The effect of specialism and attainment in secondary school on the choice of Higher Education institution and field of study

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Introduction

Progression from secondary to Higher Education (HE) has direct implications on wage returns and social mobility. The recent expansion of HE in the majority of European countries has highlighted that returns to HE are not just associated with the decision to study at university rather than enter the labour market, but also with the choice of studying in a particular field (Chevalier, 2011; Greenwood, Harrison & Vignoles, 2011) at a specific HE institution (Chevalier & Conlon, 2003; Hussain, McNally & Telhaj, 2009; Walker & Zhu, 2013). Because the process of application and admission to universities in the United Kingdom (UK) places a strong weight on attainment, both overall and in specific subjects, the educational background of students is a key factor influencing progression from secondary education to specific fields of study and HE institutions (Vidal Rodeiro, Sutch & Zanini, 2015).

The aim of this article is to provide evidence about the relationship between educational background, measured by subject choice and attainment in the final years of secondary education, and HE participation in terms of institution attended and choice of the field of study, an area in which not much research has been carried out so far. This is a topic of particular interest especially in the United Kingdom (UK), where the HE sector is characterised by a vast subject offer and a substantial diversity among institutions. Most HE institutions are members of so-called 'mission groups', the most well-known and prestigious being the Russell Group of research-oriented universities, within which they share similar aims and practices.

General Certificate of Education (GCE) Advanced levels (A levels) are the most common qualification taken by 18 year olds in England, and are available in a wide variety of academic and applied subjects. Most students take A levels in three subjects (Gill, 2012) and study them over a period of two years. Over recent years the importance of subject choice at A level in preparing students for HE has been highlighted. Fazackerly and Chant (2008) drew attention to the disparity in the attitudes of HE admissions staff towards certain A level subjects, by showing the gulf in uptake of these subjects among students at prestigious HE institutions, compared to the national uptake. Individual institutions maintained their own lists of undesirable 'soft' subjects, some of which were more open than others, and in 2011 the Russell Group published *Informed Choices* (Russell Group, 2011) in an attempt to unify and simplify the message for the benefit of prospective applicants. In it, they advised students to study at least two from a list of 'facilitating subjects', which would leave their options open for a variety of courses. However, they acknowledged that this advice would not apply to all students, and those who were definitely intending to study certain specialist courses such as Music would be best served otherwise. The concept of 'facilitating subjects' has gained traction with the Government, which since 2012 has included statistics in its school performance tables on the percentage of students achieving good grades in facilitating subjects at A level[1]. However, there is evidence that the attitudes of admissions staff at Russell Group universities towards various subjects are more mixed than *Informed Choices* might suggest (Candy, 2013). Outside the Russell Group, there is less information available to prospective applicants to guide subject choices. Although requirements for each university and course are available to applicants via the Universities and Colleges Admissions Service (UCAS) website and others, and many of these websites have provided general advice to students wishing to study specific subjects[2], the underlying data on entry requirements is not freely available. As such, students are heavily dependent on guidance from schools and others in order to make sense of their options at age 16.

The recent expansion and diversification of the HE sector has led to many questioning whether the growth has been evenly felt and access has become more equitable, or whether some students are disadvantaged because of their background. Accordingly, studies have been carried out on the effect of socio-economic status (e.g., Gayle, Berridge & Davies, 2002; Chowdry, Crawford, Dearden, Goodman & Vignoles, 2013), vocational qualifications (e.g., Hoelscher, Hayward, Ertl & Dunbar-Goddet, 2008) or school background (e.g., Sutton Trust, 2009; Crawford, 2014) on progression to HE and subject of study. In these, attainment at A level is typically used as a controlling factor but it is not the primary variable of interest. Perhaps surprisingly, there has been little focus on attainment at A level itself, except in certain subject-specific studies.

Progression to university is a matter of interest not just from a research point of view but also for students, HE institutions, awarding bodies and policy makers. A better understanding of how students' choices are influenced by their educational background at A level is important, especially in a time of change in the English educational system. This work examined how students' choice of A level subjects and attainment influence their HE destinations by answering the following research questions:

1. is there a systematic relationship between A level background and progression to specific types of HE institutions?;
2. is there a systematic relationship between A level background and progression to specific fields of study?

1. Available at http://www.education.gov.uk/schools/performance/
2. For example, http://university.which.co.uk/advice/what-a-levels-do-you-need-to-study-history

Data and methods

Data and variables

The data for the analyses was provided by the Higher Education Statistics Agency (HESA)[3] and covers all full-time, first year undergraduates aged 17–19, domiciled in England, studying at UK universities in the academic year 2011/12. The dataset includes information on the HE course studied at university as well as qualifications obtained prior to starting the course. The analyses were restricted to 181,190 students with at least 3 A level passes (excluding General Studies[4]), around 72 per cent of the entire cohort of full-time, first year undergraduates. Although this group may not be representative of the whole student body, focusing on this particular qualification enables the use of a comparable measure of prior attainment.

In this research, the HE institutions were considered in mission groups: Russell Group, 1994 Group[5], University Alliance and Million+, which are mutually exclusive. Universities that did not belong to any of these groups were included in a separate group, labelled as Other. The Russell Group consists of research-led institutions, which tend to be the most prestigious and generally have the most competitive admissions criteria. Some other 'top' universities were included in the 1994 Group. University Alliance and Million+ bring together most of the newest universities and colleges, with the former including the more status-conscious 'post-1992' institutions (Scott, 2013).[6]

For each student, information on up to three subjects of study and the subject percentage (i.e., the relative contribution of that subject to the university degree) was available in the data. The subject of study was then aggregated into 20 broad subject areas[7] and analyses were carried out at this level. It should be noted that the subject area relates to the principal subject of study. For degrees with more than one subject (e.g., joint honours) the subject area corresponds to the subject with the largest percentage. If a student took a balanced combination, or a triple honours degree in three different subject areas, then the subject area was 'Combined'.

A level subjects were categorised as one of the following (Bramley, 2014): *Applied, Expressive, Humanities, Languages, STEM* (Science, Technology, Engineering and Mathematics). Students were then assigned to specialisms based on the subjects they passed (at grades A*–E). For example, if a student took two A levels in Humanities subjects and one Expressive subject, they would be classed as a Humanities specialist. Some students did not specialise in a particular area (e.g., taking one A level in each of three categories), or specialised in several areas (taking two subjects in each of two or more categories), and we assigned these to *None* and *Multiple* respectively. The distribution of specialism is shown in Table 1.

Table 1: Number and percentage of students with different A level specialisms

		Number	*%*
A level specialism	None	22,515	12.4
	Applied	7,520	4.2
	Expressive	3,620	2.0
	Humanities	87,040	48.0
	Languages	2,380	1.3
	STEM	54,950	30.3
	Multiple	3,165	1.7
Average A level attainment	Grade C or above	151,210	83.5
	Grade A or above	37,930	20.9
Total		**181,190**	

For A level attainment, the following measures were used:

a. The average grade of a candidate's A level passes, excluding General Studies (assigning the grades nominal values of A*=7, A=6, B=5, C=4, D=3, E=2);

b. Two binary variables indicating whether the candidate's average grade (across all A level passes, excluding General Studies) was:
   - C or above;
   - A or above.

c. Three binary variables for each of the five A level subject categories (Applied, Expressive, Humanities, Languages, STEM) indicating whether the candidate's average grade in this category was:
   - E or above;
   - C or above;
   - A or above.

The variables within each of b) and c) are not mutually exclusive, so a candidate with an average of an A grade in a particular subject category would satisfy all three of the conditions in c), for example[8]. For subject categories in which students had not taken any A levels, the variables within c) would all be zero. The average A level grade, described above, takes a limited number of values in practice (although we have treated it as continuous in our modelling), because most students included in the research take three or four A levels. The most frequent average grade was B, and the majority of students scored between a C and an A on average. This is shown in Table 1 which gives the breakdown of the discrete overall attainment variables described in b) above.

Detailed student-level information such as gender, the LSOA[9] of the student's home address and a previous institution identifier was also available. Information about the type of the previous institution was obtained from the National Pupil Database (NPD)[10] and matched to the HESA data using the previous institution identifier. The following previous institution types were considered: comprehensive schools, academies, independent schools, selective schools, sixth form colleges, further education (FE) colleges and other/unknown.

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3. Source: HESA Student Record 2011/12. Copyright Higher Education Statistics Agency Limited 2012. HESA cannot accept responsibility for any inferences or conclusions derived from the data by third parties.
4. General Studies has been considered separately from other A levels in previous research and many universities do not include it in their offers.
5. The 1994 Group was disbanded in November 2013.
6. A full list of members and more detailed information about the scope and the practices of each group can be obtained from the groups' websites.
7. The university subject areas used are those defined by Version 2 of the Joint Academic Coding System (JACS). The subject group is denoted by the first letter in the JACS code.
8. Fails (grade U) could not be taken into account in calculating these attainment measures (to provide a correct denominator for the calculation of average grades) because they had previously been removed from the dataset. However, given that the analysis was restricted to those students with three A level passes (excluding General Studies) the effect of this should be minimal.
9. LSOA (Lower Layer Super Output Area) is a conglomeration of a number of census output areas (each output area has about 150 households). They usually have a minimum population size of 1,000 and an average of 1,500. There are over 34,000 LSOAs in England.
10. The National Pupil Database, compiled by the Department for Education (DfE), is a longitudinal database for all children in schools in England, linking student characteristics to school and college learning aims and attainment. The NPD holds pupil and school characteristics such as age, gender, ethnicity, level of deprivation, attendance and exclusions, matched to pupil level attainment data (Key Stage 2 to Key Stage 5 assessments and other external examinations).

A proxy for the students' socio-economic background was determined by the students' level of deprivation using the Income Deprivation Affecting Children Index (IDACI). This index, obtained from the Office for National Statistics, shows the percentage of children in the LSOA in which the student resides who live in families that are income deprived. We assigned students into one of three groups depending on the value of the IDACI index.

Methods

An assessment of the universities and subject areas in which different types of A level students are over- or under-represented can be made using the odds ratios derived from multilevel logistic regressions. The regression analyses allowed us to take into account students' background characteristics (e.g., gender, prior educational institution and socio-economic status) when looking at the probability of attending a specific university group or pursuing a specific course.

Multilevel models were proposed due to the hierarchical or clustered structure of the data (as students were grouped within schools). If this hierarchical structure were not recognised, then the standard errors of the regression coefficients would be underestimated, leading to an overstatement of the statistical significance. Detailed discussions of the implementation and outcomes of the multilevel logistic regression can be found in Goldstein (2011).

Two different specifications of multilevel logistic regression were considered. In the first (Model A) the dependent variable was the enrolment in a university group, whilst the dependent variable in the second (Model B) was pursuing a university course in a subject area. Separate models were fitted for each university group and course. Although the specifications of the regression models employed to study the two dependent variables were slightly different, in both models the explanatory variables included: gender, prior educational institution, socio-economic status, A level student category, and measures of attainment at A level.

The inclusion of these variables allowed us to control for several factors when investigating the type of university attended and the subject area studied by A level students. A detailed breakdown of the dependent and independent variables included in the regression models is presented in Table 2.

Table 2: Description of the variables included in the multilevel logistic regression models

Name	*Description*	*Range of values (Baseline value underlined)*	*Model*	
			A	*B*
DEPENDENT VARIABLES				
Candidate enrolled in a type of university	Indicator of university enrolment	Discrete variable: 0 was not enrolled at the university; 1 was enrolled at the university.	●	
Candidate pursuing a course in a subject area	Indicator of subject area uptake	Discrete variable: 0 did not take a course in the subject area; 1 took a course in the subject area.		●
INDEPENDENT VARIABLES				
Gender	Gender of the candidate	Discrete variable: <u>male</u>; female	●	●
Level of deprivation (IDACI)	Candidate level of deprivation based on the IDACI	Discrete variable: low, <u>average</u>, high	●	●
Centre type	Type of institution the candidate attended prior to university	Discrete variable: <u>comprehensive</u>; independent; academy; sixth form college; selective; FE college; other	●	●
Student category	A level subject specialism	Discrete variable: <u>None</u>; Applied; Expressive; Humanities; Languages; STEM; Multiple	●	●
University subject area	University subject area studied	Discrete variable: Architecture, Building and Planning; <u>Biological Sciences</u>; Business and Administrative Studies; Creative Arts and Design; Eastern, Asiatic, African, American and Australasian Languages, Literature and related subjects; Education; Engineering; European Languages, Literature and related subjects; Historical and Philosophical Studies; Law; Linguistics, Classics and related subjects; Mass Communications and Documentation; Mathematical and Computer Sciences; Medicine and Dentistry; Other/Combined; Physical Sciences; Social Studies; Subjects allied to Medicine; Technologies; Veterinary Sciences, Agriculture and related subjects	●	
A level score	Average grade across all A level subjects taken	(Quasi-) continuous variable: 2 represents an average of grade E; 7 represents an average of grade A*		●
Overall grade thresholds	Indicator of whether a candidate gained an average of C or above, an A or above, across all A levels	Two discrete variables: 1 if the student achieved an average A level grade greater than or equal to C/A; 0 otherwise	●	
A level specialism grade thresholds	Indicator of whether a candidate gained an average E or above (i.e., passed any A levels), a C or above, an A or above, in each of the five A level specialism categories	15 discrete variables: 1 if the student achieved an average A level grade greater than or equal to each threshold value in each A level specialism; 0 otherwise.		●

In modelling students' decisions to enrol at university we have assumed (following Maringe, 2006) that their choice of subject of study comes before their choice of institution; thus, we have allowed the university type to be influenced by the subject, but not vice versa.

The rationale for Model A is that university participation, in terms of the type of institution attended, might be expected to depend on a student's general academic ability and the subject area of study (as some subject areas are predominantly offered in certain university groups). A student's broad choice of A levels might also have an influence on the type of institution they attend, due to differing admission policies.

The rationale for Model B is that the subject studied at university might be expected to depend on a student's general academic ability, their broad choice of A levels, whether they have taken A levels in particular subject areas (represented by the 'E or above' dummy variables) and their A level grades in particular subject areas (represented by the 'C or above' and 'A or above' dummy variables).

Results of the estimated regression models are presented in the form of odds ratios for A level subject specialism and A level attainment[11].

Results

Descriptive analyses

Table 3 presents the destinations of A level students, in terms of HE mission groups, and shows a wide variation across specialisms at A level. Students who had specialised in Applied or Expressive subjects at A level were more likely to attend University Alliance or Million+ institutions. Linguists were particularly likely to go on to study at Russell Group universities (reflecting the concentration of Language degrees at these institutions), and those specialising in STEM or Multiple areas were also more likely than average to attend Russell Group universities. Humanities specialists were represented more evenly across all mission groups.

Table 3: University mission group by A level specialism (percentage of students in category)

A level specialism	*Russell Group*	*1994 Group*	*University Alliance*	*Million+*	*Other*
None	20.0	6.3	32.8	15.4	25.4
Applied	8.5	4.1	41.1	22.7	23.5
Expressive	8.5	4.4	36.3	18.4	32.4
Humanities	27.5	8.1	25.8	14.0	24.6
Languages	61.2	7.2	10.2	4.0	17.4
STEM	47.4	7.3	20.1	7.1	18.1
Multiple	54.2	7.9	14.4	6.5	17.0
All A level students	32.4	7.4	25.4	12.3	22.6

Students who had specialised in Expressive or STEM subjects at A level were most likely to have enrolled on a single honours degree, while linguists were much more likely than average to have gone on to study a joint honours course. Investigation of the joint honours courses (balanced and major/minor combinations) studied by Language specialists revealed that 94 per cent of these students took at least one Language subject in their degree, and 62 per cent of students took two Language subjects.

Table 4 shows the subjects that students with each A level specialism went on to study in HE. As might be expected, there is a strong relationship between A level subject choices and the subject area studied at university. For example, 63 per cent of students specialising in Expressive subjects at A level studied 'Creative Arts and Design' at university; likewise, 58 per cent of those specialising in Languages at

11. Odds ratios for the other independent variables are not reported as they are not the focus of the research, although they are available upon request. However, it is important to note that their inclusion in the regression models allows interpretation of the odds ratios for attainment and subject specialism accounting for their effect.

Table 4: University subject area by A level specialism (percentage of students in category)

University subject area	*A level specialism*							*All A level students*
	None	*Applied*	*Expressive*	*Humanities*	*Languages*	*STEM*	*Multiple*	
Architecture, Building and Planning	4.0	1.8	6.8	0.9	0.2	1.4	1.4	1.6
Biological Sciences	12.9	12.3	1.2	9.7	1.6	15.7	11.9	11.8
Business and Administrative Studies	17.5	40.5	4.8	8.3	4.4	3.9	6.0	9.3
Creative Arts and Design	13.8	2.4	63.3	8.7	2.7	1.5	5.8	7.8
Eastern, Asiatic, African, American and Australasian Languages, Literature and related subjects	0.3	0.0	0.0	0.6	2.2	0.1	0.5	0.4
Education	3.3	4.4	2.5	3.8	1.3	0.5	1.5	2.7
Engineering	2.5	1.5	3.3	0.4	0.2	14.3	3.0	5.0
European Languages, Literature and related subjects	3.0	0.1	0.2	1.1	57.5	0.3	7.4	1.9
Historical and Philosophical Studies	2.3	0.9	0.9	10.2	1.8	0.9	5.6	5.6
Law	4.1	9.3	0.2	6.6	2.8	1.2	6.2	4.6
Linguistics, Classics and related subjects	2.0	0.6	1.0	9.4	2.8	0.4	4.2	5.0
Mass Communications and Documentation	2.0	1.5	2.2	5.3	0.2	0.2	0.9	3.0
Mathematical and Computer Sciences	5.1	5.9	1.7	1.3	0.8	12.6	7.4	5.5
Medicine and Dentistry	0.0	0.0	0.0	0.0	0.0	8.3	2.6	2.6
Physical Sciences	3.6	1.1	0.4	2.8	0.8	14.8	6.6	6.5
Social Studies	7.3	6.4	1.1	14.2	3.6	3.5	11.9	9.3
Subjects allied to Medicine	5.3	3.5	1.0	2.8	0.9	12.0	4.4	5.9
Technologies	0.8	0.3	3.5	0.3	0.1	0.6	0.3	0.5
Veterinary Sciences, Agriculture and related subjects	1.3	0.7	0.6	0.5	0.1	2.0	0.4	1.1
Other/Combined	8.8	6.6	5.2	13.2	16.2	5.8	11.9	10.0

A level enrolled on degree courses in 'European Languages, Literature and related subjects'.

Students with multiple specialisms at A level were particularly well represented in 'Biological Sciences', 'European Languages, Literature and related subjects', 'Law', 'Mathematical and Computer Sciences', and 'Social Studies'. Students with no specialism, who had taken a mixture of subjects, were highly represented in 'Business and Administrative Studies' and 'Creative Arts and Design' courses at university.

A particularly strong association between A level subject choices and university subject area was found in 'Medicine and Dentistry'. While 8.3 per cent of STEM specialists, and 2.6 per cent of Multiple specialists went on to study a degree in this area, hardly any students from other specialisms did. This is because Medicine courses typically require Biology and Chemistry at A level, which would put students in the STEM category, or the Multiple category if they had taken more additional subjects to add breadth.

A surprising result at first glance is the high proportion of students in many categories going on to take courses in 'Biological Sciences'. This can be explained by the fact that, as well as Biology, this group includes courses in Psychology and Sports Science, and these subjects were classed as a Humanities and Applied subject respectively at A level.

Enrolment in type of university (Model A)

Table 5 presents the odds of attending each university group for the baseline case, alongside estimates of the odds ratios associated with the explanatory variables of interest: overall attainment and subject specialism at A level.

Looking first at the effect of overall attainment at A level, 9 out of 10 odds ratios were significant at the 5 per cent level, leading to the conclusion that, as expected, average attainment was a significant determinant of the institution group attended by students. The first column of odds ratios in Table 5 (alongside the baseline odds) relate to students graded C or above overall. With other conditions held fixed, students having an average attainment of grade C or above were much more likely to enrol in a Russell Group or 1994 Group university than students with an average attainment below grade C. The odds ratio for the Russell Group was particularly large, reflecting the low odds of students attending a university in this group with an average grade of below C at A level. Conversely, an average attainment above grade C reduced the likelihood of students attending HE institutions other than those in the Russell or 1994 mission groups.

The second column of odds ratios refers to students with an average grade at A level of A or above: these results should be interpreted as the odds ratios on top of those shown by the previous column, which referred to overall attainment of grade C or above. It is clear that students attaining an average grade of A or above were much more likely than students with grade C or above to attend a Russell Group university and less likely to enrol at universities in other groups; however, students with a grade A or above were still more likely than A level students in general to study at 1994 Group universities. For those students with an overall level of attainment above grade A, with respect to those below grade A, the likelihood of attending a University Alliance or Million+ institution was particularly low.

The remainder of Table 5 shows the odds ratios of the A level specialism category with respect to enrolment in each university group. In particular, specialising in STEM or Multiple areas greatly improved the likelihood of studying in a Russell Group university and reduced the chance of enrolling in other HE institutes. Students that had specialised in Humanities or Languages were also more likely to attend universities in the Russell Group, but the size of the association was smaller than in the former case. Conversely, students specialising in Applied and Expressive subjects at A level were less likely to attend Russell and 1994 Group universities. Finally, the likelihood of attending Million+ and University Alliance universities was higher for specialists in Applied and Expressive A level subjects than for those with no specialism.

Subject area at university (Model B)

Results from Model B are presented in Table 6 and Figure 1. Table 6 presents the odds associated with studying each subject area at university (for the baseline case) alongside odds ratios for each A level subject category in comparison to those with no specialism. Figure 1 shows the odds ratios for the achievement variables, both overall and in each A level subject category. In interpreting the results, two important dependencies should be borne in mind. Firstly, students specialising in a particular category must by definition have passed at least two A levels in this category, and so at least one of the odds ratios associated with A level attainment will also apply. For example, considering the odds of studying Historical and Philosophical Studies at university, the odds ratio associated with specialising in Humanities at A level is 1.95, but a further ratio from having an overall grade of at least an E in Humanities subjects, as shown in Figure 1, would also always be compounded. Secondly, there is a clear dependency of overall attainment on the individual subject

Table 5: Odds ratios for average A level attainment, and specialism category, in comparison to no specialism (Model A)

University Group	*Odds (intercept)*	*Odds ratios*							
		Average attainment at A level		*A level specialism category (with respect to no specialism)*					
		Grade C or above (with respect to all A level students)	*Grade A or above (with respect to 'C or above')*	*Applied*	*Expressive*	*Humanities*	*Languages*	*STEM*	*Multiple*
Russell Group	0.004	**37.81**	**7.92**	**0.67**	**0.61**	**1.12**	**1.47**	**2.19**	**2.75**
1994 Group	0.012	**7.98**	**0.77**	**0.77**	**0.82**	**1.08**	0.91	1.02	1.01
University Alliance	0.653	**0.87**	**0.10**	1.06	**1.14**	**0.89**	**0.63**	**0.69**	**0.54**
Million+	0.607	**0.24**	**0.11**	**1.11**	1.08	1.03	0.96	**0.64**	**0.64**
Other	0.366	0.97	**0.37**	**0.92**	0.98	1.00	1.00	**0.91**	**0.78**

Note: Significant estimates at the 5% level are presented in bold.

Table 6: Odds ratios for specialism category, in comparison to no specialism (Model B)

University subject area	*Odds (intercept)*	*Odds ratio for A level specialism category (with respect to no specialism)*					
		Applied	*Expressive*	*Humanities*	*Languages*	*STEM*	*Multiple*
Architecture, Building and Planning	0.015	**1.63**	**1.99**	1.11	**0.25**	0.92	1.24
Biological Sciences	0.093	1.04	**0.20**	**0.93**	**0.24**	**1.29**	1.05
Business and Administrative Studies	0.387	**3.04**	**0.74**	1.04	**0.76**	**0.56**	0.93
Creative Arts and Design	0.683	**0.29**	**2.24**	**0.58**	**0.28**	**0.19**	**0.71**
Eastern, Asiatic, African, American and Australasian Languages, Literature and related subjects	0.004	**0.13**	**0.00**	1.04	**1.72**	**0.14**	0.86
Education	0.284	**1.18**	**0.68**	0.93	0.73	**0.30**	0.75
Engineering	0.054	**0.66**	0.99	**0.38**	**0.17**	**4.58**	**1.67**
European Languages, Literature and related subjects	0.003	**0.17**	**0.17**	**0.44**	**4.39**	**0.15**	**1.48**
Historical and Philosophical Studies	0.002	**0.51**	**0.36**	**1.95**	**0.35**	**0.33**	1.01
Law	0.003	**2.17**	**0.29**	**2.16**	0.82	**0.69**	**2.15**
Linguistics, Classics and related subjects	0.000	**0.48**	**0.34**	**2.00**	**0.44**	**0.27**	0.96
Mass Communications and Documentation	0.374	**0.38**	**0.39**	**1.16**	**0.12**	**0.16**	**0.44**
Mathematical and Computer Sciences	0.023	**1.63**	0.88	**0.75**	**0.49**	**2.30**	**2.02**
Medicine and Dentistry	0.000	0.99	0.49	0.72	0.09	**49.54**	**15.59**
Physical Sciences	0.044	**0.39**	**0.17**	**0.81**	**0.29**	**1.95**	1.09
Social Studies	0.028	0.95	**0.29**	**1.48**	**0.46**	**0.49**	1.06
Subjects allied to Medicine	0.027	**0.77**	**0.40**	**0.63**	**0.35**	**2.12**	**0.88**
Technologies	0.091	**0.55**	**1.83**	**0.48**	0.38	0.99	0.67
Veterinary Sciences, Agriculture and related subjects	0.017	0.76	**0.55**	**0.53**	**0.28**	**1.38**	**0.41**
Other/Combined	0.069	**0.78**	**0.57**	**1.12**	**0.84**	**0.56**	0.93

Note: Significant estimates at the 5% level are presented in bold.

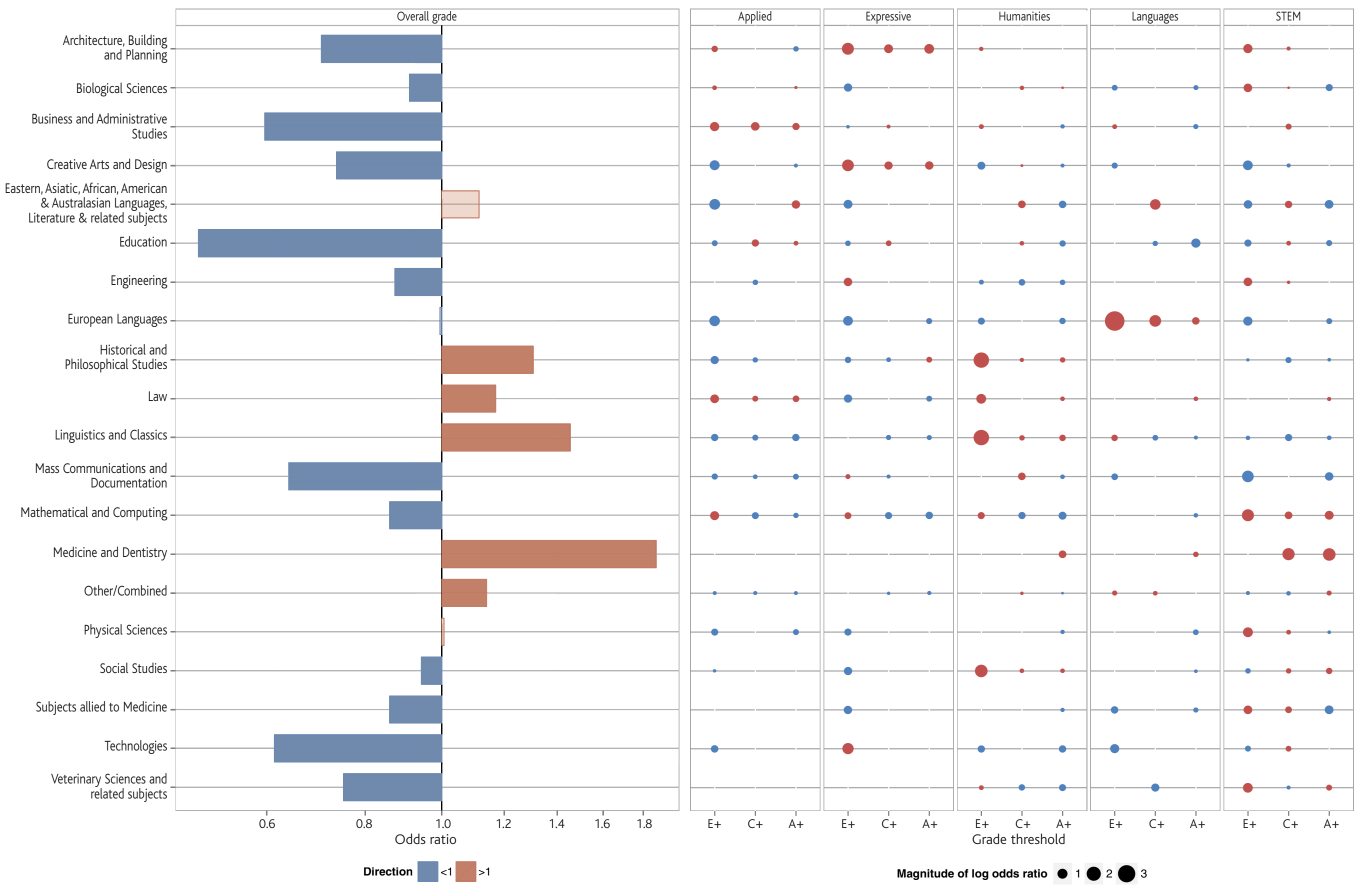

Figure 1: A level choice and attainment

category attainment variables: for a student gaining three A grades in Science subjects at A level, four odds ratios for attainment apply (overall grade and each of the binary variables relating to grades in STEM subjects), as well as STEM specialism. The breakdown of these odds ratios allows an assessment of the relative contribution from specialism and attainment.

The odds ratios in Table 6 show that subject choices at A level had a significant effect on the likelihood of studying in a particular subject area at university, even if students had not achieved very highly. For example, STEM specialists at A level were significantly more likely than average to study STEM subjects at university, and particularly 'Medicine and Dentistry'. Conversely, students who had specialised in Humanities subjects at A level were more likely to pursue courses in 'Historical and Philosophical Studies', 'Law', 'Linguistics, Classics and related subjects' and 'Social Studies'.

Students who specialised in Multiple areas at A level were significantly more likely to study 'Engineering', 'European Languages, Literature and related subjects', 'Law', 'Mathematical and Computer Sciences', and especially 'Medicine and Dentistry'. The Multiple specialists who went on to study 'Medicine and Dentistry' courses (of whom there were fewer than 100) were investigated: in most cases they studied two Humanities subjects as well as Biology and Chemistry. The most popular Humanities A levels taken by these students were History and English Literature.

Most university subject areas were associated with higher odds in only one A level specialism (with the addition of students with Multiple specialisms in some cases), but 'Architecture, Building and Planning', 'Law' and 'Mathematical and Computer Sciences' were associated with two individual specialisms. Interestingly these subject areas all span the vocational/academic divide, and the mix may reflect the variety of courses available in these subject areas.

Figure 1 presents the odds ratios associated with attainment, under Model B. The bars on the left show the effect of increasing the overall average A level grade by one (e.g., moving from an average of D to C, or B to A) on the chances of studying a particular course. A subject area with an odds ratio greater than 1 denotes that students with a higher average A level grade were more likely than average to study in this area. Subject areas associated with significantly higher than average A level grades were 'Medicine and Dentistry', 'Linguistics, Classics and related subjects', 'Historical and Philosophical Studies', 'Law' and 'Eastern, Asiatic, African, American and Australasian Languages, Literature and related subjects' as well as 'Other/Combined'.[12] 'Education', 'Business and Administrative Studies' and 'Technologies' (all of which are vocational areas) were associated with lower than average A level grades. Despite the concentration of 'European Languages, Literature and related subjects' courses in Russell Group universities which might be expected to have higher admissions criteria, there was no significant effect for overall A level score for this subject area. This may be because grades in particular A levels, such as Languages, were of more importance.

The circles on the right of Figure 1 show the odds ratios associated with achieving threshold grades in each of the five A level subject categories, for each university subject area. Only statistically significant odds ratios are shown. The 'E or above' values (denoted as 'E+' for brevity) represent the change in the odds associated with having an A level pass in that subject area (at any grade). As with the overall score dummy variables in Model A, the 'C or above' and 'A or above' values show the *extra effect* of having these grades, compared to the previous attainment category. For example, the odds of a student enrolling on an 'Architecture, Building and Planning' course at university were significantly greater if they had an A level in an Expressive subject (at any grade). Scoring an average of grade C or above in their Expressive subjects at A level was associated with a significant increase in the odds. Finally, scoring an average of grade A or above was associated with a further significant increase in the odds.

There was generally a correspondence between the university subject area and A level subject category in terms of the sensitivity to grade. For example, students were more likely to follow a course in 'Creative Arts and Design' if they achieved good grades in expressive subjects at A level, but those with A levels in other subject categories, especially at higher grades, were less likely to pursue a course in this area. However, in some university subject areas, there was an association with A level grades in several categories. These tended to be more vocational areas (such as 'Engineering' and 'Technologies'), where A levels may not be the primary route to these courses, and also for 'Eastern, Asiatic, African, American and Australasian Languages, Literature and related subjects' where students might not have studied directly relevant subjects at A level (and which might encompass a variety of subject areas).

As expected, the sensitivity to A level grade (as measured by the 'C or above' and 'A or above' odds ratios) was particularly marked for courses in 'Medicine and Dentistry', which are highly competitive, concentrated in Russell Group universities and have stringent entry requirements. While taking at least two STEM subjects (Table 6) gave rise to a higher probability of studying 'Medicine and Dentistry' at university, having an average A level grade in these subjects of at least an A increased the odds by a further factor of 22. The highest increase in odds was found for 'European Languages, Literature and related subjects' courses. While the baseline odds of studying in this area were low, having an A level in one or more Languages increased the odds by 47 times, and scoring an average of grade A or above in Language A levels increased the odds by a further factor of 7 to 330 times. Specialising in Languages, that is, taking at least two Languages at A level, resulted in a further factor of 4.39.

Conclusions and discussion

In the current educational climate, it is important to better understand how A levels are used by students to progress to HE. This research aimed to provide quantitative evidence to show how different subjects and students' attainment channelled learners in particular directions.

We considered HESA data gathered at individual level which covered all full-time, first year undergraduates aged 17–19, domiciled in England, studying at UK universities in the 2011/12 academic year. We further filtered the data to consider students with at least three A levels (181,190 students, 72 per cent of the whole cohort of undergraduates). Considering data on undergraduates does not allow us to study the determinants of the probability of progressing to HE, but enables us to focus on university participation in terms of institution attended and subject chosen for the students who did progress. Along with socio-demographic characteristics, the data used throughout the article included information on each student's qualifications prior to starting the course, the subject studied at university and the HE mission group of the institution the student attended.

12. The odds ratio for 'Eastern, Asiatic, African, American and Australasian Languages, Literature and related subjects' is greater than 1 but not statistically significant, hence it is not fully shaded in Figure 1.

Together with simple descriptive statistics which show the popularity of A level subject areas in relation to university participation, multilevel logistic regressions were employed to study the likelihood of students with different combinations of A levels to study in specific HE institutions and subjects, once students' characteristics had been accounted for.

Importance of subject choice

It has frequently been argued (e.g., Purcell et al., 2008; Fazackerly & Chant, 2008; Russell Group, 2011) that careful choice of subjects post-16 is crucial to avoid students inadvertently closing their options down prematurely. Our research supports that view, as we have found that subject choice has a significant effect, not only on the subject area of study but on the institution studied at.

The modular A level system has allowed learners to drop a subject after one year (perhaps the one in which they performed least well), so affording a degree of flexibility and allowing deferral of final A level subject choice until shortly before applying for university. However, this may be more difficult as the A level is now reverting to a linear form, so it will be even more crucial that students choose their subjects wisely at age 16.

A level subject and the subject choice at university

It should not be surprising that A level subject choice is linked to the subject of study at university, as if a student is interested and able enough in a subject to pursue it at HE it is probable that their interest and ability was stimulated and developed by earlier study in that subject or a related area. We have found that the strongest link between A level subject choice and university subject area is in 'Medicine and Dentistry', where the specialist knowledge required means that students need to have specialised in Science (or Multiple areas including Science) at A level, taking at least two STEM subjects. Some university subject areas were linked to several fields at A level, for example 'Architecture, Building and Planning' which attracted students who had previously specialised in Applied and Expressive areas. These university subject areas span the vocational/academic divide, and the mixture of backgrounds may reflect the variety of courses available in these subject areas.

Those students who had not specialised in a particular field (e.g., choosing three A levels in different categories) were more likely to study in more vocational areas at university, such as 'Business and Administrative Studies' and 'Creative Arts and Design'. These students may have benefited from taking a traditional academic subject to support their interest in Applied or Expressive subjects. For example, taking Mathematics or Economics in addition to Business Studies A level.

Some students, who have been termed Multiple specialists, took a broad and yet still deep curriculum, studying two A levels in each of two subject areas. They were most likely to study Economics or Mathematics at university. The popularity of Mathematics among this group is probably due to the special case of Further Mathematics A level which is almost invariably taken alongside Mathematics: if a student took Mathematics, Further Mathematics and two non-Science subjects they would be classified as a Multiple specialist.

A level subject and the type of university

The statistical analyses carried out in this research revealed that there is a relationship between A level subject specialism and the type of university attended. In particular, it is interesting to note that specialising in STEM or Multiple subject areas greatly increased the likelihood of studying in a Russell Group university. This also holds for Languages and Humanities, although in this case the magnitude of the association is smaller.

Applied and Expressive A level specialisms, conversely, reduced the likelihood of attending a Russell Group university. Students taking A levels in these subjects were more likely to study at a University Alliance or Million+ institution. Humanities students were quite widespread across different types of institution, but together with the aforementioned positive association with the Russell Group, they seemed to be positively linked to the 1994 Group and negatively associated with the University Alliance, even if the magnitude of the association was barely significant.

These results contribute to the debate about the crucial role of subject choice, and not only the type of qualification taken, after age 16 in the future career opportunities of young students, because these associations hold also when controlling for other variables, such as level of attainment and prior institution attended. Although membership of the Russell Group is not necessarily important in determining the quality of undergraduates' university experiences, empirical evidence has shown that obtaining a degree from a Russell Group institution leads to a higher wage return in the labour market (Hussain et al, 2009; Chevalier & Conlon, 2003). In other words, even if our study is not exhaustive[13], there is some indication that A level choice might indirectly influence students' future career opportunities and their social and economic status after their university studies.

Attainment at A level and the subject choice at university

Attainment at A level, as measured by both average grade and grades in five subject areas, did have a significant effect on the subject area of study. The greatest effect of overall grade was observed for 'Medicine and Dentistry', which is a particularly competitive area as already discussed, and 'Linguistics, Classics and related subjects'. However, somewhat surprisingly we did not observe a similar effect for overall grade in 'European Languages, Literature and related subjects', courses which are offered predominantly by Russell Group universities; instead, attainment in Language A levels in particular was important. As with the overall choice of A levels, the areas in which students' performance had a significant effect on university subject area were closely linked to the university subject area. For example, students were more likely to study 'Historical and Philosophical Studies' if they had achieved higher grades in Humanities subjects at A level. Sensitivity to grades in specific subject areas was most marked in 'Medicine and Dentistry' (focusing particularly on STEM subjects).

Our research has confirmed that subject choice at university is linked to attainment at A level more generally as well as attainment in specific subject areas. Variation in admissions offers across subject areas is likely to account for much of this relationship, but it may also be the case that more academically able students favour certain subject areas.

Attainment at A level and the type of university

As discussed earlier, much of the literature on progression to HE does not focus on attainment at A level per se, but uses it as a controlling variable when investigating for other factors. There is thus an acknowledgement

13. The breakdown by HE mission group does not make allowances for the fact that reputation and prestige vary in different ways for many subjects. Notably, some courses at post-1992 universities (typically within the University Alliance or Million+ Group) within certain subject areas have excellent research ratings and reputations, and as such are in a position to make high offers to applicants. For these reasons, when the specific university is available it is possible to consider alternative measures. However, usually Russell Group universities are included among high status institutions (see, as an example, Chowdry et al. 2013).

that prior attainment does have a strong effect on HE destinations, and there is widespread knowledge that Oxford, Cambridge and other prestigious universities (most of which are in the Russell Group) have stringent entry criteria. Our research has confirmed that, after controlling for other factors, students with an average grade of C or above were much more likely to enrol in a Russell Group or 1994 Group university than students with a lower grade, and those with an average of grade A or above were even more likely to study at a Russell Group university. Conversely, high attaining A level students were least likely to attend Million+ institutions.

Without comprehensive information on the offers made to applicants, it is impossible to separate the variation in entry requirements specified by different institutions from the competition for places (whereby institutions can select the best of the applicants, who might achieve in excess of what is nominally required) or simply the types of institutions and courses favoured by students with a certain level of attainment. For example, courses in 'Medicine and Dentistry', predominantly offered at Russell Group universities, have high entry requirements and a high demand compared to the number of places available. As a result, admissions are competitive, leading to a relatively high proportion of non-placed applicants (Wilde & Hoelscher, 2007) and the average entry tariff associated with some institutions is far in excess of the typical offers quoted by these institutions.

Recent policy developments

This research is a snapshot of the distribution of prior qualifications in HE in one academic year, 2011/12. During recent years there have been many changes in education and assessment, particularly relating to Level 3 qualifications and university admissions policies, which could potentially affect some of our findings. Three in particular stand out.

Firstly, new qualifications have been introduced at Level 3 that aim to prepare learners for study at university (e.g., Cambridge Pre-U or the Extended Project), qualifications have been withdrawn (e.g., final awarding of diplomas took place in 2014) and other qualifications are being comprehensively reformed (e.g., Advanced Subsidiary level [AS level] and A levels). The uptake of these qualifications will probably fluctuate and therefore patterns of entry at university of undergraduates holding them could also vary in the next few years. In particular, the influence of subject attainment may differ for other qualifications such as the Cambridge Pre-U, and may change under the reformed A levels.

Secondly, the Government has recently relaxed controls on student numbers (which determine the number of funded university places). If institutions expand and adapt to attract more high-achieving students, this may affect the relationship between prior attainment and HE institution group.

Thirdly, from the academic year 2012/13, students attending universities in the UK have been charged new, higher university tuition fees of up to £9,000. While initial evidence (Higher Education Funding Council for England [HEFCE], 2013) suggests that this has not directly deterred applicants from disadvantaged areas, as some had feared, there are indications that students are more likely to choose courses in Science and Medicine, and less likely to choose Arts courses.

Within these considerations, however, the findings presented here can be beneficial for a better understanding of how the choice of studying in a particular field at a specific type of HE institution can be influenced by the subjects studied at A level and the level of attainment achieved. A thorough analysis of the pathways towards university participation is, in fact, a necessary step to ensure that policies and practices of educational organisations involved in the HE admission system are designed to guarantee equality of opportunities to students pursuing university studies.

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The Mathematics needs of prospective Architecture undergraduates

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Background to the study

The General Certificate of Education (GCE) Advanced level (A level) qualifications in Mathematics and Further Mathematics are being reformed for first teaching in England in 2017. All A levels are moving from a modular to a linear system, requiring students to take their examinations at the end of a two-year course, rather than throughout as is currently the case. Furthermore, the Office of Qualifications and Examinations Regulation (Ofqual), the regulator of qualifications in England, and the Department for Education (DfE) have introduced 100 per cent prescribed content for A level Mathematics, and 50 per cent prescribed content for A level Further Mathematics. Although this will help reduce the variability in students' mathematical backgrounds when entering university, the Applied Mathematics content (Statistics, Mechanics or Decision Mathematics) that students are able to study will inevitably be reduced.

These two qualifications prepare students for undergraduate study in a wide range of subjects, including Science and Social Science in addition to tertiary Mathematics. Consequently, the reforms will have implications for a large number of prospective students' readiness for undergraduate study. This article reports on current undergraduate architects' perceptions of the existing A levels as preparation for undergraduate Architecture, including the Applied Mathematics content they perceived to be most useful. Architecture was a chosen subject of focus as it is a field of study which requires some mathematical understanding, yet there is no existing research on Architecture undergraduates' mathematical abilities in the United Kingdom (UK) context.

Undergraduate Architecture

Undergraduate Architecture degrees are traditionally the first step in the process of becoming a professional architect. Some undergraduate courses form part of the formal training process as they are accredited by the Architects Registration Board (ARB), which ensures that they comply with particular skills requirements. Although not all undergraduate courses entitled 'Architecture' are officially accredited, there is nonetheless a direct link between the skills required in the Architecture profession and the content of Architecture degrees.

No university in the UK currently requires a post-compulsory Mathematics qualification for admission to study Architecture. The Universities of Bath and Cambridge both recommend A level Mathematics, whilst other universities set a minimum entry requirement of a grade C or above at GCSE[1].

Nonetheless, a relatively high proportion of students entering Architecture, Building and Planning[2] courses have taken at least A level Mathematics. In 2010, 42.8% of first year students in these disciplines had studied Mathematics at A level, and 3.9% had studied Further Mathematics (Vidal Rodeiro & Sutch, 2013). Consequently, whilst mathematical entry requirements may be limited, the high percentage of Architecture students with a post-compulsory Mathematics qualification suggests that students may perceive further study in Mathematics to be either relevant or helpful to their undergraduate aspirations.

Many universities require prospective Architecture students to have an Art qualification or to present a portfolio with their application. Perhaps reflecting this, the most popular A level subject amongst new Architecture, Building and Planning undergraduates was Art and Design (45.8%), followed by Mathematics and Physics (20.8%) (Vidal Rodeiro & Sutch, 2013).

Mathematics in Architecture

The disciplines of Architecture and Mathematics are considered to have a close relationship, predominantly because of the importance of geometry in architectural design. Traditionally there has been a focus on Euclidean geometry, although the rise of modernism in Architecture has led to a recent interest in newer topics such as fractal and topological geometry (Cikis, 2010; Megahed, 2013; Salingaros, 1999).

The Mathematics content in university Architecture courses can be broadly classified into three areas:

1. General Mathematics, based on calculus and algebra;
2. Applied Mathematics, predominantly related to building construction; and
3. Design-orientated Mathematics, including areas such as geometry and proportion.

The emphasis on Applied Mathematics, in particular the Mathematics needed in Building Design and Construction, is reflected in the incorporation of Architecture courses into Engineering faculties in countries such as Egypt. Cikis (2010) reviewed the mathematical content of Architecture courses in the United States of America (USA) and Europe and found that the most frequently occurring topics were calculus, descriptive geometry, geometry and analytical geometry, Applied Mathematics, and trigonometry (in decreasing order of frequency).

1. Correct at December 2015.
2. Architecture is grouped with Building and Planning by the Universities and Colleges Admissions Service (UCAS) when they supply applications data.