	32.7	20.1	4.8	<u>0.8</u>	21.8
		Girls	55.7	44.7	26.3	6.9	<u>1.6</u>	30.6
Chemistry	Chemistry	Boys	53.9	35.4	15.9	3.2	<u>0.4</u>	24.3
		Girls	58.0	36.6	17.2	3.1	<u>0.2</u>	26.6
Physics	Physics	Boys	49.5	35.4	17.0	3.8	<u>0.1</u>	24.8
		Girls	26.2	12.3	4.9	0.7	<u>0.1</u>	9.8
English	English	Boys	29.3	17.0	8.1	2.1	<u>0.3</u>	4.8
		Girls	42.1	26.8	14.3	4.1	<u>0.5</u>	11.1
History	History	Boys	48.7	40.6	26.4	10.3	<u>1.6</u>	17.6
		Girls	47.9	35.7	21.4	7.7	<u>1.1</u>	17.5
Geography	Geography	Boys	35.1	34.1	24.7	8.1	<u>1.2</u>	12.7
		Girls	37.4	31.4	19.2	5.2	<u>0.5</u>	13.4
Maths	Maths	Boys	75.6	41.3	7.3	0.3	<u>0</u>	8.5
		Girls	59.2	24.4	3.0	0.1	<u>0</u>	5.3
Double Science	Biology	Boys	29.6	22.0	9.2	1.1	<u>0</u>	4.3
		Girls	42.1	29.1	13.2	1.7	<u>0</u>	6.9
Double Science	Chemistry	Boys	37.5	19.0	5.5	0.4	<u>0</u>	3.7
		Girls	35.9	16.6	4.4	0.4	<u>0</u>	4.0
Double Science	Physics	Boys	39.1	21.3	6.7	0.6	<u>0</u>	4.1
		Girls	10.4	3.8	0.9	0.1	<u>0</u>	1.0
Maths	Physics	Boys	41.2	24.0	6.7	0.6	<u>0</u>	5.3
		Girls	15.1	5.6	1.0	0.1	<u>0</u>	1.4

Table 2: Summary statistics for variables included in the multilevel models

	No of candidates	%Taking Physics
Gender		
Female	127,249	3.6
Male	104,733	16.5
School type (KS4)		
Comprehensive	174,363	7.8
Grammar	18,470	15.9
Independent	35,028	13.4
School type (KS5)		
Comprehensive	110,932	8.3
Grammar	20,546	15.9
Independent	31,153	14.9
FE/Tertiary/Other	21,524	5.4
Sixth Form College	48,491	7.4
School 'gender'		
Female-Female	19,658	7.7
Female-Mixed	14,592	6.4
Male-Male	10,706	21.5
Male-Mixed	15,521	11.0
Mixed-Mixed	160,544	9.0
Mixed 6 th form (no KS4)	10,627	7.9
GCSE Science taken		
Applied	4,148	0.8
Double	171,471	6.9
Physics	38,834	23.3
Single	8,683	1.4
None	8,846	8.8
Ethnic group ^a		
African	1,935	7.1
Other Asian	1,535	13.2
Other Black	394	5.6
Other Mixed	1,312	11.2
Other White	4,151	10.0
Bangladeshi	1,029	4.9
Caribbean	1,120	3.6
Chinese	1,034	22.4
Indian	5,266	10.8
Irish	681	7.2
Other	1,341	11.2
Pakistani	2,718	7.1
Refused	1,609	10.8
White British	106,254	9.5
White and Asian	880	12.2
White and Black African	278	5.8
White and Black Caribbean	737	4.9
GCSE Science best grade		
Yes	61,132	22.2
No	161,889	4.6
GCSE Maths best grade		
Yes	64,275	19.3
No	158,746	5.2

Notes

^a There were 19 different ethnic groups in the data, the following of which were combined into an 'Other' group: Other Ethnic Group, Gypsy/Romany, Traveller of Irish Heritage. 'Information not Obtained' was set to missing.

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Table 3: Multilevel model of probability of A-level physics uptake (school type)

	Est.	S.E.
Fixed		
Constant	-1.7	<0.1
Female	-2.2	<0.1
Independent	-0.2	<0.1
FE/Tertiary	-0.2	0.1
Sixth Form	-0.1	0.1
Grammar	-0.1	0.1
Best 5 GCSEs	0.2	<0.1
Independent*female	0.5	0.1
FE/Tertiary*female	-0.2	0.1
Sixth Form*female	0.0	0.1
Grammar*female	0.4	0.1
Random		
School	0.2	<0.1

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Table 4: Multilevel model of probability of A-level physics uptake (school gender)

	Est.	S.E.
Fixed		
Constant	-1.8	<0.1
Female	-2.2	<0.1
Female-Mixed	-0.2	0.1
Female-Female	n/a	n/a
Male-Mixed	-0.4	0.1
Male-Male	-0.3	0.1
None-Mixed	-0.1	0.1
Best 5 GCSEs	0.2	<0.1
Female-Mixed*female	0.1	0.1
Female-Female*female	0.9	0.3
Male-Mixed*female	0.3	0.1
Male-Male*female	n/a	n/a
None-Mixed *female	0.3	0.1
Random		
School	0.2	<0.1

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Table 5: Multilevel model of probability of A-level physics uptake (school ability)

	Est.	S.E.
Fixed		
Constant	-1.8	<0.1
Female	-2.1	<0.1
School ability	-0.1	<0.1
Best 5 GCSEs	0.2	<0.1
School ability*Female	0.5	<0.1
Random		
School	0.3	<0.1

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Table 6: Multilevel model of probability of A-level physics uptake (ethnicity)

	Estimate	SE
Constant	-1.9	<0.1
Female	-2.2	<0.1
Best 5 GCSEs	0.2	<0.1
African	0.1	0.1
Other Asian	0.3	0.1
Other Black	-0.1	0.2
Other Mixed	0.2	0.1
Other White	-0.1	0.1
Bangladeshi	-0.4	0.2
Caribbean	-0.4	0.2
Chinese	0.8	0.1
Indian	0.1	0.1
Irish	-0.5	0.2
Other	0.2	0.1
Pakistani	<-0.1	0.1
Refused	0.1	0.1
White and Asian	0.1	0.1
White and Black African	-0.6	0.3
White and Black Caribbean	-0.4	0.2
School-level variance	0.2	<0.1

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Table 7: Multilevel model of probability of A-level physics uptake (neighbourhood characteristics)

	Estimate	SE
IADCI Score	-0.147	0.081
Percent no Qualifications	0.000	0.001
Percent level 4/5 Qualifications	-0.001	0.001
Percent no cars	-0.004	0.001
Unemployment rate	-0.007	0.007
Percent Lone Parents	-0.007	0.004

For Peer Review Only