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Royal Society: Computing Education
Analysis of administrative education data

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1. Introduction

This report presents analysis of computing education at Key Stage 4, Key Stage 5 and Higher Education using data from educational administrative databases.

This report is in four sections. The first three sections describe computing education at Key Stage 4, Key Stage 5 and Higher Education. The final section presents two statistical models which investigate particular aspects of computing education, namely (i) uptake of computing at Key Stage 4, and (ii) continuation of computing study from Key Stage 4 to Key Stage 5.

The analysis is based on five main sources:

- The **National Pupil Database** (NPD) is a record of all pupils in state schools in England, held by the Department for Education (DfE). It includes demographic data and information about exams taken and grades achieved at Key Stages 4 and 5
- The **Individualised Learner Record** (ILR) records data for individuals in the Further Education system in England. It is managed by the Education and Skills Funding Agency. It includes demographic data and information about further education courses taken. The ILR is important for analysis of Key Stage 5 as it includes pupils in education but no longer in the state school system (for example, at sixth form colleges or further education colleges) who are not covered by the NPD.
- The **Higher Education Statistics Agency** (HESA) collect data regarding the higher education system in the UK. This includes information for both staff and students at UK higher education institutions.
- **Edubase** provides information about schools in England and Wales.
- The **Schools Workforce Census** (SWC) collects data about staff at schools in England.

Further information about these sources, including coverage, can be found in the links listed below:

- NPD: https://www.gov.uk/government/collections/national-pupil-database
- ILR: https://www.gov.uk/government/collections/individualised-learner-record-ilr
- HESA: https://www.hesa.ac.uk/data-and-analysis
- Edubase: http://www.education.gov.uk/edubase/about.xhtml
- SWC: https://www.gov.uk/guidance/school-workforce-census

2. Computing at Key Stage 4

In this chapter, we investigate patterns in uptake and attainment for GCSE computing[1] in relation to pupil and school-level characteristics. We look at four aspects of GCSE computing:

i. **Availability of GCSE computing** – *the proportion of pupils attending a school where at least one pupil completed GCSE computing*. Not all schools offer GCSE computing. As we cannot identify directly from the data which schools do offer the subject, we define 'availability' as a pupil attending a school where at least one pupil completed GCSE computing. We look at availability rates across different population sub-groups in terms of pupil demographics and school characteristics.

ii. **Uptake of GCSE computing** – *the proportion of pupils achieving GCSE computing*. We look at uptake rates across different population sub-groups in terms of pupil demographics and school characteristics.

iii. **Subject choices** – *the proportion of GCSE computing pupils achieving GCSEs in a range of other subjects*. Here we look at which GCSE subjects are commonly taken in combination with computing. We look at the proportion of computing students completing GCSEs in a range of other subjects and compare these to those pupils who did not take GCSE computing, as well as those pupils who took GCSE ICT.

iv. **Attainment in GCSE computing** – *the grade distributions achieved in GCSE computing*. We compare these distributions across different population sub-groups in terms of pupil demographics and school characteristics.

The analysis in this chapter focuses on pupils who were in Year 11 in the 2014/15 academic year (although it does include any GCSEs completed by these pupils in earlier academic years).

2.1 Availability of GCSE computing

Availability is defined as a pupil attending a school where at least one pupil achieved GCSE computing. Under half (45%) of all pupils in Year 11 in 2014/15 attended a school where at least one pupil achieved GCSE computing. From this, we estimate that around 55% of pupils attended schools where the subject was not offered.

Table 2.1 shows the availability rates across a range of pupil demographic groups. Availability rates were lower for pupils with any identified learning disability / SEN (31%, compared with 47% of those with no identified learning disability / SEN) or who were eligible for free school meals (38%, compared with 46% of those not known to be eligible for free school meals). Pupils from more deprived areas were less likely to attend a school where GCSE computing was available: 38% of pupils in the most deprived areas attended a school where at least one pupil achieved GCSE computing, compared with 52% of those in the least deprived areas.

Table 2.2 shows the availability rates by a range of school characteristics. There was some regional variation in availability, with 52% of pupils in the South East and South West attending a school where at least one pupil achieved GCSE computing, compared with 36% in the North East and 38% in the West Midlands.

Availability was also strongly associated with a number of other school characteristics:

[1] GCSE computing includes the following courses: OCR Computing, AQA Computer science, WJEC Computer science, Pearson Edexcel Computer science.

- **Admissions policy:** Availability was higher in selective schools (56%) than non-selective schools (46%)
- **Gender of admissions:** Availability was higher in single sex boys schools (55%) than mixed schools (46%). Availability was *lower* in single sex girls schools (31%)
- **School size:** Availability was positively correlated with the number of Key Stage 4 pupils in a school. 24% of pupils in the smallest schools (up to 250 KS4 pupils) attended a school where at least one pupil completed GCSE computing, compared with 58% of pupils in the largest schools (more than 500 KS4 pupils)
- **Free school meals:** Availability was negatively correlated with the proportion of pupils in a school eligible for free school meals. 59% of pupils in schools with the lowest proportion eligible for free school meals attended a school where at least one pupil completed GCSE computing, compared with 32% of pupils in schools with the highest proportion eligible for free school meals
- **School performance:** Availability was positively correlated with the proportion of pupils achieving at least five GCSEs at A*-C (including English and Maths). 33% of pupils in the lowest performing schools attended a school where at least one pupil completed GCSE computing, compared with 56% of pupils in the highest performing schools.

Table 2.1: Availability of GCSE computing by pupil demographics (Key Stage 4 pupils in Year 11 in 2014/15)

	Pupils in school where at least one pupil completed GCSE computing	Total number of pupils		Pupils in school where at least one pupil completed GCSE computing	Total number of pupils
All pupils	*253,095* *45.1%*	*560,813*			
Sex					
Male	132,081 46.0%	287,290	Female	121,014 44.2%	273,523
Ethnicity					
White	203,475 45.8%	443,788	Mixed	10,218 44.5%	22,957
Black	11,551 41.7%	27,713	Asian	20,672 41.5%	49,789
Chinese	1,035 49.8.%	2,080	Other	3,399 43.2%	7,875
Learning disability / SEN					
No identified learning disability / SEN	217,130 46.6%	466,395	Any identified learning disability / SEN	10,400 31.4%	33,070
Eligibility for free school meals					
Yes, known to be eligible	29,642 38.3%	77,357	No, not known to be eligible	223,453 46.2%	483,456
IDACI (quintiles)					
1 – most deprived	42,775 38.2%	111,886	2	46,183 41.3%	111,917
3	51,365 45.9%	111,910	4	54,135 48.4%	111,906
5 – least deprived	58,116 51.9%	111,899			

Table 2.2: Availability of GCSE computing by school characteristics (Key Stage 4 pupils in year 11 in 2014/15)

	Pupils in school where at least one pupil completed GCSE computing	Total number of pupils		Pupils in school where at least one pupil completed GCSE computing	Total number of pupils
All pupils	*253,095* *45.1%*	*560,813*			
Region					
East Midlands	22,190 45.2%	49,131	East of England	29,129 46.4%	62,829
London	33,075 42.6%	77,670	North East	9,643 36.4%	26,476
North West	34,139 44.4%	76,960	South East	46,403 52.2%	88,822
South West	27,579 51.6%	53,478	West Midlands	23,390 38.5%	60,798
Yorkshire and the Humber	24,991 44.2%	56,545			
Rural / urban classification			Rural	28,247 41.3%	68,315
Urban (town and city)	129,461 48.1%	269,203	Urban (conurbation)	92,347 43.0%	214,699
School admissions policy			Not selective	236,766 46.3%	510,866
Selective	12,592 56.0%	22,492	Not applicable (e.g. special schools)	689 3.8%	17,911
School gender admissions			Mixed	227,524 45.9%	496,087
Single sex – Boys	12,741 54.8%	23,246	Single sex – Girls	10,274 30.8%	33,376
School size (total number of Key Stage 4 pupils)			Up to 250 pupils	18,289 24.1%	75,741
250-299 pupils	21,211 33.8%	62,753	300-399 pupils	78,063 46.1%	169,477
400-499 pupils	76,987 52.2%	147,396	500 pupils or more	55,989 57.5%	97,329
Proportion of pupils eligible for free school meals			Under 5% of pupils	80,090 58.8%	136,116
5%-9.9% of pupils	75,481 46.5%	162,283	10%-14.9% of pupils	44,190 46.4%	95,189
15%-24.9% of pupils	35,577 33.7%	105,543	25% of pupils or more	14,839 31.7%	46,859
School performance: Proportion of pupils achieving at least 5 GCSEs at A*-C, including English and Maths					
Under 40% of pupils	21,325 33.5%	63,747	40%-49% of pupils	34,000 35.9%	94,691
50%-59% of pupils	67,152 50.9%	131,946	60%-69% of pupils	61,189 48.9%	125,105
70%-84% of pupils	47,946 52.2%	91,902	85% of pupils or above	17,065 56.2%	30,342

2.2 Uptake of GCSE computing

In total, 31,391 pupils in Year 11 in 2014/15 completed GCSE computing, which is around 6% of all pupils (Table 2.3). More than three times as many (18%) completed GCSE ICT.

Table 2.3: GCSE computing and ICT uptake (Key Stage 4 pupils in Year 11 in 2014/15)

Achieved GCSE computing	31,391
	5.6%
Achieved GCSE ICT	98,609
	17.6%
Not achieved GCSE in either computing or ICT	434,963
	77.6%
Base	*560,813*

Table 2.4 shows the uptake rates for GCSE computing across a range of pupil demographic groups. These rates are shown in two ways:

i. The percentage of *all pupils* achieving GCSE computing

ii. The percentage achieving GCSE computing *out of pupils attending a school where at least one pupil completed GCSE computing*

In other words, the first rate considers uptake of GCSE computing among the whole pupil population, while the second rate considers uptake among only those pupils attending a school where we believe GCSE computing was offered to pupils.

Uptake was much higher among male pupils than female pupils (9% of all male pupils and 20% of male pupils in schools offering computing, compared with 2% and 4% respectively for female pupils). The effect of this was that 84% of pupils taking GCSE computing were male and only 16% female.

Uptake was also higher among pupils from Asian and Chinese backgrounds; in schools where computing was available, 18% of Asian pupils and more than a quarter (26%) of Chinese pupils took the subject, compared with 12% of pupils from white backgrounds.

Table 2.5 shows the uptake rates for GCSE computing by a range of school characteristics. Uptake was higher in selective schools than non-selective schools (22% of pupils in selective schools where at least one pupil completed GCSE computing, compared with 12% in non-selective schools). It was also higher in single sex boys schools than in either single sex girls schools or mixed schools (21% of pupils in single sex boys schools where at least one pupil completed GCSE computing, compared with 12% in single sex girls schools and 12% in mixed schools).

In section 2.1, we noted that GCSE computing was less likely to be available in smaller schools. However, *where GCSE computing was offered,* uptake was slightly higher in smaller schools: 16% of pupils achieved GCSE computing in the smallest schools where at least one pupil completed the subject, compared with 11% in the largest schools.

Table 2.4: Uptake of computing by pupil demographic (Key Stage 4 pupils in Year 11 in 2014/15)

	Pupils within all schools		Pupils within schools where at least one pupil completed GCSE computing	
	Pupils completing GCSE computing	Total number of pupils	Pupils completing GCSE computing	Total number of pupils
All pupils	*31,391* *5.6%*	*560,813*	*31,391* *12.4%*	*253,095*
Sex				
Male	26,330 9.2%	287,290	26,330 19.9%	132,081
Female	5,061 1.9%	273,523	5,061 4.2%	121,014
Ethnicity				
White	24,250 5.5%	443,788	24,250 11.9%	203,475
Mixed	1,248 5.4%	22,957	1,248 12.2%	10,218
Black	1,141 4.1%	27,713	1,141 9.9%	11,551
Asian	3,728 7.5%	49,789	3,728 18.0%	20,672
Chinese	264 12.7%	2,080	264 25.5%	1,035
Other	476 6.0%	7,875	476 14.0%	3,399
Learning disability / SEN				
No identified learning disability / SEN	28,487 6.1%	466,395	28,487 13.1%	217,130
Any identified learning disability / SEN	932 2.8%	33,070	932 9.0%	10,400
Eligibility for free school meals				
Yes, known to be eligible	2,676 3.5%	77,357	2,676 9.0%	29,642
No, not known to be eligible	28,715 5.9%	483,456	28,715 12.9%	223,453
IDACI (quintiles)				
1 – most deprived	4,803 4.3%	111,886	4,803 11.2%	42,775
2	5,489 4.9%	111,917	5,489 11.9%	46,183
3	6,496 5.8%	111,910	6,496 12.6%	51,365
4	6,897 6.2%	111,906	6,897 12.7%	54,135
5 – least deprived	7,644 6.8%	111,899	7,644 13.2%	58,116

Table 2.5: Uptake of computing by school characteristics groups (Key Stage 4 pupils in Year 11 in 2014/15)

	Pupils within all schools		Pupils within schools where at least one pupil completed GCSE computing	
	Pupils completing GCSE computing	Total number of pupils	Pupils completing GCSE computing	Total number of pupils
All pupils	*31,391* *5.6%*	*560,813*	*31,391* *12.4%*	*253,095*
Region				
East Midlands	2,643 5.4%	49,131	2,643 11.9%	22,190
East of England	3,376 5.4%	62,829	3,376 11.6%	29,129
London	4,236 5.5%	77,670	4,236 12.8%	33,075
North East	1,066 4.0%	26,476	1,066 11.1%	9,643
North West	4,154 5.4%	76,960	4,154 12.2%	34,139
South East	6,024 6.8%	88,822	6,024 13.0%	46,403
South West	3,375 6.3%	53,478	3,375 12.2%	27,579
West Midlands	3,230 5.3%	60,798	3,230 13.8%	23,390
Yorkshire and the Humber	2,971 5.3%	56,545	2,971 11.9%	24,991
Rural / urban classification				
Rural	3,441 5.0%	68,315	3,441 12.2%	28,247
Urban (town and city)	15,941 5.9%	269,203	15,941 12.3%	129,461
Urban (conurbation)	11,646 5.4%	214,699	11,646 12.6%	92,347
School admissions policy				
Not selective	28,217 5.5%	510,866	28,217 11.9%	236,766
Selective	2,740 12.2%	22,492	2,740 21.8%	12,592
Not applicable (e.g. special schools)	58 0.3%	17,911	58 8.4%	689
School gender admissions				
Single sex – Boys	2,735 11.8%	23,246	2,735 21.5%	12,741
Single sex – Girls	1,259 3.8%	33,376	1,259 12.3%	10,274
Mixed	27,081 5.5%	496,087	27,081 11.9%	227,524

Table 2.5 (cont.)

	Pupils within all schools		Pupils within schools where at least one pupil completed GCSE computing	
	Pupils completing GCSE computing	Total number of pupils	Pupils completing GCSE computing	Total number of pupils
School size (total number of Key Stage 4 pupils)				
Under 250 pupils	2,933 3.9%	75,741	2,933 16.0%	18,289
250-299 pupils	3,241 5.2%	62,753	3,241 15.3%	21,211
300-399 pupils	10,098 6.0%	169,477	10,098 12.9%	78,063
400-499 pupils	8,704 5.9%	147,396	8,704 11.3%	76,987
500 pupils or more	6,099 6.3%	97,329	6,099 10.9%	55,989
Proportion of pupils eligible for free school meals				
Under 5% of pupils eligible	10,772 7.9%	136,116	10,722 13.4%	80,090
5%-9.9% of pupils eligible	8,743 5.4%	162,283	8,743 11.6%	75,481
10%-14.9% of pupils eligible	5,402 5.7%	95,189	5,402 12.2%	44,190
15%-24.9% of pupils eligible	4,339 4.1%	105,543	4,339 12.2%	35,577
25% of pupils or more eligible	1,804 3.8%	46,859	1,804 12.2%	14,839
School performance: Proportion of pupils achieving at least 5 GCSEs at A*-C, including English and Maths				
Under 40% of pupils	2,371 3.7%	63,747	2,371 11.1%	21,325
40%-49% of pupils	3,994 4.2%	94,691	3,994 11.7%	34,000
50%-59% of pupils	8,133 6.2%	131,946	8,133 12.1%	67,152
60%-69% of pupils	7,353 5.9%	125,105	7,353 12.0%	61,189
70%-84% of pupils	5,766 6.3%	91,902	5,766 12.0%	47,946
85% of pupils or above	3,301 10.9%	30,342	3,301 19.3%	17,065

2.3 Subject choices

Figure 2.1 plots the proportion of pupils studying a range of GCSE subjects for (i) pupils who achieved GCSE computing and (ii) pupils who did not achieve GCSE computing. Each point on the plot represents a different GCSE subject. The diagonal line corresponds to a 1:1 correlation i.e. any point on the line represents a subject with exactly the same uptake rates for pupils who took GCSE computing and those who did not take GCSE computing. This allows us to see which subjects were more commonly taken in combination with GCSE computing (the blue region) or less commonly taken in combination with GCSE computing (the orange region).

From figure 2.1, it can be seen that pupils studying computing GCSE were more likely than their peers to study English literature (87%, compared to 77% of those not taking GCSE computing) and Triple science (41%, compared with 21% of those not taking GCSE computing).

Conversely, they were less likely to take subjects such as:

- Core science (55%, compared with 63% of those not taking GCSE computing)
- Art and design (16%, compared with 29% of those not taking GCSE computing)
- Physical education (13%, compared with 21% of those not taking GCSE computing)
- Drama (6%, compared with 12% of those not taking GCSE computing)

Figure 2.1: Proportion of GCSE computing / non-computing students taking a range of GCSE subjects

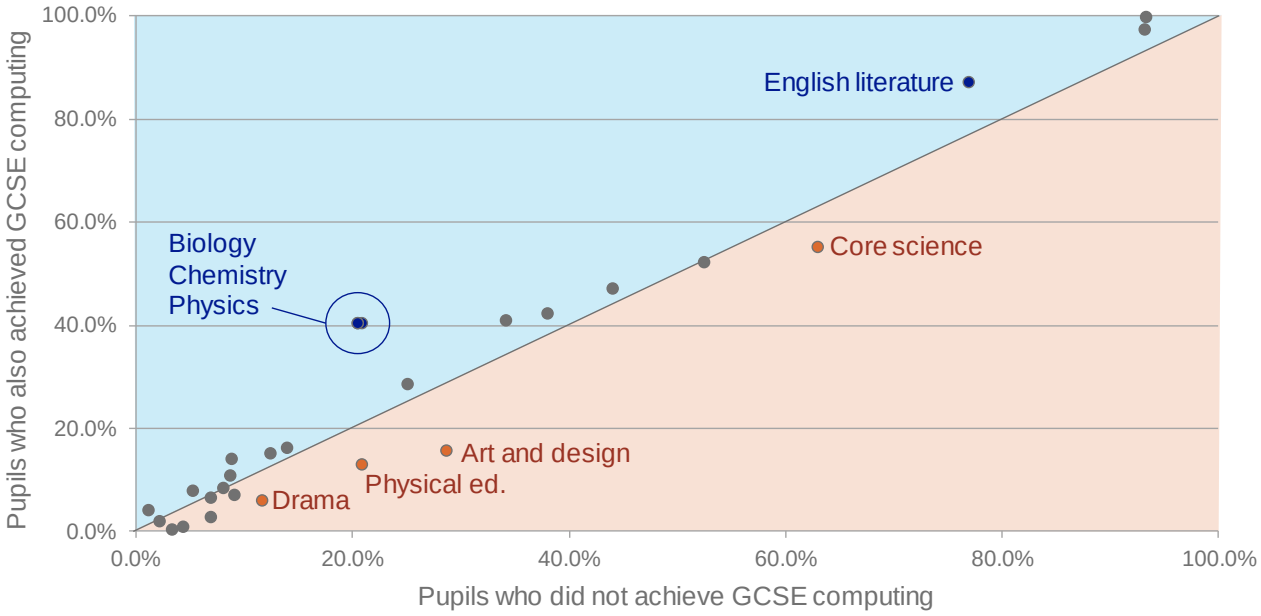
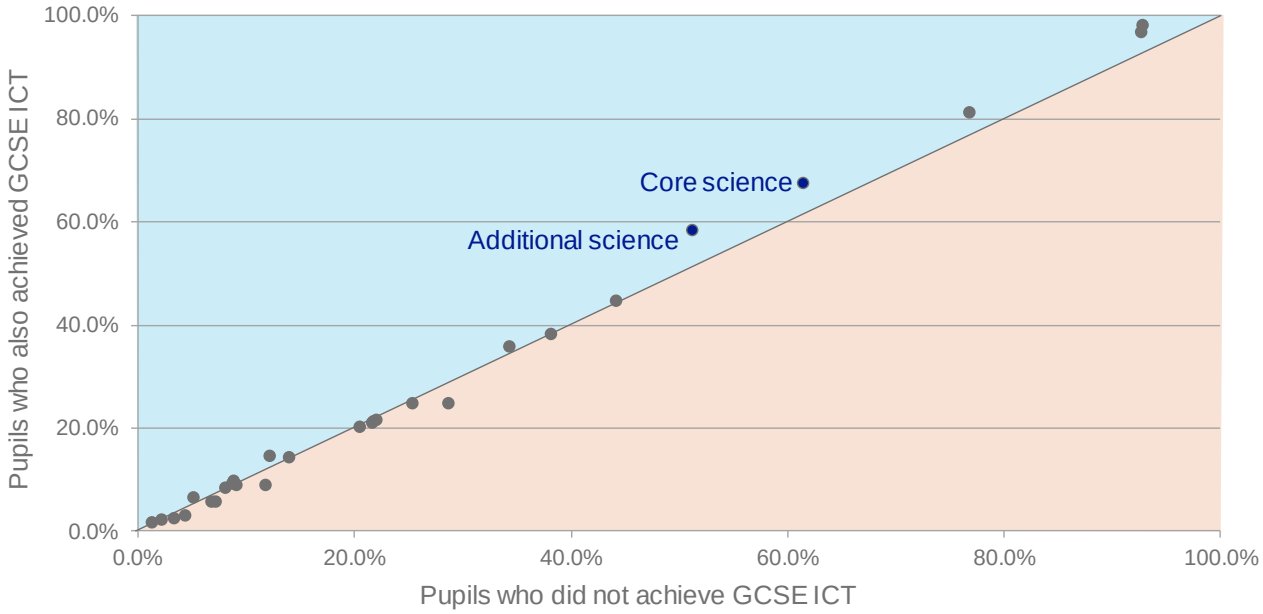


Figure 2.2 shows the equivalent plot for GCSE ICT pupils i.e. comparing the subjects taken by ICT students and those who did not take GCSE ICT. In this case, subject choices of ICT students were very much in line with other pupils, although ICT students were more likely to take Core science (68%, compared to 61% of those not taking ICT) and Additional science (58%, compared with 51% of those not taking ICT).

Figure 2.2: Proportion of GCSE ICT / non-ICT students taking a range of GCSE subjects



2.4 Attainment

Table 2.6 shows the cumulative grade distributions for GCSE computing across a range of demographic sub-groups[2].

Female pupils scored higher on average than male pupils (50% achieving at least a B, compared with 41% of male pupils). Pupils from Chinese backgrounds also had particularly strong computing grades: 70% achieved at least a B, compared with 42% of white pupils. Attainment decreased with higher levels of deprivation: 35% of pupils in the most deprived areas achieved at least a B, compared with 53% of pupils in the least deprived areas.

Table 2.7 shows the cumulative grade distributions for GCSE computing by a range of school characteristics. Attainment was higher in selective schools than non-selective schools (82% achieving at least a B, compared with 39%) and in single sex schools (64% of pupils in single sex boys schools and 67% of pupils in single sex girls schools achieving at least a B, compared with 40% in mixed schools).

[2] This shows the proportion of pupils achieving this grade *or higher*. For example, the 'B' column shows the proportion of pupils achieving a grade B or above in GCSE computing.

Table 2.6: Cumulative grade distributions in GCSE computing by pupils demographics (Key Stage 4 pupils in Year 11 in 2014/15)

	A*	A	B	C	D	E	F	G	U
All pupils	1,967	6,845	13,803	20,968	25,792	28,590	30,288	31,391	32,210
	6.1%	21.3%	42.9%	65.1%	80.1%	88.8%	94.0%	97.5%	100%
Sex									
Male	1,538	5,463	11,216	17,273	21,390	23,804	25,322	26,330	27,075
	5.7%	20.2%	41.4%	63.8%	79.0%	87.9%	93.5%	97.2%	100%
Female	429	1,382	2,587	3,695	4,402	4,786	4,966	5,061	5,135
	8.4%	26.9%	50.4%	72.0%	85.7%	93.2%	96.7%	98.6%	100%
Ethnicity									
White	1,462	5,098	10,397	15,906	19,709	21,952	23,335	24,250	24,908
	5.9%	20.5%	41.7%	63.9%	79.1%	88.1%	93.7%	97.4%	100%
Mixed	91	323	604	886	1,059	1,166	1,216	1,248	1,271
	7.2%	25.4%	47.5%	69.7%	83.3%	91.7%	95.7%	98.2%	100%
Black	48	185	418	700	929	1,039	1,104	1,141	1,175
	4.1%	15.7%	35.6%	59.6%	79.1%	88.4%	94.0%	97.1%	100%
Asian	278	935	1,835	2,713	3,214	3,476	3,632	3,728	3,810
	7.3%	24.5%	48.2%	71.2%	84.4%	91.2%	95.3%	97.8%	100%
Chinese	37	113	184	225	243	256	262	264	264
	14.0%	42.8%	69.7%	85.2%	92.0%	97.0%	99.2%	100%	100%
Other	31	112	220	331	395	435	463	476	487
	6.4%	23.0%	45.2%	68.0%	81.1%	89.3%	95.1%	97.7%	100%
Learning disability / SEN									
No identified learning disability / SEN	1,859	6,437	12,922	19,447	23,762	26,189	27,611	28,487	29,105
	6.4%	22.1%	44.4%	66.8%	81.6%	90.0%	94.9%	97.9%	100%
Any identified learning disability / SEN	40	131	283	480	648	764	857	932	994
	4.0%	13.2%	28.5%	48.3%	65.2%	76.9%	86.2%	93.8%	100%
Eligibility for free school meals									
Yes, known to be eligible	67	309	779	1,444	1,968	2,292	2,524	2,676	2,856
	2.3%	10.8%	27.3%	50.6%	68.9%	80.3%	88.4%	93.7%	100%
No, not known to be eligible	1,900	6,536	13,024	19,524	23,824	26,298	27,764	28,715	29,354
	6.5%	22.3%	44.4%	66.5%	81.2%	89.6%	94.6%	97.8%	100%
IDACI (quintiles)									
1 – most deprived	163	711	1,738	3,001	3,861	4,332	4,617	4,803	4,993
	3.3%	14.2%	34.8%	60.1%	77.3%	86.8%	92.5%	96.2%	100%
2	247	938	2,076	3,332	4,299	4,868	5,242	5,489	5,730
	4.3%	16.4%	36.2%	58.2%	75.0%	85.0%	91.5%	95.8%	100%
3	342	1,212	2,564	4,055	5,133	5,803	6,225	6,496	6,662
	5.1%	18.2%	38.5%	60.9%	77.0%	87.1%	93.4%	97.5%	100%
4	507	1,721	3,298	4,808	5,784	6,358	6,683	6,897	7,028
	7.2%	24.5%	46.9%	68.4%	82.3%	90.5%	95.1%	98.1%	100%
5 – least deprived	705	2,250	4,112	5,741	6,669	7,177	7,464	7,644	7,734
	9.1%	29.1%	53.2%	74.2%	86.2%	92.8%	96.5%	98.8%	100%

Table 2.7: Cumulative grade distributions in GCSE computing by school characteristics (Key Stage 4 pupils in Year 11 in 2014/15)

	A*	A	B	C	D	E	F	G	U
All pupils	1,967	6,845	13,803	20,968	25,792	28,590	30,288	31,391	32,210
	6.1%	21.3%	42.9%	65.1%	80.1%	88.8%	94.0%	97.5%	100%
Region									
East Midlands	147	498	1,019	1,600	2,066	2,358	2,517	2,643	2,722
	5.4%	18.3%	37.4%	58.8%	75.9%	86.6%	92.5%	97.1%	100%
East of England	253	810	1,572	2,339	2,828	3,110	3,264	3,376	3,444
	7.3%	23.5%	45.6%	67.9%	82.1%	90.3%	94.8%	98.0%	100%
London	274	1,048	2,104	3,087	3,657	3,969	4,153	4,236	4,321
	6.3%	24.3%	48.7%	71.4%	84.6%	91.9%	96.1%	98.0%	100%
North East	66	195	456	731	905	992	1,038	1,066	1,090
	6.1%	17.9%	41.8%	67.1%	83.0%	91.0%	95.2%	97.8%	100%
North West	234	800	1,661	2,652	3,381	3,792	4,017	4,154	4,245
	5.5%	18.8%	39.1%	62.5%	79.6%	89.3%	94.6%	97.9%	100%
South East	444	1,397	2,727	3,988	4,820	5,399	5,792	6,024	6,168
	7.2%	22.6%	44.2%	64.7%	78.1%	87.5%	93.9%	97.7%	100%
South West	208	740	1,493	2,278	2,775	3,065	3,252	3,375	3,490
	6.0%	21.2%	42.8%	65.3%	79.5%	87.8%	93.2%	96.7%	100%
West Midlands	185	703	1,416	2,151	2,640	2,928	3,100	3,230	3,317
	5.6%	21.2%	42.7%	64.8%	79.6%	88.3%	93.5%	97.4%	100%
Yorkshire and the Humber	121	564	1,189	1,915	2,448	2,678	2,847	2,971	3,087
	3.9%	18.3%	38.5%	62.0%	79.3%	86.8%	92.2%	96.2%	100%
Rural / urban classification									
Rural	184	697	1,423	2,186	2,738	3,096	3,325	3,441	3,506
	5.2%	19.9%	40.6%	62.4%	78.1%	88.3%	94.8%	98.1%	100%
Urban (town and city)	1,029	3,470	6,969	10,553	12,997	14,450	15,331	15,941	16,353
	6.3%	21.0%	42.6%	64.5%	79.5%	88.4%	93.8%	97.5%	100%
Urban (conurbation)	719	2,584	5,230	7,980	9,755	10,711	11,280	11,646	11,977
	6.0%	21.6%	43.7%	66.6%	81.4%	89.4%	94.2%	97.2%	100%
School admissions policy									
Not selective	1,319	5,232	11,367	18,123	22,774	25,480	27,143	28,217	29,016
	4.5%	18.0%	39.2%	62.5%	78.5%	87.8%	93.5%	97.8%	100%
Selective	612	1,517	2,259	2,585	2,683	2,724	2,733	2,740	2,743
	22.3%	55.3%	82.4%	94.2%	97.8%	99.3%	99.6%	99.9%	100%
Not applicable (e.g. special schools)	-	2	2	12	27	39	47	58	61
	0.0%	3.3%	3.3%	19.7%	44.3%	63.9%	77.0%	95.1%	100%
School gender admissions									
Single sex - Boys	372	1,063	1,764	2,243	2,484	2,616	2,689	2,735	2,769
	13.4%	38.4%	63.7%	81.0%	89.7%	94.5%	97.1%	98.8%	100%
Single sex – Girls	203	529	849	1,061	1,160	1,220	1,247	1,259	1,267
	16.0%	41.8%	67.0%	83.7%	91.6%	96.3%	98.4%	99.4%	100%
Mixed	1,357	5,163	11,024	17,437	21,876	24,455	26,044	27,081	27,848
	4.9%	18.5%	39.6%	62.6%	78.6%	87.8%	93.5%	97.2%	100%

Table 2.7 (cont.)

	A*	A	B	C	D	E	F	G	U
All pupils	1,967	6,845	13,803	20,968	25,792	28,590	30,288	31,391	32,210
	6.1%	21.3%	42.9%	65.1%	80.1%	88.8%	94.0%	97.5%	100%
School size (total number of Key Stage 4 pupils)									
Under 250 pupils	224	676	1,273	1,878	2,340	2,642	2,810	2,933	3,038
	7.4%	22.3%	41.9%	61.8%	77.0%	87.0%	92.5%	96.5%	100%
250-299 pupils	211	683	1,387	2,099	2,591	2,913	3,112	3,241	3,330
	6.3%	20.5%	41.7%	63.0%	77.8%	87.5%	93.5%	97.3%	100%
300-399 pupils	685	2,254	4,413	6,741	8,335	9,216	9,758	10,098	10,368
	6.6%	21.7%	42.6%	65.0%	80.4%	88.9%	94.1%	97.4%	100%
400-499 pupils	450	1,792	3,765	5,800	7,136	7,929	8,402	8,704	8,901
	5.1%	20.1%	42.3%	65.2%	80.2%	89.1%	94.4%	97.8%	100%
500 pupils or more	362	1,350	2,799	4,223	5,118	5,591	5,898	6,099	6,247
	5.8%	21.6%	44.8%	67.6%	81.9%	89.5%	94.4%	97.6%	100%
Proportion of pupils eligible for free school meals									
Under 5% of pupils	1,167	3,488	6,171	8,311	9,503	10,179	10,536	10,772	10,885
	10.7%	32.0%	56.7%	76.4%	87.3%	93.5%	96.8%	99.0%	100%
5%-9.9% of pupils	439	1,704	3,567	5,589	6,998	7,850	8,397	8,743	8,993
	4.9%	18.9%	39.7%	62.1%	77.8%	87.3%	93.4%	97.2%	100%
10%-14.9% of pupils	185	834	1,953	3,274	4,199	4,750	5,150	5,402	5,628
	3.3%	14.8%	34.7%	58.2%	74.6%	84.4%	91.5%	96.0%	100%
15%-24.9% of pupils	120	542	1,353	2,450	3,349	3,860	4,146	4,339	4,474
	2.7%	12.1%	30.2%	54.8%	74.9%	86.3%	92.7%	97.0%	100%
25% of pupils or more	21	186	592	1,111	1,461	1,641	1,737	1,804	1,888
	1.1%	9.9%	31.4%	58.8%	77.4%	86.9%	92.0%	95.6%	100%
School performance: Proportion of pupils achieving at least 5 GCSEs at A*-C, including English and Maths									
Under 40% of pupils	49	205	542	1,086	1,589	1,939	2,180	2,371	2,515
	1.9%	8.2%	21.6%	43.2%	63.2%	77.1%	86.7%	94.3%	100%
40%-49% of pupils	75	400	1,087	2,126	2,956	3,437	3,764	3,994	4,214
	1.8%	9.5%	25.8%	50.5%	70.1%	81.6%	89.3%	94.8%	100%
50%-59% of pupils	316	1,282	3,002	4,946	6,366	7,234	7,788	8,133	8,365
	3.8%	15.3%	35.9%	59.1%	76.1%	86.5%	93.1%	97.2%	100%
60%-69% of pupils	353	1,484	3,166	4,989	6,143	6,788	7,149	7,353	7,503
	4.7%	19.8%	42.2%	66.5%	81.9%	90.5%	95.3%	98.0%	100%
70%-84% of pupils	474	1,680	3,185	4,448	5,137	5,477	5,657	5,766	5,823
	8.1%	28.9%	54.7%	76.4%	88.2%	94.1%	97.1%	99.0%	100%
85% of pupils or more	656	1,681	2,589	3,047	3,202	3,276	3,291	3,301	3,304
	19.9%	50.9%	78.4%	92.2%	96.9%	99.2%	99.6%	99.9%	100%

3. Computing at Key Stage 5

In this chapter, we investigate patterns of uptake and attainment for A level and AS level computing in relation to pupil and school-level characteristics:

i. **Uptake of A level computing** – *the proportion of pupils achieving A level computing*. We look at uptake rates across different population sub-groups in terms of pupil demographics and school characteristics.

ii. **Subject choices** – *the proportion of A level / AS level computing pupils achieving A levels in a range of other subjects*. Here we look at which subjects are commonly taken in combination with computing. We look at the proportion of computing students completing A levels in a range of other subjects and compare these to those pupils who did not take A level / AS level computing, as well as those pupils who took A level / AS level ICT.

iii. **Attainment in A level computing** – *the grade distributions achieved in A level computing*. We compare these distributions across different population sub-groups in terms of pupil demographics and school characteristics.

This chapter focuses on two academic year cohorts: pupils who were in Years 12 or 13 in the 2014/15 academic year. For Year 12 pupils, the data includes any qualifications they would go on to achieve in Year 13 in 2015/16.

3.1 Uptake of A level computing

Overall, 8,932 pupils achieved A level computing, and 15,630 pupils achieved AS level computing, around 1% and 2% of all pupils respectively. Uptake rates for A level / AS level ICT were at similar levels.

Table 3.1: Key Stage 5 computing and ICT uptake (Key Stage 5 pupils in Years 12/13 in 2014/15)

Achieved any computing / ICT KS5 qualification	***44,102***
	5.4%
Achieved A level computing	8,932
	1.1%
Achieved AS level computing	15,630
	1.9%
Achieved A level ICT	11,017
	1.4%
Achieved AS level ICT	17,231
	2.1%
Achieved A level Double Award ICT	363
	0.0%
Achieved AS level Double Award ICT	528
	0.1%
Achieved Applied A level ICT	6,947
	0.9%
Achieved Applied AS level ICT	11,335
	1.4%
No KS5 computing / ICT qualification	***771,414***
	94.6%
Base	*815,516*

Table 3.2 shows the uptake rates for A level computing across a range of pupil demographic groups. Uptake was much higher among male pupils (3.7%) than female pupils (0.4%). It was also higher for pupils from a Chinese background (5.0%, compared with 2.0% of pupils from White backgrounds), as well as those attending a selective institution (3.7%) or a sixth form college (3.5%).Uptake was lower in more deprived areas: 1.4% of pupils in the most deprived areas completed A level or AS level computing, compared with 2.4% in the least deprived areas.

Table 2.2: Uptake of A level/AS level computing by pupil demographic (Key Stage 5 pupils in Years 12/13 in 2014/15)

	Pupils achieving A level or AS level computing	Total number of pupils		Pupils achieving A level or AS level computing	Total number of pupils
All pupils	*15,945* *2.0%*	*815,516*			
Sex					
Male	14,418 3.7%	389,553	Female	1,527 0.4%	425,963
Ethnicity					
White	12,277 2.0%	626,639	Mixed	682 2.0%	33,693
Black	568 1.3%	45,260	Asian	1,755 2.1%	84,102
Chinese	241 5.0%	4,842	Other	209 1.9%	11,010
Learning disability / SEN					
No identified learning disability / SEN	13,732 2.0%	698,053	Any identified learning disability / SEN	730 1.4%	50,461
Eligibility for free school meals					
Yes, known to be eligible	891 1.2%	76,417	No, not known to be eligible	14,968 2.0%	732,357
IDACI (quintiles)					
1 – most deprived	2,378 1.4%	166,489	2	2,837 1.7%	164,782
3	3,340 2.1%	162,190	4	3,495 2.2%	160,169
5 – least deprived	3,852 2.4%	158,693			
Institution type					
Comprehensive	7,281 1.9%	374,728	Modern[3]	67 0.5%	13,977
Selective	1,853 3.7%	49,493	Other maintained	330 1.8%	18,572
Independent	30 1.1%	2,845	Sixth form college	4,710 3.5%	134,069
Other further education college	1,630 1.0%	166,017			

[3] 'Modern' refers to non-selective schools in areas with selective schools.

3.2 Subject choices

Figures 3.1 plot subject choices for pupils taking A level or AS level computing against those not taking computing. Subjects in the blue region are those which were more commonly taken by computing students, while subjects in the orange region were less commonly taken by computing students. Figure 3.2 is the equivalent plot for A level / AS level ICT.

Computing students were much more likely than their peers to also study Maths, Physics and/or Further maths at Key Stage 5: 60% of computing students also completed Maths A level (compared with 24% of non-computing students), 35% completed Physics A level (compared with 9% of non-computing students), and 15% completed Further maths A level (compared with 4% of non-computing students).

Meanwhile, they were less likely to take A level Biology, or a range of humanities and social science subjects such as: History, English literature, Psychology, Sociology, Geography, Media Film and TV studies.

ICT students were less likely to complete A level maths than non-ICT students. They were more likely to study A level Business Studies (19%, compared with 8% of non-ICT students).

Figure 3.1: Proportion of A level / AS level computing / non-computing students taking a range of A level subjects

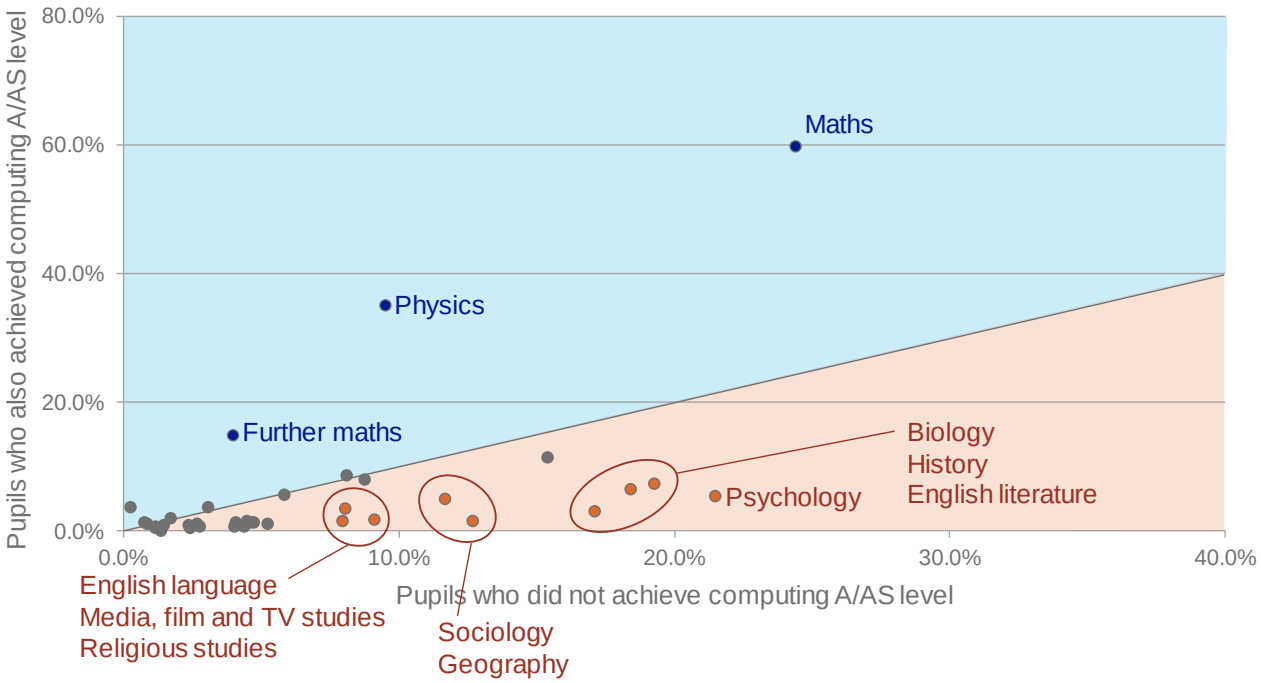
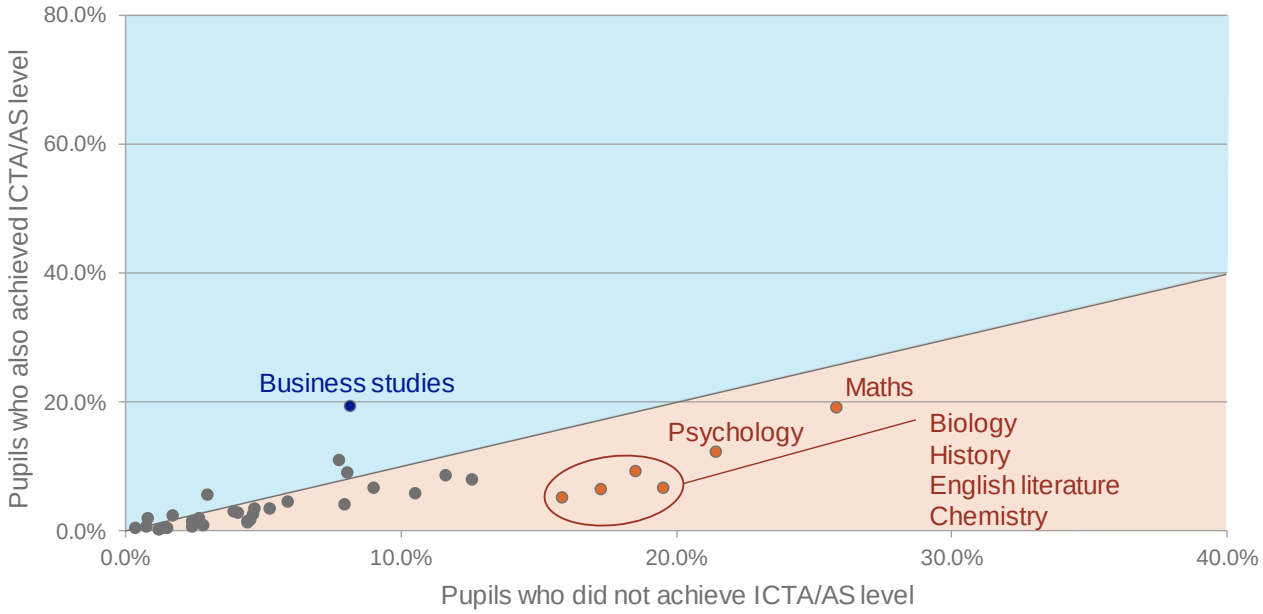


Figure 3.2: Proportion of A level / AS level ICT / non-ICT students taking a range of A level subjects



3.3 Attainment

Table 3.3 shows the cumulative grade distributions for A level computing across a range of demographic sub-groups.

As with KS4 computing attainment, female pupils scored higher on average than male pupils (46% achieving at least a B, compared with 37% of male pupils). Attainment decreased with higher levels of deprivation (32% of pupils in the most deprived areas achieved at least a B, compared with 43% of pupils in the least deprived areas). Pupils in selective schools scored, on average, higher grades with 57% achieving at least a B, compared with 33% of pupils in comprehensive institutions.

Table 3.3: Cumulative grade distributions in A level computing by demographic groups (Key Stage 5 pupils in Years 12/13 in 2014/15)

	A*	A	B	C	D	E	U
All pupils	265	1,507	3,504	5,664	7,659	8,932	9,217
	2.9%	16.4%	38.0%	61.5%	83.1%	96.9%	100%
Sex							
Male	228	1,333	3,123	5,117	6,961	8,133	8,396
	2.7%	15.9%	37.2%	60.9%	82.9%	96.9%	100%
Female	37	174	381	547	698	799	821
	4.5%	21.2%	46.4%	66.6%	85.0%	97.3%	100%

Table 3.3 (cont.)

	A*	A	B	C	D	E	U
All pupils	265	1,507	3,504	5,664	7,659	8,932	9,217
	2.9%	16.4%	38.0%	61.5%	83.1%	96.9%	100%
Ethnicity							
White	219	1,205	2,788	4,506	6,087	7,082	7,303
	3.0%	16.5%	38.2%	61.7%	83.3%	97.0%	100%
Mixed	19	79	161	229	307	357	369
	5.1%	21.4%	43.6%	62.1%	83.2%	96.7%	100%
Black	4	27	81	154	225	288	302
	1.3%	8.9%	26.8%	51.0%	74.5%	95.4%	100%
Asian	13	136	331	534	738	869	897
	1.4%	15.2%	36.9%	59.5%	82.3%	96.9%	100%
Chinese	7	30	65	109	126	135	137
	5.1%	21.9%	47.4%	79.6%	92.0%	98.5%	100%
Other	-	13	37	67	87	98	101
	0.0%	12.9%	36.6%	66.3%	86.1%	97.0%	100%
Learning disability / SEN							
Any identified learning disability / SEN	9	61	140	240	332	394	409
	2.2%	14.9%	34.2%	58.7%	81.2%	96.3%	100%
No identified learning disability / SEN	227	1,291	3,018	4,899	6,616	7,715	7,959
	2.9%	16.2%	37.9%	61.6%	83.1%	96.9%	100%
Eligibility for free school meals							
Yes, known to be eligible	9	48	134	242	374	453	474
	1.9%	10.1%	28.3%	51.1%	78.9%	95.6%	100%
No, not known to be eligible	256	1,454	3,355	5,400	7,257	8,447	8,710
	2.9%	16.7%	38.5%	62.0%	83.3%	97.0%	100%
IDACI (quintiles)							
1 – most deprived	20	150	411	721	1,015	1,228	1,282
	1.6%	11.7%	32.1%	56.2%	79.2%	95.8%	100%
2	34	206	555	903	1,288	1,544	1,619
	2.1%	12.7%	34.3%	55.8%	79.6%	95.4%	100%
3	50	308	712	1,144	1,572	1,836	1,903
	2.6%	16.2%	37.4%	60.1%	82.6%	96.5%	100%
4	72	379	806	1,329	1,751	2,016	2,059
	3.5%	18.4%	39.1%	64.5%	85.0%	97.9%	100%
5 – least deprived	89	461	1,012	1,555	2,016	2,287	2,332
	3.8%	19.8%	43.4%	66.7%	86.4%	98.1%	100%
Institution type							
Comprehensive	86	555	1,414	2,503	3,507	4,160	4,299
	2.0%	12.9%	32.9%	58.2%	81.6%	96.8%	100%
Selective	60	351	641	868	1,029	1,114	1,132
	5.3%	31.0%	56.6%	76.7%	90.9%	98.4%	100%
Sixth form college	93	447	1,077	1,697	2,294	2,694	2,782
	3.3%	16.1%	38.7%	61.0%	82.5%	96.8%	100%
Other further education college	19	114	273	454	637	745	776
	2.4%	14.7%	35.2%	58.5%	82.1%	96.0%	100%

4. Computing at higher education

In this chapter, we investigate patterns of uptake of computer science in higher education in relation to a range of student characteristics:

i. **Overview of computing at higher education** – the proportion of higher education students taking a course involving computing, as well as the types of courses taken

ii. **Uptake of computing courses among higher education students** – the proportion of higher education students taking a course involving computing across a range of demographic groups

iii. **Key Stage 5 choices** – the A levels taken by higher education computing students, as compared to other higher education students

This chapter focuses on higher education students completing their first degree in 2014/15. For consistency with previous chapters, it is limited to students in higher education institutions in England.

4.1 Overview of computing at higher education

9,648 students completing their first degree in English higher education institutions in 2014/15 completed a course involving computer science. This was 4% of all higher education students in English institutions. Table 4.1 shows the proportion of students completing a degree involving computer science, in comparison with other subject areas. The most common subject areas were Business and administrative studies, Creative arts and design, Biological sciences and Social studies. The number of students completing courses involving computer science was similar to the number of students completing courses involving Law. Table 4.2 breaks down the types of computer science courses in greater detail.

Table 4.3 shows the type of course taken by computer science students, as compared to other higher education students. Computer science students were much more likely to be taking a sandwich course and less likely to be taking a full-time course than other students: more than one in five (21%) computer science students were taking a sandwich course, compared with 7% of other higher education students.

Table 4.1: Proportion of higher education students taking a course involving computer science and other subject areas (All higher education students completing first degree in English institutions in 2014/15)

Computer science	***9,648***
	4.1%
Business and administrative studies	30,944
	13.1%
Creative arts and design	29,496
	12.5%
Biological sciences	29,490
	12.5%
Social studies	26,812
	11.4%
Subjects allied to medicine	21,595
	9.2%
Historical and philosophical studies	13,422
	5.7%
Education	13,064
	5.5%
Linguistics, Classics and related subjects	12,843
	5.4%
Physical sciences	12,572
	5.3%
Engineering	11,930
	5.1%
Law	10,135
	4.3%
Mass communication and documentation	8,307
	3.5%
Mathematical sciences	6,707
	2.8%
Medicine / Dentistry	6,525
	2.8%
European languages, literature and related subjects	5,453
	2.3%
Architecture, building and planning	4,572
	1.9%
Veterinary subjects, agriculture and related subjects	2,551
	1.1%
Base	*235,691*

Table 4.2: Higher education computing courses taken by computer science students (Higher education computer science students completing first degree in English institutions in 2014/15)

Computer science	7,026
	72.8%
Information systems	1,676
	17.4%
Games	549
	5.7%
Software engineering	516
	5.3%
Computer generated visual and audio effects	102
	1.1%
Artificial intelligence	64
	0.7%
Other	26
	0.3%
Base	*9,648*

Table 4.3: Type of higher education course taken (Higher education students completing first degree in English institutions in 2014/15)

	Computer science students	Other students
Full-time course	6,679	194,455
	69.2%	86.0%
Sandwich course	1,985	16,221
	20.6%	7.2%
Part-time course	609	9,950
	6.3%	4.4%
Other	375	5,417
	3.9%	2.4%
Base	*9,648*	*226,043*

4.2 Uptake of computer science among higher education students

Table 4.4 shows the uptake of courses involving computer science among all higher education students completing their first degree in English institutions in 2014/15.

As at Key Stages 4 and 5, uptake was much higher among male students (7.8%) than female students (1.2%). The impact of this was that 84% of computer science students were male and 16% female.

Uptake was higher among non-white students, in particular, students from Black (5.8%), Asian (7.2%) and Chinese (7.0%) backgrounds. Uptake was also higher for students from further education colleges (6.5%) and lower for students from independent (1.6%) or selective (2.4%) schools.

Table 4.4: Uptake of computer science among higher education students (Higher education students completing first degree in English institutions in 2014/15)

	Computer science students	Total number of students		Computer science students	Total number of students
All students	***9,648 4.1%***	***235,691***			
Sex					
Male	8,067 7.8%	103,806	Female	1,577 1.2%	131,858
Ethnicity					
White	5,816 3.4%	169,905	Mixed	496 4.3%	11,633
Black	767 5.8%	13,155	Asian	1,852 7.2%	25,706
Chinese	158 7.0%	2,267			
Student's nationality					
UK	8,185 3.9%	212,155	Not UK	1,272 6.0%	21,134
Disability					
No known disability	8,346 4.1%	203,170	Any known disability	1,098 3.7%	29,979
Previous eligibility for free school meals					
Yes, known to have been eligible for free school meals	823 6.7%	12,239	No, not known to have been eligible for free school meals	6,891 3.9%	177,659
IDACI (quintiles)					
1 – most deprived	1,127 3.2%	35,532	2	1,311 3.3%	39,482
3	1,897 3.8%	50,568	4	1,944 4.7%	41,260
5 – least deprived	2,582 6.2%	41,406			
School type (KS5)					
Comprehensive	3,169 4.0%	79,982	Modern[4]	110 4.9%	2,249
Selective	412 2.4%	17,152	Other maintained	54 6.2%	873
Independent	433 1.6%	27,430	Sixth form college	1,294 3.7%	35,034
Other further education college	2,436 6.5%	37,263			

[4] 'Modern' refers to non-selective schools in areas with selective schools.

4.3 Key stage 5 choices

Table 4.5 shows the proportion of computer science students who completed A levels and AS levels in computing or ICT subjects. For comparison, it also shows the proportion of non-computer science students completing A levels / AS levels in these subjects.

Fewer than half (42%) of computer science students who completed KS5 in England had a KS5 qualification in computing or ICT: 13% had achieved A level computing, 12% achieved A level ICT and 10% achieved Applied A level ICT. 29% achieved A level maths.

Table 4.5: Selected Key Stage 5 qualifications taken by higher education students (Higher education students completing first degree in English institutions in 2014/15, matched to KS5 records[5])

	Computer science students	Other students
Achieved any KS5 computing or ICT qualification	***3,520***	***13,549***
	41.7%	***6.6%***
Achieved A level computing	1,073	1,082
	12.7%	0.5%
Achieved AS level computing	1,080	1,873
	12.8%	0.9%
Achieved A level ICT	978	4,227
	11.6%	2.0%
Achieved AS level ICT	1,025	5,649
	12.1%	2.7%
Achieved A level Double Award ICT	179	118
	2.1%	0.1%
Achieved AS level Double Award ICT	162	157
	1.9%	0.1%
Achieved Applied A level ICT	868	3,605
	10.3%	1.7%
Achieved Applied AS level ICT	945	4,306
	11.2%	2.1%
No KS5 computing or ICT qualification	***4,919***	***193,286***
	58.3%	***93.4%***
Achieved A level Maths	2,400	52,078
	28.7%	25.2%
Achieved A level Further maths	550	9,044
	6.6%	4.4%
Achieved A level Physics	1,305	20,970
	15.6%	10.1%
Base	*8,349*	*206,835*

[5] Around 12% of higher education students were not matched to KS5 records from the NPD. This will be primarily students who did not complete KS5 in England. These students are not included in table 4.5.

5. Modelling the uptake of computing in secondary education

This section presents two statistical models that explore the uptake of GCSE computing at Key Stage 4 (KS4) and A level computing at Key Stage 5 (KS5) with regard to the characteristics of pupils and their schools. More specifically:

- The first model considers computing uptake at GCSE, focusing on schools where at least one pupil has completed GCSE computing (i.e. schools where it is safe to assume that the subject was offered). The model processes data about pupil-level and school-level characteristics to isolate their individual effect on GCSE computing uptake. For simplicity, we will refer to this model as the *computing entry (CE) model.*
- The second model considers computing uptake at A level for a particular subset of pupils: those who have previously taken up computing at KS4. The model examines data about pupil-level and school/college-level characteristics to understand their individual effect on whether pupils continue with computing education at KS5, once they have entered computing education at KS4. For simplicity, we will refer to this model as the *computing continuation (CC) model.*

Combining insights from the CE and CC models, the underlying objective of the analysis presented in this section is to investigate the journey of pupils who choose computing throughout secondary education, reflecting on its possible determinants. The paragraphs that follow describe the methodological approach to constructing the CE and CC models and present their statistical outputs. We then reflect on the modelling findings and discuss the insights that emerge on the basis of the analysis.

5.1 Methodological approach to constructing the CE and CC models

The process of constructing the CE and CC models involved (a) the preparation of corresponding analysis datasets using secondary data sources; (b) the selection of pupil-level and school-level characteristics that should be accounted for when exploring computing uptake; and finally (c) fitting the models.

5.1.1 Preparing the analysis datasets

To facilitate the construction of the CE and CC models, two analysis datasets (the CE analysis dataset and the CC analysis dataset, respectively) were compiled using available data sources:

- **The CE analysis dataset** was compiled by linking data from three data sources maintained by the Department for Education: the National Pupil Database (NPD); the School Workforce Census (SWC); and Edubase. The dataset was filtered to only include pupils at year 11 in the academic year 2014-15. Further filtering excluded from the dataset pupils studying at schools where no year 11 pupils had completed computing GCSE. This exclusion aimed to narrow down the scope of the CE models to schools where it is safe to assume that computing GCSE was offered. We acknowledge that there may be some inaccuracy in the assumption that computing GCSE was not offered at schools where no pupils completed it; however, this methodological decision was deemed as more preferable than its alternative (i.e. maintaining in the dataset pupils at schools

where no pupils completed GCSE computing) as it will allow us to focus more closely on the determinants of entering KS4 computing education *other than the school-level provision of KS4 computing education*.

- **The CC analysis dataset** was compiled by linking four secondary data sources maintained by the Department for Education: the National Pupil Database (NPD); the Individualised Learner Record (ILR); the School Workforce Census (SWC); and Edubase. The dataset included year 12 and year 13 pupils during the academic year 2014-15. The CC analysis dataset was filtered to only include pupils who had completed GCSE computing at KS4. By including only this particular subset of KS5 pupils (as opposed to all KS5 pupils), the CC analysis dataset will help us understand which pupil-level and school/college-level characteristics are most likely to determine whether pupils *continue* their computing secondary education after KS4.

It is noted that the CE and CC analysis datasets include data from a particular cross-section of pupils: the 2014-15 cross-section. However, the two analysis datasets can be seen as representative of two theoretical populations of pupils *beyond the particular 2014-15 cross-section*: (a) the (wider) population of year 11 pupils at schools where computing GCSE is offered; and (b) the (wider) population of year 12 and year 13 pupils who have taken up computing at KS4. Inferences based on the analysis presented in this section aim to use the data from the particular 2014-15 cross-section in order to draw inferences regarding the wider pupil-populations of interest.

Constructing the CE and CC analysis datasets involved an extensive phase of data pre-processing. The pre-processing was implemented using the statistical package SPSS 23 and comprised two elements:

- A **variable-inspection** element, whereby variables in the original data sources (i.e. the NPD; the SWC; the ILR, and Edubase) were examined one by one using statistics of central tendency and dispersion; frequency distributions; and appropriate visualisation tools. This process focused on ensuring that the data included in the CE and CC analysis datasets are informative and of high-quality by (a) eliminating duplicate records; (b) removing variables with high proportions of missing values which may limit the statistical power of the analysis (i.e. variables with more than 50% of their values missing); and (c) discarding variables that based on their frequency distribution are expected to perform poorly in differentiating between units of analysis (i.e. variables where the modal code has a frequency greater than 95%). At the same time, the data was inspected for outliers that could indicate potential data-quality issues.
- A **variable-transformation** element, whereby new variables were derived based on variables in the original data sources (i.e. the NPD; the SWC; the ILR, and Edubase), where this was deemed as necessary. This process aimed to generate data-points that are more appropriate for the purposes of the analysis and involved (a) the computation of new categorical variables by combining codes of the original categorical variables together; and (b) the computation of new continuous variables by applying scaling transformations on original continuous variables (such as centring around their mean value).

5.1.2 Selecting CE and CC modelling variables

Constructing the CE and CC models involved a systematic variable-selection process. The objective of this process was to distinguish between two tiers of variables: (a) those that are likely to be relevant to pupils' choices regarding computing at KS4 or KS5 and (b) those that are not. The first tier of variables was subsequently included in the proposed substantive CE and CC models, while the second tier was excluded. Including relevant variables in the modelling process is important in order to analytically account for the theoretically interesting factors that potentially shape the outcomes that the analysis intends to study. At the same time, excluding non-relevant variables from the modelling process mitigates the risk of over-fitting, i.e. the risk of proposing substantive models that are specific to the particular datasets used for the analysis, rather than models that are descriptive of the mechanism that underlies the outcomes we intend to study in the wider pupil-populations of interest (see paragraph 5.1.1).

The relevance of variables in the CE and CC analysis datasets with regard to the outcomes that interest the CE and CC models (i.e. whether pupils enter computing at KS4 or whether they continue with computing at KS5, respectively), was determined by means of bivariate and multivariate techniques:

- **Bivariate techniques** examined each of the outcomes of interest against individual variables in the CE and CC analysis datasets. By assessing measures of statistical dependency and correlation, bivariate techniques highlighted variables with strong links to the outcomes of interest. Through this process, we identified *disjoint* two-dimensional data-spaces within the CE and CC analysis datasets, where it is potentially interesting to explore the distribution of the outcomes that interest the analyst.
- Selecting variables for the CE and CC models solely on the basis of bivariate analysis risks overlooking theoretically interesting variables, when their relationship to the outcomes of interest is not immediately obvious. For example, variable X may appear unrelated to the outcome variable Y; however, an interesting relationship may emerge within a sub-space of the analysis data-space defined by a third variable Z. To ensure that the variable-selection process does not exclude potentially interesting variables from the proposed substantive CE and CC models, bivariate variable-selection techniques were complemented with a **multivariate approach.** Schematically speaking, the multivariate approach controlled for an extensive mix of variables in the CE and CC analysis datasets *simultaneously* to identify variables that have a statistically significant "predictive value" in relation to the outcomes of interest. To determine this "predictive value", the analysis employed one-level logistic regression models that eliminated non-relevant variables based on a pre-defined algorithm[6].

The set of variables selected from the CE and CC datasets based on bivariate and multivariate statistical criteria was further reviewed using expert knowledge in the domain of computing in secondary education. This process aimed to ensure that key variables of theoretical interest have not been omitted from the scope of the modelling exercise. The final mix of variables used in the CE and CC models is presented in Table 5.1, below. Appendix 1 presents the complete list of variables that the analysis considered (some of which were eliminated by the bivariate and multivariate variable-selection techniques described just above).

[6] The algorithm used employs a statistical criterion based on the probability of the likelihood-ratio statistic and the maximum partial likelihood estimates.

Table 5.1: Variables in the computing entry (CE) and the computing continuation (CC) models

Variables in the CE model	Variables in the CC model
Gender	Gender
Ethnic background	Ethnic background
Special education needs (SEN)	Total GCSE (and equivalents) score
First language	Attainment in KS4 Computing
Total GCSE (and equivalents) score	Attainment in KS4 Maths
Attainment in KS4 Maths	School type
Quintiles of the number of KS4 pupils in school	Deciles of the Income Deprivation Affecting Children Index (IDACI) for pupils' school postcode
Gender of school admissions	Region where pupil's school is
Quintiles of percentage of pupils who are white British in school	
Percentage of pupils whose first language is other than English	
Percentage of pupils recorded as eligible for free school meals	
Percentage of pupils achieving at least 5 GCSE's A star to C	
Percentage of pupils with special education needs (SEN) in school	
Deciles of the Income Deprivation Affecting Children Index (IDACI) for pupils' school postcode	
Region where pupil's school is	
Urbanisation level where pupil's school is	
Number of teachers at pupil's school known to have computing qualification(s)[7]	

5.1.3 Fitting the substantive CE and CC models

Having selected the sets of variables that should feature in the CE and CC models (see paragraph 5.1.2), the analysis proceeded with fitting the substantive model specifications using a *multilevel binary logistic regression* mechanism. This particular modelling mechanism accounts for the hierarchical structure of the CE and CC analysis datasets, whereby individual pupils (level 1) are nested within schools (level 2). It therefore acknowledges that (a) pupils in the same school are likely to be (collectively) more similar than pupils in different schools; and (b) the relationship between the outcomes of interest (i.e. whether pupils enter computing at KS4 or whether they continue with computing at KS5) and the variables featuring in the CE and CC models may vary between different schools.

[7] Information about teachers' qualification is provided by the School Workforce Census (SWC). The SWC describes teachers' qualifications using the Joint Academic Council's code-set of principal subjects. This can be accessed at https://www.hesa.ac.uk/support/documentation/jacs. The list of computing qualifications comprises: computational science foundations; computer architectures; computer architectures & operating systems; computer science; computer vision; computing science not elsewhere classified; human-computer interaction; mathematical and computing sciences not elsewhere classified; multi-media computing science; neural computing; other computing sciences; other mathematical and computing Sciences.

To fit the substantive CE and CC models, each of the CE and CC analysis datasets was partitioned into two *randomly selected, non-overlapping* subsets:

- The *training CE and CC datasets*, which comprised 80% of records in the complete CE and CC analysis datasets, respectively; and
- The *testing CE and CC datasets*, which comprised the remainder 20% of records in the complete CE and CC analysis datasets, respectively.

The substantive CE and CC (multilevel binary logistic) models were initially fitted upon the training datasets and the modelling outputs were inspected. Then, the CE and CC models were fitted upon the testing datasets and these modelling outputs were compared against the outputs from models fitted upon the training datasets. The motivation for this comparison was to assess if the substantive CE and CC models generate comparable, non-contradictory insights when fitted upon different datasets, which represent the same pupil populations[8].

The comparisons confirmed that the substantive CE and CC models were "stable" when fitted on different datasets representing the same pupil population, suggesting that the proposed CE and CC model specifications should be expected to generalise well to the wider pupil populations they intend to describe (see paragraph 5.1.1).

Once the stability of the substantive CE and CC models was confirmed, the models were re-fitted to the complete CE and CC analysis datasets. A final inspection of the model outputs ensured that insights derived based on the complete CE and CC analysis datasets align to the insights derived based on the training and testing subsets. The final outputs from the CE and CC models are presented in paragraph 5.2.

5.2 The outputs of the CE and CC models

This paragraph presents the statistical outputs from the proposed substantive CE and CC models, which respectively aim to help us understand the determinants of entering computing education at KS4 and the determinants of continuing computing education at KS5 (for pupils who have entered it KS4). The CE and CC models are summarised in Tables 5.2.1 and 5.2.2, respectively, which present key statistics yielded by the modelling process (while a reflection on the model outputs and their implications is then provided in paragraph 1.3)[9].

Tables 5.2 and 5.3 present the following statistics:

[8] If a substantive model produces contradictory insights when applied to different datasets that represent the same population, concerns should be raised with regard to the generalisability of the model. In such cases, it is likely that the substantive model has been *over-fitted* to the training dataset. It is therefore necessary to revisit the model specification and re-think the mix of variables to include in the model.

[9] Using the McFadden approach, the analysis calculated pseudo R-squared metrics for the substantive CE and CC models (5.4% and 3.6%, respectively). Effectively, this provides a quantification of the outcome variability that is explained by the substantive CE and CC models. However, we note that the usefulness of pseudo R-squared metrics is open to debate amongst data users, with concerns being raised regarding the extent to which these are intuitively interpretable in relation to non-linear outcomes (such as the binary outcomes modelled in this study). For a brief review of pseudo R-squared metrics, see: Tabachnick, B. G; & Fidell, L. S. (2007). *Using Multivariate Statistics*. Boston: Pearson / Allyn & Bacon.

- **Odds ratios and coefficients**. These statistics quantify the relationship between a variable and the outcome of interest. They are mathematically equivalent, as the odds ratio is equal to Euler's e (c.2.718) in the power of the coefficient. Both metrics are presented in the tables, as some readers may find one statistic more intuitive than the other.

Odds ratios greater than 1 (or coefficients greater than 0) suggest a positive relationship between the outcome and the variable. Odds ratios smaller than 1 (or coefficients smaller than 0) suggest a negative relationship between the outcome and the variable.

Odds ratios (i.e. exponentiated coefficients) quantify the *change in the odds* of observing the outcome, given a change in the predictor variable by one unit (when we consider numeric variables, such as the total GCSE and equivalents score) or given a shift from a reference category to a different category (when we consider categorical variables, such as gender). The odds represent the ratio of the probability of the outcome occurring to the probability of the outcome not occurring.

For example, if the odds ratio of variable X for the outcome Y is 1.5, we infer that an increase in X by one unit (if X is numeric) or a shift from the reference category to a different category (if X is categorical) means an increase in Y. We also infer than given this change in X, the odds of Y occurring are expected to increase by a factor of 1.5.

- **Standard errors of the coefficients**. These statistics help quantify the statistical uncertainty regarding the "true" magnitude of the coefficients. The uncertainty stems from the fact that the coefficients have been computed based on data from particular cross-sections of the pupil-population of interest; cross-sections, which can be deemed as representative of *wider* pupil populations of interest (see paragraph 5.1.1). The uncertainty here, therefore, reflects the fact that the analysis may have yielded different coefficients, if a different cross-section of the wider population of interest had been used.

- **The p-values**, quantify the probability of inferring that a certain relationship between a variable and the outcome occurs in the analysis datasets, if this *actually* does not occur (within the wider pupil population of interest that the analysis datasets represent). Where p-values are below the (conventionally accepted) threshold of 0.05, we infer that a certain relationship (between a variable and the outcome) has a negligibly small probability of being observed by chance if it were not real. The relationship is therefore deemed as statistically significant and can be seen as likely to generalise more widely.

- Finally, **the lower and upper bounds of a coefficient's 95% confidence interval** represent a range of plausible values that can quantify the strength of a relationship between a variable and the outcome of interest. If this range includes both positive and negative values, then there is uncertainty about the direction of the effect (i.e. whether a certain change in the predictor corresponds to an increase or a decrease in the outcome).

Table 5.2: CE model output (outcome: uptake of GCSE computing amongst pupils at schools where the subject is offered; specification: multilevel model; base: 248,145 pupil records from 1,296 school clusters)

Variable	Category label vs. reference category label (for categorical variables)	Odds Ratio	Coefficient	Standard error of coefficient	p-value	Coefficient lower bound of 95% Confidence Interval	Coefficient upper bound of 95% Confidence Interval
Gender	Male [vs. female]	8.847	2.180	0.019	0.000	2.143	2.218
Ethnic background	Mixed [vs. white including missing ethnic background]	0.995	-0.005	0.035	0.877	-0.074	0.063
	Black [vs. white including missing ethnic background]	0.852	-0.160	0.040	0.000	-0.238	-0.083
	Asian [vs. white including missing ethnic background]	1.375	0.319	0.031	0.000	0.257	0.380
	Chinese [vs. white including missing ethnic background]	1.547	0.437	0.084	0.000	0.272	0.601
	Other [vs. white including missing ethnic background]	1.110	0.104	0.060	0.085	-0.014	0.222
Special education needs (SEN)	SEN identified [vs. no SEN identified]	1.004	0.004	0.040	0.920	-0.075	0.083
First language	Other than English [vs. English including unspecified]	1.067	0.065	0.027	0.016	0.012	0.118
Total GCSE (and equivalents) score		1.003	0.003	0.000	0.000	0.002	0.003
Attainment in KS4 Maths		1.362	0.309	0.008	0.000	0.293	0.325
Quintiles of the number of KS4 pupils in school	Second quintile [vs. first quintile]	0.882	-0.126	0.066	0.056	-0.256	0.003
	Third quintile [vs. first quintile]	0.811	-0.210	0.071	0.003	-0.349	-0.070
	Fourth quintile [vs. first quintile]	0.674	-0.395	0.075	0.000	-0.542	-0.247
	Fifth quintile [vs. first quintile]	0.701	-0.355	0.082	0.000	-0.516	-0.195
Gender of school admissions	Single-sex school [vs. mixed school]	1.290	0.254	0.085	0.003	0.087	0.421
Quintiles of percentage of pupils who are white British in school	First quintile [vs. fifth quintile]	1.055	0.054	0.134	0.690	-0.210	0.317

	Second quintile [vs. fifth quintile]	0.947	-0.055	0.087	0.531	-0.226	0.116
	Third quintile [vs. fifth quintile]	1.067	0.064	0.079	0.413	-0.090	0.219
	Fourth quintile [vs. fifth quintile]	0.992	-0.008	0.076	0.912	-0.157	0.140
Percentage of pupils whose first language is other than English		0.999	-0.001	0.002	0.725	-0.006	0.004
Percentage of pupils recorded as eligible for free school meals		1.002	0.002	0.004	0.670	-0.006	0.010
Percentage of pupils achieving at least 5 GCSE's A star to C		0.305	-1.187	0.183	0.000	-1.547	-0.828
Percentage of pupils with special education needs (SEN) in school		0.256	-1.361	1.439	0.344	-4.182	1.460
Deciles of the Income Deprivation Affecting Children Index (IDACI) for pupils' school postcode		0.986	-0.014	0.009	0.124	-0.033	0.004
Region where pupil's school is	South East [vs. London]	1.287	0.252	0.112	0.025	0.032	0.472
	South West [vs. London]	1.161	0.149	0.123	0.224	-0.092	0.390
	East of England [vs. London]	1.040	0.039	0.117	0.738	-0.191	0.269
	East Midlands [vs. London]	1.327	0.283	0.122	0.021	0.043	0.522
	West Midlands [vs. London]	1.318	0.276	0.111	0.013	0.058	0.494
	Yorkshire and the Humber [vs. London]	1.233	0.210	0.114	0.065	-0.013	0.432
	North East [vs. London]	1.147	0.137	0.151	0.364	-0.159	0.434
	North West [vs. London]	1.239	0.214	0.109	0.049	0.001	0.427
Urbanisation level where pupil's school is	Urban - city or town [vs. rural]	0.973	-0.027	0.079	0.732	-0.181	0.127
	Urban - major	0.982	-0.018	0.097	0.853	-0.209	0.173

	conurbation [vs. rural]						
Number of teachers at pupil's school known to have computing qualification(s)		1.064	0.062	0.020	0.001	0.024	0.101
Constant		0.004	-5.611	0.161	0.000	-5.926	-5.296

Table 5.3: CC model output (outcome: uptake of A level computing amongst pupils who completed GCSE computing; specification: multilevel model; base: 14,679 pupil records from 1,201 school clusters)

Variable	Category label vs. reference category label (for categorical variables)	Odds Ratio	Coefficient	Standard error of coefficient	p-value	Coefficient lower bound of 95% Confidence Interval	Coefficient upper bound of 95% Confidence Interval
Gender	Male [vs. female]	2.897	1.064	0.111	0.000	0.847	1.280
Ethnic background	Mixed [vs. white including missing ethnic background]	0.903	-0.102	0.141	0.472	-0.378	0.175
	Black [vs. white including missing ethnic background]	0.590	-0.527	0.185	0.004	-0.890	-0.164
	Asian [vs. white including missing ethnic background]	0.486	-0.721	0.114	0.000	-0.944	-0.499
	Chinese [vs. white including missing ethnic background]	0.619	-0.480	0.275	0.081	-1.020	0.060
	Other [vs. white including missing ethnic background]	0.818	-0.201	0.235	0.392	-0.662	0.260
Total GCSE (and equivalents) score		0.996	-0.004	0.000	0.000	-0.005	-0.004
Attainment in KS4 Computing		2.692	0.990	0.036	0.000	0.919	1.061
Attainment in KS4 Maths		1.178	0.164	0.038	0.000	0.089	0.239
School type	Selective or independent school [vs. comprehensive, modern, other maintained school]	0.738	-0.304	0.168	0.071	-0.634	0.026
	Sixth-form college [vs. comprehensive, modern, other maintained school]	1.216	0.195	0.166	0.239	-0.130	0.520
	Other Further Education	0.307	-1.181	0.199	0.000	-1.571	-0.792

	(FE) college [vs. comprehensive, modern, other maintained school]						
Deciles of the Income Deprivation Affecting Children Index (IDACI) for pupils' school postcode		1.041	0.040	0.017	0.017	0.007	0.073
Region where pupil's school is	South East [vs. London]	1.149	0.139	0.225	0.539	-0.303	0.581
	South West [vs. London]	1.110	0.104	0.250	0.677	-0.386	0.594
	East of England [vs. London]	0.988	-0.012	0.243	0.960	-0.489	0.465
	East Midlands [vs. London]	0.947	-0.055	0.254	0.829	-0.553	0.444
	West Midlands [vs. London]	0.998	-0.002	0.229	0.995	-0.451	0.448
	Yorkshire and the Humber [vs. London]	0.485	-0.723	0.255	0.005	-1.223	-0.223
	North East [vs. London]	0.760	-0.274	0.299	0.359	-0.860	0.312
	North West [vs. London]	1.106	0.101	0.217	0.643	-0.325	0.526
Urbanisation level where pupil's school is	Urban - city or town [vs. rural]	0.979	-0.021	0.147	0.886	-0.309	0.267
	Urban - major conurbation [vs. rural]	0.951	-0.051	0.187	0.786	-0.416	0.315
Constant		0.000	-10.180	0.403	0.000	-10.970	-9.391

5.3 Reflection on the outcomes of the CE and CC models

Here, we discuss key insights derived based on the CE and CC models, using contextual information where helpful. For a description of the statistical concept of *odds* (which is frequently quoted in this paragraph), see paragraph 5.2.

5.3.1 Pupil-level characteristics

Gender

A pupil's gender is very strongly associated with both uptake of computing at KS4 (see CE model) and continuation of the subject at KS5 (see CC model). After controlling for other factors, male pupils have almost nine times the odds of female pupils of studying GCSE computing (CE model). This is a far stronger effect than seen for any other variable in the CE model. Male pupils also have almost three times the odds of female pupils of continuing with computing at KS5

(CC model). This is a broadly similar strength effect to a pupil's GCSE computing grade; in other words, the effect of gender on continuation at KS5 appears to be roughly equivalent to achieving an extra grade in computing at KS4 after controlling for other factors.

The two models underline the very heavy influence of gender in computing education, especially concerning uptake at KS4. Taken together, the two models show that not only are male pupils much more likely than female pupils to study GCSE computing, this gender gap then worsens for A level computing, even after controlling for other factors.

Ethnicity

After controlling for other factors, Asian and Chinese pupils were significantly more likely than white pupils to study GCSE computing, while Black pupils were significantly less likely than white pupils to take the subject (CE model). Black pupils were also less likely than white pupils to continue with computing at Key Stage 5 (CC model).

Despite having higher levels of uptake at KS4, Asian pupils had lower levels of continuation to KS5 computing than white pupils, after controlling for other factors (CC model). Previous research has shown that Asian pupils are on average more likely to take A levels than white pupils[10]. In particular, Asian pupils are more likely to study subjects such as chemistry, biology and mathematics at A level (see Table 5.4). This in turn is related to the fact that Asian pupils are more likely to go on to study subjects such as medicine at university (see Table 5.5). The lower continuation levels in computing for Asian pupils may therefore be partly due to pupils positively making decisions about their future plans and career routes which they feel do not require further computing qualifications.

Nonetheless, within the broader question of higher education, there is a concern that computing is not sufficiently valued as a subject for making university applications – for example, it is not considered a facilitating subject by Russell Group universities. Persuading pupils, schools/colleges and higher education institutions of the value of computing for making higher education applications – regardless of the subject being applied for – could help encourage pupils from all backgrounds to choose to continue with the subject.

Table 5.4: A level subjects taken by major ethnic group (base: KS5 pupils in year 12 and year 13 in 2014-15)

	White	Mixed	Black	Asian	Chinese	Other
Maths	79,562	5,077	5,428	18,224	2,413	2,153
	12.7%	15.1%	12.0%	21.7%	49.8%	19.6%
Biology	57,822	3,752	4,573	15,049	947	1,648
	9.2%	11.1%	10.1%	17.9%	19.6%	15.0%
Chemistry	42,762	3,112	4,396	14,716	1,205	1,608
	6.8%	9.2%	9.7%	17.5%	24.9%	14.6%
Physics	35,189	2,036	1,555	5,138	860	671
	5.6%	6.0%	3.4%	6.1%	17.8%	6.1%
Computing	7,082	357	288	869	135	99
	1.1%	1.1%	0.6%	1.0%	2.8%	0.9%

[10] Social and ethnic inequalities in choice available and choices made at age 16 (*Allen et al. 2016*)

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/574708/SMC_social_and_ethnic_inequalities_in_post_16_report.pdf

Total	626,639	33,693	45,260	84,102	4,842	11,010

Table 5.5: Full-time HE student enrolments by ethnicity 2015/16[11] (base: full-person equivalent of UK-domiciled HE student enrolments in 2015-16)

Course involves…	White	Black	Asian	Other	Unknown ethnicity
Business and administrative studies	91,680 10.0%	15,280 17.9%	24,005 17.6%	8,310 11.5%	1,285 10.0%
Medicine / Dentistry	25,790 2.8%	1,275 1.5%	9,815 7.2%	2,675 3.7%	475 3.7%
Subjects allied to medicine	100,390 11.0%	14,855 17.4%	18,585 13.6%	5,990 8.3%	1,015 7.9%
Computer sciences	39,705 4.3%	4,195 4.9%	9,310 6.8%	2,890 4.0%	545 4.2%
Creative arts and design	104,030 11.4%	5,625 6.6%	5,335 3.9%	7,140 9.8%	940 7.3%
Total	915,030	85,275	136,585	65,410	9,755

Attainment

Although overall KS4 attainment[12] had a significant positive association with uptake of GCSE computing, the effect of this is very weak after controlling for other factors (CE model). Instead, pupils' GCSE mathematics grades were more strongly associated with uptake of GCSE computing: an additional grade at GCSE mathematics was associated with an increase of 1.4 times the odds of studying GCSE computing.

A pupil's GCSE mathematics grade was also positively associated with continuation of computing study at KS5 (CC model). In this case, an additional grade was associated with an increase of 1.2 times the odds of continuing with computing.

There thus appears to be a clear relationship with more mathematically able pupils being more likely to study GCSE computing and more likely to continue with the subject at KS5. In the case of continuation to KS5, the relationship between studying computing and mathematics attainment holds even after controlling for a pupil's computing attainment at GCSE[13].

[11] HESA statistical first release SFR242, Jan. 2017
https://www.hesa.ac.uk/news/12-01-2017/sfr242-student-enrolments-and-qualifications

[12] We conceptualise overall KS4 attainment and GCSE mathematics grade as proxies for pupils' general academic ability and mathematical ability at age 14 when pupils choose their GCSE courses.

[13] A pupil's GCSE computing grade was strongly associated with likelihood to continue with the subject at A level, each grade at GCSE being associated with an increase of 2.7 times the odds of studying computing A level. This relationship is to be expected as pupils will generally prioritise continuing with their strongest subjects at A level.

After controlling for other factors, there was a small significant negative association between overall attainment at KS4 and continuation at KS5; that is, pupils with higher attainment in their GCSEs were less likely to continue with computing at KS5 (CC model). It should be stressed that, although statistically significant, the effect of this is very small. Given that pupils' attainment in computing and maths are controlled for separately, this may simply be reflective of more able pupils prioritising subjects other than computing which they consider more relevant for their own future study and career plans.

5.3.2 School/college level characteristics

Given the differences in school/college characteristics between the two models, we discuss first, school level characteristics associated with uptake of GCSE computing; second, school/college level characteristics associated with continuation of computing study at KS5. Finally, we discuss regional variation in in both uptake and continuation.

Uptake of GCSE computing: Attainment

After controlling for other factors, school level attainment was negatively associated with uptake of computing at KS4. It is important to remember that individual attainment is also controlled for within the model. In other words, if there were two equally able pupils, identical in every regard apart from the school they attended, the pupil at a school with lower general levels of attainment would be more likely to study computing at KS4.

One possible explanation is that higher performing schools may be encouraging their pupils to prioritise other subjects that may be considered more useful for continuing on to higher education. If this is the case, there is an important challenge to persuade pupils, schools and higher education institutions of the value of the computing GCSE.

Uptake of GCSE computing: Size of school

Size of school was negatively associated with uptake of computing; after controlling for other factors, pupils in smaller schools were more likely to study GCSE computing than pupils in larger schools.

Again, it is important to remember that the model is concerned with uptake within schools where at least one pupil took GCSE computing. Considering all schools, we note that the smallest schools were less likely to enter any pupils for computing GCSE (see paragraph 2.1)[14]. There thus remains a challenge to support the smallest schools in offering GCSE computing.

Uptake of GCSE computing: Gender mix

There was a positive association between uptake of GCSE computing and attending a single sex school; pupils at single sex schools had 1.3 times the odds of pupils at mixed schools of studying GCSE computing.

Looking at pupils' gender within mixed and single sex schools (Table 5.6), there appears to be a particularly strong influence of a single sex environment on female pupils: uptake of GCSE computing among female pupils was 12% at single sex schools where at least one pupil took the subject, compared with only 3% at mixed schools. Girls at single sex schools will have quite a different experience of computing to girls at mixed schools, for whom the vast majority of their classmates are likely to be male. This kind of difference in learning environment could be helping to reduce the substantial gender-related barriers to uptake for female pupils.

[14] See also The Roehampton annual computing education report: 2015 data from England (Kemp, Wong and Berry 2016)
https://www.researchgate.net/publication/311595274_The_Roehampton_Annual_Computing_Education_Report_2015_data_from_England

Table 5.6: Uptake of GCSE computing within schools where at least one pupil completed GCSE computing
(base: KS4 pupils in year 11 at schools where at least one pupil completed GCSE computing in 2014-15)

	Male pupils		Female pupils	
	Boys schools	Mixed schools	Girls schools	Mixed schools
Uptake of GCSE computing	2,735 21.5%	23,307 19.8%	1,259 12.3%	3,774 3.4%
Total	12,740	117,898	10,274	109,626

Uptake of GCSE computing: Teachers with a computing qualification

The number of teachers with a computing qualification was positively associated with uptake of GCSE computing. This finding is particularly important in light of the difficulties in recruiting computing teachers. Each additional teacher with a computing qualification was associated with an increase of 1.1 times the odds of studying GCSE computing.

Uptake of GCSE computing: Deprivation and SEN

It is notable that measures of deprivation – IDACI rank, eligibility for free school meals, percentage of pupils in the school eligible for free school meals – do not appear to have a significant association with uptake of GCSE computing, after controlling for other factors. In addition, a statistically significant association between uptake and SEN status was not detected either at the pupil level (whether the individual has an identified SEN or learning disability) or at the school level (the percentage of pupils in the school with an identified SEN or learning disability).

It appears then the main barrier to access for these groups may be schools failing to offer computing in the first place. Within schools where at least one pupil studies GCSE computing these factors do not appear to have a significant impact on uptake, after controlling for other pupil-level and school-level characteristics.

Continuation of pupils to A level computing: Institution type and deprivation

Aside from region (discussed below), two school/college level variables had a significant association with continuation of computing at KS5. First, institution type was significantly associated, with pupils who completed GCSE computing and then studying at Further Education colleges much less likely to continue to KS5. This reflects the fact that pupils at FE colleges are less likely to study A levels and more likely to take other kinds of courses. This variable is therefore controlling for the different educational paths pupils take after KS4.

Second, deprivation as measured by IDACI was also significantly associated with continuation; pupils in less deprived areas were more likely to continue with computing at KS5.

Regional variation

There is some regional disparity in uptake of computing with pupils in the South East, East Midlands, West Midlands and North West more likely to study GCSE computing than pupils in London, after controlling for other factors.

In terms of continuation of computing study at KS5, geographic region generally has little impact after controlling for other factors, although continuation is notably lower in Yorkshire and the Humber.

Appendix 1 – The complete list of variables considered by the analysis conducted at Strand 3

Table A1 presents the complete list of variables that the CE and CC modelling process considered. Some of the variables presented in Table A1 were not used in the final substantive CE and CC models; they were eliminated based on the bivariate and multivariate variable-selection processes described in paragraph 5.1.2.

Table A1: Complete list of variables considered for the computing entry (CE) and the computing continuation (CC) models

Complete list of variables considered for the CE model	Complete list of variables considered for the CC model
Attainment at KS4 Maths	Attainment at KS4 Computing
Eligibility for free school meals	Attainment at KS4 Maths
Ethnic background	Eligibility for free school meals
Language	Ethnic background
Number of GCSE entries	Language
Special education needs (SEN)	Special education needs (SEN)
Gender	Gender
Total GCSE (and equivalents) point score	Total GCSE (and equivalents) point score
Gender of school admissions	Deciles of the Income Deprivation Affecting Children Index (IDACI) for pupils' school postcode
Deciles of the Income Deprivation Affecting Children Index (IDACI) for pupils' school postcode	Gender of school admissions
Number of KS4 pupils in school	Number of KS5 pupils in school
Number of teachers in school known to have computing qualification	Percentage of KS4 pupils with Special Educational Needs (SEN) with a statement or Education, health and care (EHC) plan (at pupil's school)
Percentage of KS4 pupils with Special Educational Needs (SEN) with a statement or Education, health and care (EHC) plan (at pupil's school)	Percentage of pupils achieving at least 5 GCSEs at A*-C including English and Maths (at pupil's school)
Percentage of pupils achieving at least 5 GCSEs at A*-C including English and Maths (at pupil's school)	Percentage of pupils recorded as eligible for free school meals (at pupil's school)
Percentage of pupils recorded as eligible for free school meals (at pupil's school)	Percentage of pupils who are White British (at pupil's school)
Percentage of pupils who are White British (at pupil's school)	Percentage of pupils whose language group is 'other than English' (at pupil's school)
Percentage of pupils whose language group is 'other than English' (at pupil's school)	Region where pupil's school is
Region where pupil's school is	Urbanisation level where pupil's school is

Urbanisation level where pupil's school is	School Type
School type	
Whether pupil's school is a selective school	