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Inequalities in students' choice of STEM subjects

An exploration of intersectional relationships

Natasha Codiroli

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Abstract:

The relative lack of students studying post-compulsory STEM (Science, Technology, Engineering and Mathematics) subjects is a key policy concern. A particular issue is the disparities in uptake by students' family background, gender and ethnicity. It remains unclear whether the effects of family background can be explained by academic disparities, and prior research has only considered student characteristics as having additive effects, and has not yet considered whether these characteristics interact in determining choices. Using data from more than 4,000 students in England from the 'Next Steps', I use logistic regression methods to consider these questions. Disparities by students' ethnicity are shown to increase when considering prior attainment. Parents' education and social class are differentially related to uptake for male and female students. Disparities in degree choice by parents' education persist when conditioning on prior attainment suggesting a leak in the pipeline', particularly for young women from less educated families. Disparities in uptake by gender are only observed for low and middle Socio-Economic Position (SEP) families. Implications for policy and future research are discussed.

Keywords: Subject choice, STEM, A-level, Degree, Ethnicity, Gender, Socio-economic background, Intersectional, Logistic Regression.

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1. Introduction

There is a long-standing skills-gap in the supply of graduates with much sought-after expertise in STEM (Science, Technology, Engineering and Mathematics) causing concern for how economies will cope with our increasing dependence on technology in everyday life (Winterbotham, 2014). A rich literature has emerged with policy-makers, academics and stake-holders in industry working to further understand the full extent of the problem, and *why* young people seem reluctant to choose STEM when the subjects are no longer compulsory. The Social Market Foundation has identified there is already a shortage of up to 40,000 workers with STEM skills, and considering trends in industry it is predicted this will increase significantly if steps are not taken to close the gap (Broughton, 2013). A particular problem is that socio-economic background; gender and ethnicity are all associated with STEM study (CaSE, 2012; Equality Challenge Unit, 2014).

The economic case for increased participation and diversity in STEM fields is clear, but there are also substantial benefits to be had for individuals. For example those who study STEM subjects at degree level and A-level typically earn higher salaries later in life (Dolton and Vignoles, 2002; Greenwood, Harrison and Vignoles, 2011). Despite this, the problem of low uptake seems particularly large concern in UK; which one of the lowest shares of 15 year olds aspiring to pursue STEM careers (OECD, 2012). In the interests of the promotion of social mobility and equality of opportunity, it is important individual benefits are not restricted by student's social background, gender or ethnicity. Recent policy changes have led to an increase in post-compulsory mathematics qualifications available, which may contribute to increased basic skills in math, however will not necessarily lead in an increase in participation at degree level. It is therefore important to understand why students do not study STEM subjects, and why particular groups have lower participation.

Family background, gender, ethnicity and subject choice

Family background has been identified as a predictor of students' academic progress and a strong association persists between income deprivation and achievement across subjects at age 11 in the UK (see The Royal Society, 2008). There is a growing literature on access to Higher Education and student's background (e.g. Anders, 2012; Blanden and Gregg, 2004; Gayle, Berridge and Davies, 2003). The question of subject choices, however, is relatively under-researched.

The Royal Society identified prior attainment as the strongest predictor of subject's choice (The Royal Society, 2008), and considering there are large differences in attainment by students background it is possible disparities in uptake by social position reflects these academic disparities. Gorard, See and Smith (2008), using large longitudinal data sets and a comprehensive SEP measure of parent occupation, highest educational qualification and income of parents showed a clear disparity in numbers of students choosing to study STEM subject post-16 by background. Attainment differences were thought to be an important reason for the decrease in uptake of STEM, although the authors argue no one reason seems to fully explain this disparity. It is clear, however, the relationship between background and uptake, given prior attainment, has yet to be fully unpicked.

It has been observed that there are large gender differences in uptake of STEM subjects throughout students' academic careers, and these disparities seem to grow larger over time, with only 19% of jobs in scientific careers held by women (Kirkup *et al.*, 2010). HESA statistics show in 2013-2014 female students made up 48.3% STEM undergraduates compared with 56.2% students overall and in engineering and technology subjects less than 10% students were female (Equality Challenge Unit, 2014). For advanced level qualification (A-level), female students were less likely to study Maths, Physics and Chemistry than boys, and were more likely to study Biology (Joint Council for Qualifications, 2014).

Unlike inequality in participation by students' family background, prior attainment cannot explain participation disparities by gender. After conditioning on attainment, Noyes (2009) identified gender as the largest predictor of uptake of Maths at university. In the UK, girls perform better in school than boys across most subjects, however attainment is most similar for Maths and Science subjects. It could be that girls are less likely to choose STEM subjects because they achieve higher grades than boys in other subjects, and therefore have more choice. Wang, Eccles and Kenny (2013) show in a US cohort students with high Math and Verbal test scores were less likely to be working in STEM fields, than those with high Math scores and average verbal scores. The current study considers the relationship between students KS2 grades in Maths, Science and English individually and whether English ability has a negative association with uptake.

Disparities in uptake by students' ethnicity are complex, and strongly intertwined family background and prior attainment. Strand (2007) studied 'Next Steps' to understand the extent of differences in student attainment by ethnicity, showing Pakistani, Bangladeshi, Black Caribbean and Black African students score lower in KS2 and KS3 examinations than their White British peers. When controlling for family background, most of these disparities were significantly reduced, however Black Caribbean students continued to perform worse than expected.

Subject choice disparities follow a very different pattern to disparities in attainment. The most recent data from the Higher Education Statistics Agency (HESA) shows overall there is much higher ethnic diversity amongst STEM and other high return university subjects (Equality Challenge Unit, 2014). For A-level choices, Black Caribbean students are least likely to study STEM subjects given their prior attainment, and White British students have particularly low uptake of Math (Boaler, Altendorff and Kent, 2011). Considering students from Black and Minority Ethnic (BME) backgrounds also tend to have lower academic attainment as well as more deprived social backgrounds, it is likely diversity will increase when these characteristics are controlled.

From a review of literature into research into ethnicity and attainment, Warikoo and Carter (2009) found the majority of studies rely on an additive model of student achievement, controlling for other student characteristics but not looking at differences in outcomes by combinations of characteristics. There is a strong tradition in qualitative study of looking the intersections between individuals' characteristics; at how individuals' experience, given their characteristics, interact in more complex ways in producing disparities in outcomes (e.g. Crenshaw, 1989). Recent quantitative research looking into academic disparities have shown evidence for interactions (e.g. Dekkers, Bosker and Driessen, 2000; Kingdon and Cassen, 2010). Strand (2014) applied this concept in the English Next Steps cohort, and found significant interactions between student characteristics in relationships with attainment.

1.1 Current Study

The ideas of intersectional relationships between background and characteristics have not yet been applied to the study on subject choices. It is unclear whether disparities in uptake by students' ethnicity and family background occur across genders, or whether disparities in uptake are driven by disparities for one gender. Along with exploring current disparities in participation by students' family background, gender and ethnicity, the research presented contributes to the literature by focusing specifically on the ways student characteristics interact in determining choice. Using 'Next Steps,' (formally the Longitudinal Study of Young People in England) a large longitudinal and representative survey of young people in education in England, the relationships between a detailed and rich set of characteristics measured when students are between 13 and 15 and later choices are explored.

I compare characteristics associated with STEM subject study, those associated with 'high-return' subjects including Social sciences, Law and Business and Administrative (SLB) studies, and other arts and humanities subjects. Models are run separately for male and female students to gauge whether influences of ethnicity and family background differ between genders. I then consider whether disparities in uptake of STEM subjects occur earlier for students, with A-level choices, the first point at which math and science study are no longer compulsory.

A variety of different measures of family background have been considered in prior research including family income, FSM status, parents' social class, parents' education or a combination of indicators. I take advantage of the comprehensive information included in Next Steps by looking at how indicators of family background (parents' education, social class and income) and school type are differentially associated with subject choice. Prior research suggests differences in choice by family background at least to some extent reflect differences in prior attainment. I then control for prior academic attainment, to assess the extent to which group differences are driven by academic disparities.

In comparing the relationship between family background and uptake of STEM subjects I am able to combine information of the different indicators of Socio-Economic Position (SEP) to reach a picture of where students stand in comparison with their peers. Using this indicator I explore whether ethnicity and gender have differing associations with subject choice for students from higher vs lower socio-economic backgrounds.

1.2 Research Questions

- What is the relationship between students' family background, gender and ethnicity with choice of STEM study at university and A-level? Specifically, which indicators account for disparities in uptake?
- Can disparities in uptake be explained by students' prior academic attainment?
- Do relationships between choice, and students' characteristics differ for male and female students, or by family background?

This paper proceeds as follows: Section 2 describes the data used for analysis, relevant variables and analytical strategy. Section 3 quantifies the proportions of students studying STEM at A-level, by students' gender, ethnicity and family background, and how these characteristics interact. Section 4 considers degree subject choice. Section 5 concludes with a discussion of results and possible implications for policy and research.

2. Methods

2.1 Data

I use Next Steps, a comprehensive dataset including interviews, surveys and demographic information of young people and their parents/ carers. Many students will have applied to university by the 7th wave giving rich information to use for analysis. The data includes information on students' family background, their attitudes and behaviours, and whether they were attending university and subjects they studied. The data has been linked with the National Pupil Database (NPD), giving detailed information on students' grades across school years. The final analysis includes 4,135 students who gave information on degree studied, and 4,128 students who studied at least one A-level.

Table 1: Next Steps waves

Wave	Year	Age	Sample Size
1	2004	13-14	15,770
2	2005	14-15	13,539
3	2006	15-16	12,439
4	2007	16-17	11,801
5	2008	17-18	10,430
6	2009	18-19	9,799
7	2010	19-20	8,682

In consideration of issues relating to attrition, weights have been used for analysis. For wave 7 data collection, variables associated with attrition included individuals' gender, ethnic group, housing tenure, interview and month, higher education application status, and some behavioural variables. The use of weights should ideally ensure the sample remains representative of the population, however weights can only be applied based on students observed, and not unobserved characteristics. It is possible there are unobserved characteristics, such as motivation, which may be associated with attrition, student characteristics and subject choice.

2.2 Key Variables

Subject choice

STEM subjects included: Medicine and dentistry; Subjects allied to medicine; Biological sciences; Veterinary sciences, agriculture and related; Physical sciences; Mathematical and computer sciences; Engineering and Technologies. 38.4% students studied a STEM degree subject. All subjects considered under the broad umbrella of science were included in the STEM category in analysis, following research into STEM uptake also including biological and medical science (e.g. Botcherby and Buckner, 2012; Equality Challenge Unit, 2014) . It is, however, acknowledged that the largest gender disparities in uptake occur in physical sciences; whilst for biological and medical sciences this disparity isn't as large (see Boaler, Altendorff and Kent, 2011; Equality Challenge Unit, 2014).

Walker and Zhu (2011) identified another group of subjects offering high returns to students following graduation: LEM (Law, Economics and Management). Because students' subject choices are grouped in Next Steps, students studying Economics and Management could not be individually identified. Instead, I included an indicator for students studying Social Studies, Law, and Business & Administration studies (SLB) (including Management & Accountancy). 29.9% students study an SLB degree. Remaining subject choices included: Architecture, building and planning; Linguistics, European language; Eastern Lit; History and philosophy; Creative arts; Education.

For A-level choices, a STEM subject is defined as Maths, Further Maths, Physics, Chemistry or Biology. Only students who completed A-levels are considered. Students in England typically study between 3-4 A-levels, so their choice of A-levels choices may tell us less than degree choices about their future outcomes and careers. There remains a considerable financial return, however, to the study of STEM A-levels even when degree subject is taken into account (i.e. for Maths A-level see (Dolton and Vignoles, 2002). Furthermore, a STEM university course will typically require at least one STEM subject studied at post-compulsory level (and usually 2 or more) for entry.

Family Background

For initial analysis considering which family background indicators explain variation in subject choice mothers' and fathers' highest academic qualifications (degree or higher, vs no degree), Parents NS-SEC occupational class[*] and students' gross family income[†] were included in all models.

Following previous research into family background differences in academic outcomes (e.g. Chowdry, Crawford and Goodman, 2011), an individual score was computed for each student to determine their SEP based on the following variables: how well the household is managing on finances; highest education qualification of parents (whichever was highest);

[*] Taken from the family member with the highest income, or responsible for paying rent/mortgage.
[†] Gross family income was initially grouped with 92 categories and included as a continuous variable; I truncated the variable at 67 groups based on the spread of scores at the top of the distribution.

family's NS-SEC class and household tenure. All indicators were converted to ordinal variables with 3-4 levels. I conducted polychoric Principle Components Analysis (PCA) (Kolenikov and Angeles, 2004) to identify a factor score and rank for each student. For the university and A-level sample the PCA factor explains 64% and 66% respectively of the variation in these indicators. Students were then split into 3 SEP groups (High to Low SEP).

In contrast to much prior research, 'eligibility' for Free School Meal (FSM) status was not used as a measure of SES. Hobbs and Vignoles (2007)) explain that generally FSM eligibility is a poor proxy for student deprivation, and richer information is included on students' family income and other family background measures.

An indicator for whether students attended an independent school, or not, was included in the final model. This follows research suggesting independent school students are more likely to study STEM and traditional subjects (e.g. CaSE, 2014). It is important to note in Next Steps independently educated students are also underrepresented; 3.4% of students in the initial sample were independently educated compared with 6.5% in England.

Ability

Students' ability was taken from NPD records and students capped GCSE scores, and individual scores in KS2 Maths, Science and English were included in analysis.

Table 2: Proportions of students scoring above average scores (compared to other cohort members) participating in each degree subject group, and for those taking at least 1 STEM subject at A-level

Subject	Take at least 1 STEM A-level	STEM Degree	SLB Degree	Other Degree
High GCSE score	73.8%	60.2%	44.2%	48.2%
Above average KS2 Math score	69.8%	58.1%	45.3%	44.1%
Above average KS2 Science score	68.2%	61.7%	44.0%	52.4%
Above average KS2 English score	64.3%	57.2%	50.0%	58.1%

Students studying STEM degree subjects are more likely to have higher scores across all indicators of attainment except KS2 English, and those studying SLB degrees have the lowest scores on average on all indicators except KS2 maths. In line with degree choices, students who study at least one STEM A-level are more likely to be high achieving on a wide range of subjects. The largest difference is in GCSE scores, where 74% students taking a STEM A-level achieved an above average score compared to the rest of their cohort.

Missing Data

Missing data is a common issue when utilizing large scale longitudinal survey data, due to attrition and non-response. Listwise deletion methods would dramatically reduce the sample, and exclude rich information of students who may have missing responses on few variables, reducing power of the models. Because proportions of non-response differ for each variable, separate missing data strategies were employed for key variables. For the outcome, and for ethnicity and sex analysis is only carried out for individuals who gave valid responses, leaving a final sample of 4135 students (4128) for the degree and (A-level) samples.

For family background characteristics, which were coded as categorical variables (social class, mothers' education and fathers' education), missing dummy variables included in analysis. Respectively, 9%, 7%, and 26% values were missing. Although there are some limitations to this method (see Allison, 2001), for example the additional variable could bias standard errors and coefficients on other variables, it allows direct modelling of the missing data, and utilizes all information available. Allison argues that this method may be optimal when missing data reflects actual non-existence of values (for example, mothers' and fathers' education level). When computing the SEP variable, missing values for categorical variables were replaced with median values (2% values were missing for 'parents' highest qualification'). Mean values were imputed for GCSE and KS2 science scores, where 5% and 8% values were missing respectively. Missing dummy variables were included in all models.

For income, given data are relatively normal and due to the large proportion of non-response, Multiple Imputation methods where employed to account for missing values (with 25% missing), using regression methods and including all relevant independent variables. 20 data sets were produced using the STATA mi command. This approach could be criticized on the basis that non-response may be associated with some unobserved characteristic that influences subject choice, but I have included a comprehensive set of predictor variables which make the 'missing at random' assumption more plausible. This approach is preferred in much of the literature due to the tendency of single imputation methods to underestimate standard errors (Sinharay, Stern and Russell, 2001).

2.3 Analytical Strategy

I present raw descriptive statistics for students' choice of STEM A-level, and of STEM and SLB degrees. I compare proportions of students within each ethnicity, choosing each group of subjects, across genders. Then I compare relative proportions of students studying each group of subject by various family background indictors, again presented across students' gender.

To understand which characteristic are most important in explaining students' subject choices, and how students' family background gender and ethnicity interact in determining choice, I ran logistic regression models. Regression methods identify to unique associations of each predictor variable with students choices, thus allows us to see which student characteristics explain the largest proportion of variance in choice, whilst other predictors are held constant. In considering the issues of interpretation of odds ratios, and log odds, across logistic regression models and samples (Mood, 2010), marginal effects at means (MEM) of all independent variables are presented throughout this paper. This shows the relative changed in probability in choice of STEM, or SLB subject (P(Y=1)), with a unit change in any independent variable, with all other variables held at their mean (Williams, 2012). For categorical variables, the marginal effects show how much P(Y=1) will change if the variable changes for 0 to 1 (with other variable held at mean values).

For A-level choices, Logistic regressions were run to ascertain the unique associations between students' characteristics and uptake of STEM A-levels. The models are built up in two stages where Model 1 considers associations with choice by characteristics and Model 2 controls for prior attainment across subjects. For degree choices, multinomial regression models stratified by gender were built up sequentially in stages. Model 1 shows students propensity to study STEM and SLB subjects, compared with arts and humanities subjects, by students' ethnicity and family background. Model 2 conditions on students' prior attainment, to better understand whether differences in uptake by student characteristics are driven by differences in student attainment. Students from lower socio-economic backgrounds especially are more likely to have lower levels of prior attainment, so it would be expected some of the differences in subject choice (especially choice of STEM subjects, which are considered 'harder' than other subjects) will be reduced when accounting for attainment. Model 3 includes an indicator for A-level choices to consider whether disparities occur earlier.

Students' social-economic background and ethnicity are strongly intertwined; the Labour Force Survey 2004 and the Pupil Leave School Census 2002 showed strikingly large differences in proportions of students identified as claiming FSMs or in relative income poverty (Bhattacharyya, Ison and Blair, 2003; Kenway and Palmer, 2007). For this reason, it is likely models which do not take account of both student characteristics will under or over-estimate diversity of uptake of STEM subjects.

In the samples used for analysis there are large differences in students' family background by their ethnicity. Proportions of students claiming FSMs broadly reflect findings from prior research, with lowest proportions from White British families, and highest proportions from Bangladeshi families.

Table 3: Differences in students' median income, and proportions eligible for FSM by ethnicity[*]

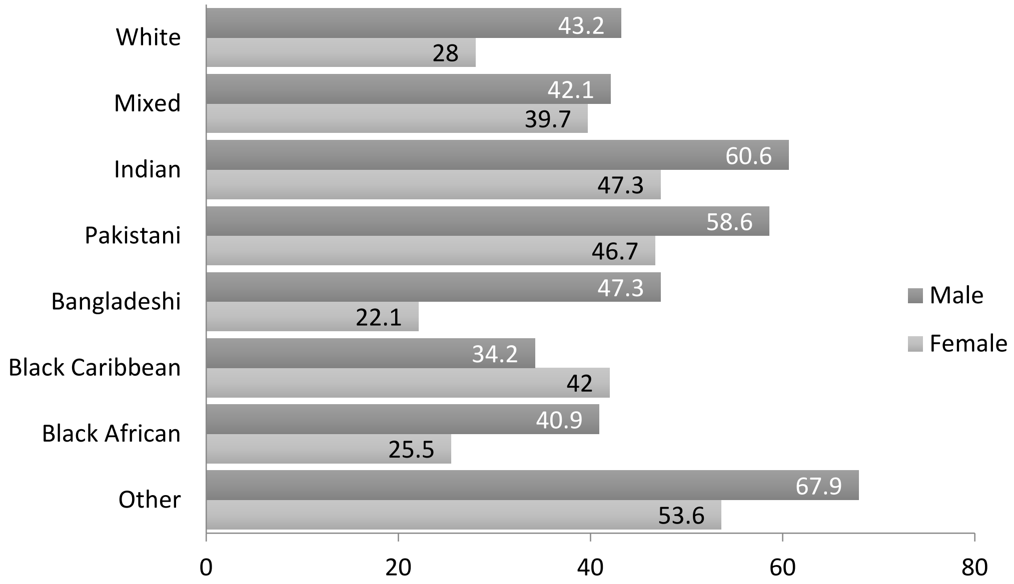
Ethnicity	Unweighted count	Proportion claiming FSM
White British	2589	3.0%
Mixed	183	10.9%
Indian	478	6.6%
Pakistani	257	30.8%
Bangladeshi	232	56.4%
Black Caribbean	110	13.6%
Black African	154	28.3%
Other	132	20.7%

[*] Taken from the sample attending university, results were similar for the A-level sample.

3. How do student characteristics interact in determining A-level subject choice?

Students typically study between 3 and 4 A-levels, and given university entrance requirements it is unlikely students who do not study at least one STEM A-level will study a STEM degree; 67% of students who studied at least one STEM subject in the next steps sample went on to study a STEM degree. There is also a separate wage premium experienced by students who study STEM regardless of later degree subject choices (Dolton and Vignoles, 2002).

Figure 1: Raw proportions of students who completed at least one STEM A-level by ethnicity



As predicted, male students are more likely to take at least one STEM A-level. Overall, Indian, Pakistani, and other ethnicity students are more likely to study STEM A-levels, and Black African students less likely. Female students of mixed ethnicity and Black Caribbean ethnicity are more likely to study STEM A-levels then white female students, whereas Black males are less likely to study STEM. Female Bangladeshi students are less likely to study STEM than white female, whilst there is little difference in propensity to study STEM between white and Bangladeshi males.

Table 4: Family background characteristics of female (male) students completing at least 1 STEM A-level[*]

Subject	Take at least 1 STEM subject	No STEM subject
Median Income band	£28600 - £31200 (£31200 -£33800)	£28600 - £31200 (£28600 -£31200)
Mother has Degree or higher	20.2% (23.4%)	14.0% (16.3%)
Father has Degree or higher	25.4% (26.3%)	13.4% (17.1%)
Household has service class occupation	58.1% (57.7%)	50.0% (52.1%)
Independently educated	19% (15.6%)	11% (13.9%)
Highest SEP	36.7% (40.7%)	27.7% (29.3%)

Male students taking at least one STEM A-level are more likely be in higher income bands. All students choosing STEM A-levels are more likely to have parents with higher educational achievements and in higher occupational classes. They are also more likely to be attending independent schools, and to be in the highest overall SEP group.

Regression models of A-level subject choices

Differences in choices by ethnicity broadly reflect raw associations. One striking difference occurs between male and female Black Caribbean students, whilst male Black Caribbean students are more likely to study STEM than white students, the differences is much larger between female Black Caribbean and white students. Figures 2 and 3 illustrate that with the introduction of prior attainment to the regressions, differences in uptake between students of different ethnicities increase substantially.

Overall, students' parents' social class does not appear to be significantly related to students' choice, given other family background characteristics, even before accounting for educational attainment. One exception is that male students whose parents work in lower managerial occupations are less likely to study STEM A-levels by around 70 percentage points, only after conditioning on attainment.

[*] Incomes are at 2003 prices, measured in wave 1 data collection. 'Service class' occupations includes parents in higher and lower managerial and professional occupations, and parent with 'at least some HE' includes parents with some HE, and those a Degree qualification or higher.

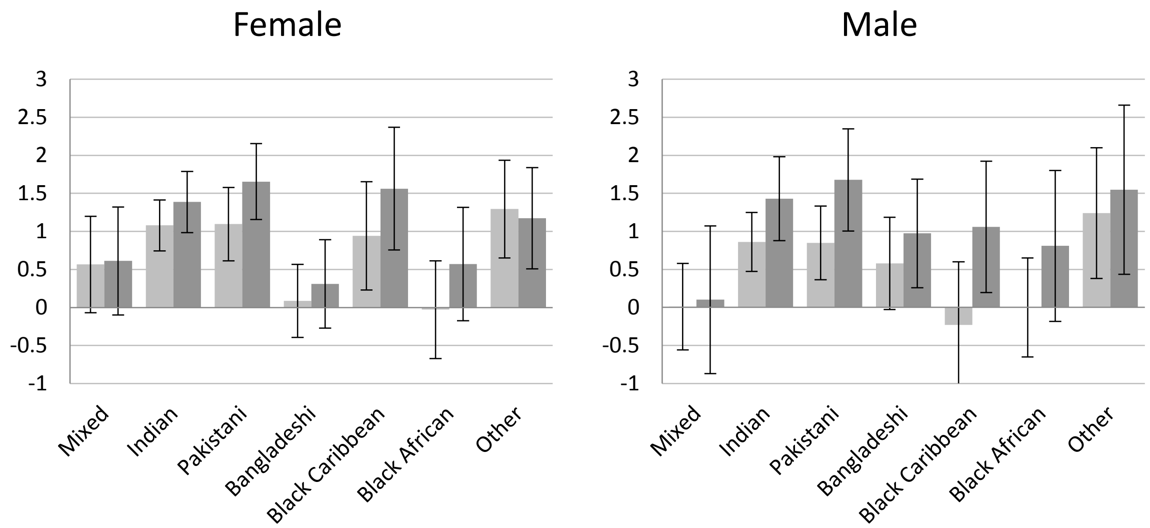
Table 5: Results of logistic regression of choice of STEM A-level.* Marginal effects are shown with standard errors in parenthesis.

1+ STEM A-level	Female		Male	
	Model 1	Model 2	Model 1	Model 2
	Marginal Effect (Standard Error)			
Ethnicity				
White				
Mixed	0.565* (0.323)	0.613* (0.362)	0.009 (0.290)	0.102 (0.495)
Indian	1.080*** (0.171)	1.387*** (0.204)	0.861*** (0.198)	1.429*** (0.281)
Pakistani	1.097*** (0.247)	1.655*** (0.255)	0.848*** (0.247)	1.677*** (0.342)
Bangladeshi	0.088 (0.245)	0.309 (0.296)	0.579* (0.310)	0.974*** (0.364)
Black Caribbean	0.941*** (0.363)	1.563*** (0.411)	-0.231 (0.424)	1.059** (0.440)
Black African	-0.028 (0.328)	0.570 (0.381)	-0.001 (0.332)	0.810 (0.506)
Other	1.294*** (0.328)	1.175*** (0.339)	1.241*** (0.439)	1.548*** (0.567)
Social class				
Higher managerial	0.550* (0.284)	0.334 (0.325)	0.192 (0.292)	-0.388 (0.350)
Lower managerial	0.400 (0.272)	0.317 (0.309)	-0.281 (0.276)	-0.842** (0.334)
Intermediate	0.431 (0.322)	0.318 (0.374)	-0.101 (0.322)	-0.204 (0.386)
Small employer	0.207 (0.298)	0.423 (0.341)	-0.200 (0.296)	-0.452 (0.360)
Lower supervisor	-0.079 (0.329)	0.104 (0.381)	-0.209 (0.330)	-0.463 (0.401)
Semi-routine	-0.131 (0.334)	0.069 (0.378)	-0.050 (0.317)	-0.286 (0.392)
Reference: Routine				
Unemployed	0.050 (0.386)	0.297 (0.454)	-0.736 (0.485)	-0.858 (0.544)
Mother has a degree of higher	0.183 (0.147)	-0.167 (0.173)	0.263* (0.149)	-0.142 (0.176)
Father has a degree or higher	0.654*** (0.149)	0.404** (0.176)	0.311** (0.155)	0.298* (0.178)
Income	-0.002 (0.005)	-0.004 (0.005)	0.010** (0.005)	0.006 (0.005)
Independent School	0.453** (0.186)	-0.211 (0.372)	-0.144 (0.197)	-0.136 (0.397)
Prior attainment				
GCSE score		1.284*** (0.103)		1.371*** (0.108)
KS2 Math		0.789*** (0.104)		0.821*** (0.101)
KS2 Science		0.076 (0.103)		0.311*** (0.105)
KS2 English		-0.529*** (0.097)		-0.709*** (0.099)
N (STEM A-level)	2275 (722)		1853 (872)	

* p < 0.10, ** p < 0.05, *** p < 0.01

*Model 1 includes student's family background indicators and in Model 2 student's prior academic attainment is included.

Figures 2 & 3: Increase in students odds of studying at least one STEM A-level by ethnicity, when accounting for prior attainment*



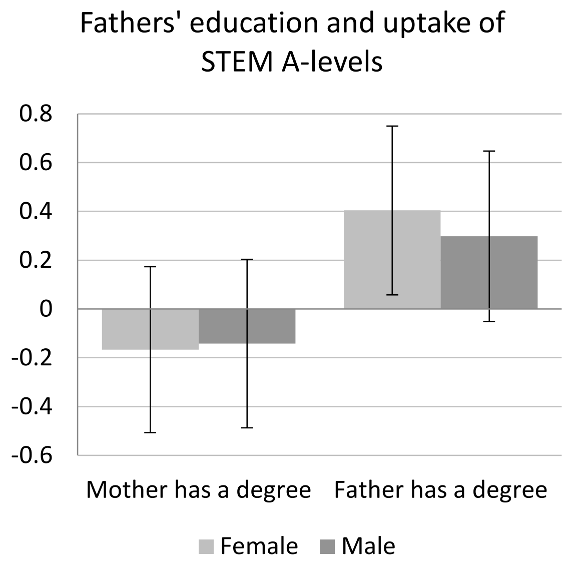
There are large differences between parents' education and uptake across genders. Mothers' education doesn't appear to be associated with students' choice of STEM A-level study. Father's highest qualification, however, appears strongly related to choice. Students whose fathers have degrees are more likely to study a STEM A-level than those whose fathers' highest qualification is lower than a degree. This association is larger for female than male students, and whilst these associations reduce somewhat when accounting for prior attainment, they remain statistically significant (for male students the association is only significant at the 10% level). This suggests fathers' education has an additional influence of parents' education level aside from that associated with academic capability.

For male students, parents' income is positively associated with uptake of STEM A-levels, however effect sizes are very small, and there is no longer an association when accounting for attainment. Boys at independent schools are no more likely to study STEM A-levels, whilst girls attending independent schools are more likely to study STEM, however this is also no longer significant when accounting for prior attainment.

With each standard deviation increase in GCSE score students are over 130 percentage points more likely to study at least one STEM A-level, and with increased KS2 Maths scores students are around 80 percentage points more likely to study STEM. Whilst KS2 Science scores are not related to females' choice (given other grades) males students are over 30 percentage points more likely to choose STEM with each standard deviation increase in grades. In line with research by Wang, Eccles and Kenny (2013), KS2 English scores are negatively associated with uptake of STEM.

* The base category is white students. The first bar represents odds before controlling for prior academic attainment, given family background. The second bar represents odds after attainment is included in the model. 95% confidence intervals are shown.

Figure 4: Gender differences in students' odds of studying at least STEM A-level by Fathers' highest qualifications, conditioning on prior attainment*



How do patterns of uptake differ by students' family background?

It is possible patterns of uptake differ not only by students' gender, but also by their socio-economic status. For example, Strand (2014) showed associations between ethnicity and attainment differed by students family background. Inequalities in attainment between white and BME students were largest for higher socio-economic groups, and smallest for those from the lowest socio-economic groups.

Separate regression models were then run for students of low, middle and high SEP groups, whilst conditioning on prior attainment at GCSE and KS2 level. Minority ethnicity students were grouped in this analysis due to the small sample sizes within each ethnic group, and because all minority ethnic groups were more likely to study both STEM and SLB subjects than white students. There were large differences in proportions of BME students within each SEP group; 20.6% of the most advantaged students were BME compared with 26.5% in the middle group and 50.4% of the most disadvantaged students.

Table 6 shows that gender differences in uptake are similar across SEP groups, with male students over 10 percentage points more likely to study STEM A-levels. This compliments findings from table 5; where many socio-economic differences in uptake of STEM A-levels can be explained by prior attainment. Disparities in choice by students' ethnicity are also similar across SEP groups, suggesting that both disadvantaged and advantaged BME students are much more likely to study STEM A-levels than white students.

* Marginal effects and 95% Confidence Intervals are shown.

Table 6: Results of logistic regression of choice of at least one STEM A-level, stratified by students SEP. Marginal effects are shown with standard errors in parenthesis.

STEM A-level	**Low SEP**	**2^{nd} SEP**	**High SEP**
Male	0.124***	0.126***	0.154***
	(0.029)	(0.031)	(0.037)
BME	0.183***	0.231***	0.271***
	(0.030)	(0.040)	(0.064)
GCSE	0.244***	0.247***	0.327***
	(0.023)	(0.024)	(0.031)
KS2 Math	0.128***	0.197***	0.173***
	(0.021)	(0.024)	(0.031)
KS2 Science	0.041*	0.010	0.068**
	(0.021)	(0.026)	(0.029)
KS2 English	-0.098***	-0.117***	-0.185***
	(0.020)	(0.023)	(0.029)
N (N STEM A-level)	1,463 (482)	1,328 (492)	1,337 (620)

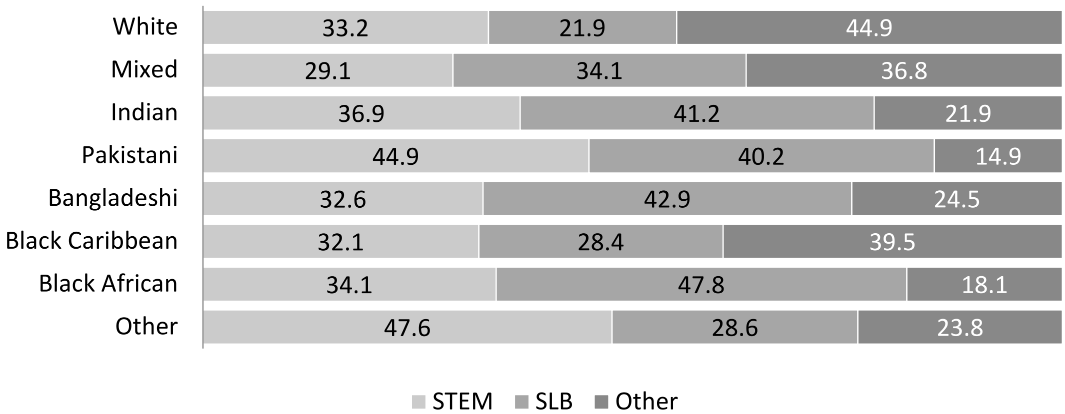
* p < 0.10, ** p < 0.05, *** p < 0.01

4. How do student characteristics interact in determining degree subject choice?

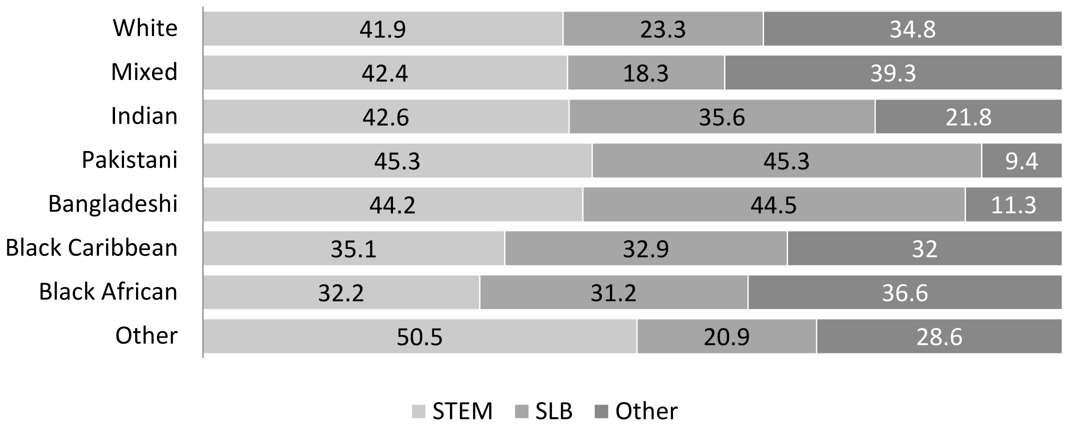
There are well-established differences in choices by students' gender; male students are more likely to study STEM subjects at university whilst female students are more likely to study arts and humanities. In terms ethnicity, HESA data covering students across the UK also reveals differences in subject choice; overall students from BME backgrounds are slightly more likely to study STEM and SLB subjects and least likely to study arts and humanities subject, although there is large heterogeneity between ethnic groups(Equality Challenge Unit, 2014).

Figure 5 & 6: Raw proportions of students studying STEM, SLB or other subjects at university by ethnicity

Female students



Male students



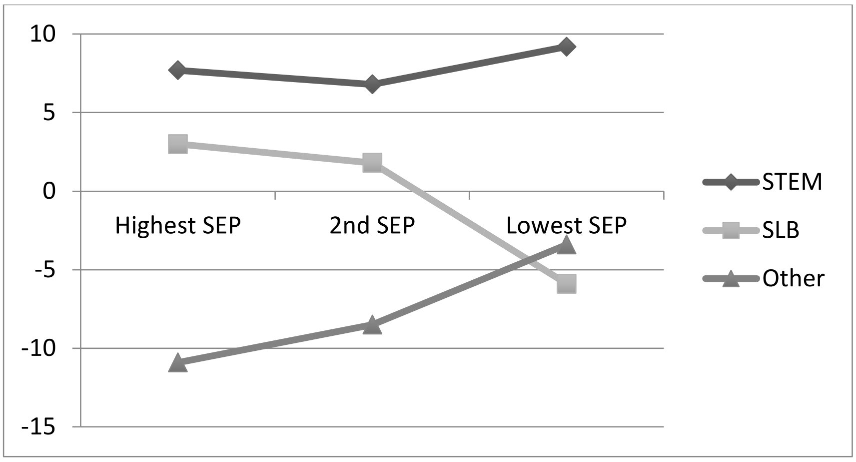
The Next Steps data also indicate there are large differences in participation by students' ethnicity and gender. White students are least likely to study high return SLB subjects. Asian students are most highly represented, and this increase in uptake is mirrored by very low uptake of arts and humanities subjects. Male Black Caribbean and Black African students stand out as being particularly under-represented in STEM subject study.

Table 7: Family background characteristics of female (male) students choosing STEM, SLB or other degree subjects*

Subject	STEM	SLB	Other
Median Income band	£28600 - £31200 (£31200 - £33800)	£26000 - £28600 (£26000 - £28600)	£28600 - £31200 (£26000 - £28600)
Mother has Degree or higher	16.5% (19.2%)	9.6% (16.3%)	17.4% (22.8%)
Father has Degree or higher	20.5% (21.7%)	12.1% (18.8%)	17.2% (23.9%)
Household has service class occupation	53.7% (55.4%)	46.4% (51%)	54.4% (54.5%)
Independently educated	1.6% (3.4%)	3.5% (4.9%)	3.1% (3.6%)
Highest SEP	32.5% (35.5%)	21.7% (30.4%)	32.1% (36.8%)

There are small differences in average income of students in each subject area. For female students those studying SLB subjects have the lowest median family incomes, whereas males studying either SLB or arts and humanities subjects have lower family incomes. Students studying STEM and Other subjects have the highest proportions of parents with a Degree or higher qualification, and in Service class occupations, compared with students studying SLB subjects. In contrast, SLB degrees appear to attract the highest proportions of independently educated students. In considering students' SEP, SLB subjects stand out as having particularly low uptake amongst the most advantaged female students whilst for male students, differences between groups are small.

Figure 7: Gender differences in subject studied by students SEP



The largest gender disparities in STEM subject choices, and smallest disparities in choice of arts and humanities subjects, occur for the least advantaged students. Male students in the highest and middle SEP groups are more likely to study SLB subjects, whilst in the lowest SEP groups this relationship is reversed.

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* Incomes are at 2003 prices, measured in wave 1 data collection. 'Service class' occupations includes parents in higher and lower managerial and professional occupations, and parent with 'at least some HE' includes parents with some HE, and those a Degree qualification or higher.

Regression models of university subject choices

Differences in choice by ethnicity are strikingly large and well determined. The associations increase across models for male students, suggesting prior attainment does not account for disparities, and in fact suppresses the extent of disparities in choice.

The first model shows, even after accounting for family background, students from BME backgrounds are much more likely to study both STEM and SLB subjects. For females, White and Black Caribbean students are most similar in their choices. Although mixed ethnicity students are more likely to study SLB subjects there are no differences in uptake of STEM subjects when compared with White students. Male Black African, Black Caribbean and other ethnicity students are similar to White students in subjects' choices. When academic attainment is accounted for, male Black Caribbean students are much more likely to study SLB subjects.

One possible reason BME students may be more likely to choose higher return subjects could be related to differences in parental and student attitudes and behaviours; BME groups generally have more favourable scores on these characteristics when considering outcomes (Strand, 2011). Whilst Strand found an increase in these attitudes and behaviours do not lead to proportionately higher academic attainment they could influence student choices. Associations largely persist when accounting for A-level choice, suggesting an additional association between degree choice and ethnicity for students who have made similar A-level choices.

In line with raw associations and prior research, clear differences in uptake of STEM and SLB subjects are observed by students' family background (The Royal Society, 2008; Gorard, See and Smith, 2008). Overall social class is not strongly related to female students' choices, however some associations persist given academic qualifications and income of parents are accounted for. For females, students with parents in intermediate occupations are less likely to study STEM compared to those with parents in routine occupations. Students with unemployed parents or parents in semi-routine occupations are less likely to study SLB subjects. Effect sizes do not differ considerably when conditioning on prior attainment.

Male students whose parents work in occupations in any social class group are less likely to study STEM degrees than those whose parents work in routine occupations. Routine occupations are defined by having the most basic and insecure labour contracts, although it is unclear from the data which occupations in particular are most highly represented in this group, and whether there is a higher concentration of jobs requiring STEM knowledge or skills. The relationships appear to increase, rather than decrease, when accounting for prior attainment and A-level choices. For example, students whose parents work in higher managerial and professional occupations are over 60 percentage points less likely to study STEM degrees, only when accounting for prior attainment. There are no statistically significant social class differences between male students studying SLB and arts and humanities degrees

Table 8: Results of multinomial logistic regression of degree choice for female students.*

Degree Subjects	STEM						SLB					
	Model 1		Model 2		Model 3		Model 1		Model 2		Model 3	
	Marginal effect (SE)											
Ethnicity												
White												
Mixed	0.004	(0.315)	0.042	(0.312)	-0.102	(0.354)	0.621*	(0.340)	0.659*	(0.338)	0.665*	(0.343)
Indian	0.808***	(0.234)	0.811***	(0.242)	0.300	(0.250)	1.322***	(0.226)	1.287***	(0.239)	1.250***	(0.243)
Pakistani	1.472***	(0.316)	1.526***	(0.317)	0.993***	(0.318)	1.800***	(0.294)	1.859***	(0.312)	1.788***	(0.314)
Bangladeshi	0.701**	(0.343)	0.770**	(0.337)	0.570	(0.348)	1.370***	(0.362)	1.403***	(0.362)	1.372***	(0.360)
Black Caribbean	0.167	(0.444)	0.382	(0.543)	-0.102	(0.616)	0.240	(0.324)	0.317	(0.348)	0.291	(0.353)
Black African	0.927***	(0.340)	1.049***	(0.346)	0.932**	(0.392)	1.767***	(0.318)	1.778***	(0.340)	1.764***	(0.339)
Other	1.040***	(0.367)	0.981***	(0.369)	0.563	(0.380)	0.851**	(0.399)	0.876**	(0.411)	0.863**	(0.412)
Social class												
Higher managerial	0.079	(0.300)	0.067	(0.303)	-0.160	(0.318)	-0.347	(0.304)	-0.288	(0.305)	-0.290	(0.305)
Lower managerial	0.006	(0.282)	0.010	(0.284)	-0.128	(0.302)	-0.414	(0.279)	-0.386	(0.279)	-0.373	(0.280)
Intermediate	-0.449	(0.346)	-0.496	(0.352)	-0.807**	(0.384)	-0.413	(0.340)	-0.412	(0.339)	-0.406	(0.340)
Small employer	-0.190	(0.316)	-0.141	(0.317)	-0.320	(0.338)	-0.419	(0.312)	-0.354	(0.312)	-0.344	(0.313)
Lower supervisor	0.010	(0.333)	0.037	(0.337)	0.050	(0.354)	-0.031	(0.324)	-0.036	(0.321)	-0.027	(0.322)
Semi-routine	0.107	(0.335)	0.195	(0.332)	0.174	(0.361)	-0.694**	(0.342)	-0.670*	(0.346)	-0.643*	(0.348)
Reference: Routine												
Unemployed	-0.446	(0.428)	-0.343	(0.430)	-0.376	(0.447)	-1.158***	(0.439)	-1.121**	(0.442)	-1.053**	(0.436)
Mother has a degree	-0.054	(0.159)	-0.118	(0.166)	-0.117	(0.177)	-0.513**	(0.204)	-0.458**	(0.209)	-0.454**	(0.208)
Father has a degree	0.315*	(0.163)	0.230	(0.166)	0.056	(0.177)	-0.130	(0.202)	-0.082	(0.207)	-0.118	(0.205)
Income	-0.004	(0.005)	-0.005	(0.005)	-0.005	(0.005)	-0.001	(0.005)	0.000	(0.005)	0.000	(0.005)
Independent School	-0.705*	(0.367)	-0.726*	(0.374)	-0.630	(0.430)	0.120	(0.364)	0.170	(0.371)	0.161	(0.375)
Prior attainment												
GCSE score			0.140	(0.102)	-0.205**	(0.095)			-0.172*	(0.088)	-0.184*	(0.098)
KS2 Math			0.467***	(0.099)	0.221**	(0.109)			0.458***	(0.102)	0.445***	(0.102)
KS2 Science			-0.008	(0.093)	-0.072	(0.100)			-0.137	(0.100)	-0.135	(0.099)
KS2 English			-0.292***	(0.096)	-0.134	(0.101)			-0.132	(0.098)	-0.122	(0.099)
Choose STEM A-level					2.292***	(0.164)					0.151	(0.200)
N	2,289 (781/ 659)											

* p < 0.10, ** p < 0.05, *** p < 0.01

*Model 1 includes student's family background indicators, in Model 2 student's prior academic attainment is included and Model 3 includes an indicator for choice of at least one STEM A-level.

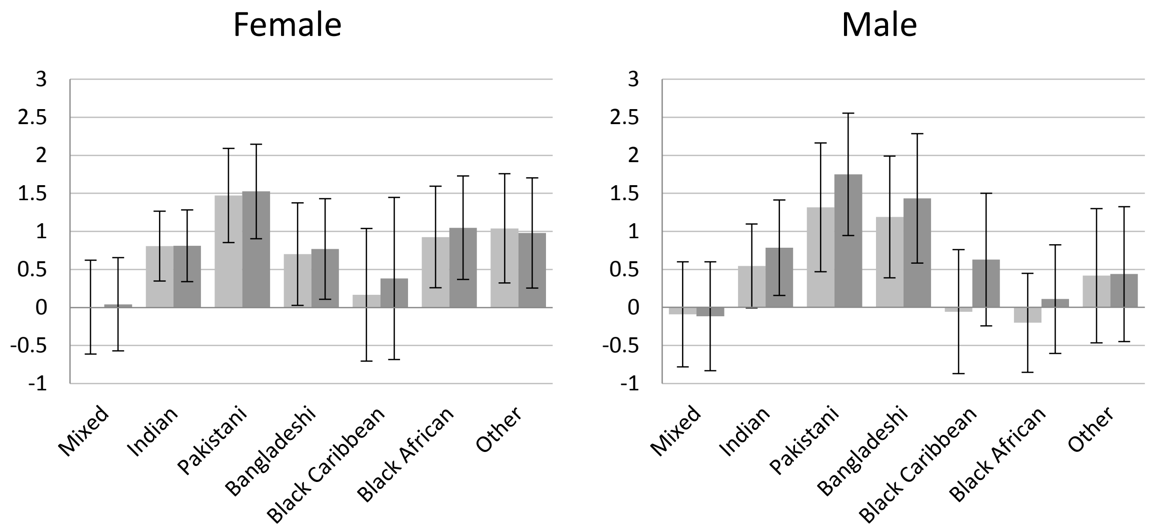
Table 9: Results of multinomial logistic regression of degree choice for male students.*

Degree Subjects	STEM						SLB					
	Model 1		Model 2		Model 3		Model 1		Model 2		Model 3	
	Marginal effect (SE)											
Ethnicity												
White												
Mixed	-0.092	(0.353)	-0.117	(0.366)	0.019	(0.356)	-0.324	(0.438)	-0.326	(0.434)	-0.313	(0.431)
Indian	0.545*	(0.281)	0.785**	(0.320)	0.376	(0.330)	0.839***	(0.296)	0.913***	(0.335)	0.845**	(0.342)
Pakistani	1.317***	(0.432)	1.750***	(0.411)	1.289***	(0.436)	1.915***	(0.431)	2.104***	(0.412)	2.028***	(0.429)
Bangladeshi	1.189***	(0.408)	1.434***	(0.435)	1.213***	(0.428)	1.623***	(0.418)	1.724***	(0.427)	1.700***	(0.427)
Black Caribbean	-0.056	(0.416)	0.628	(0.445)	0.416	(0.454)	0.519	(0.427)	0.877**	(0.435)	0.825*	(0.439)
Black African	-0.202	(0.332)	0.109	(0.364)	-0.019	(0.384)	0.371	(0.365)	0.478	(0.387)	0.460	(0.395)
Other	0.417	(0.450)	0.439	(0.453)	0.090	(0.408)	-0.017	(0.528)	-0.026	(0.554)	-0.128	(0.552)
Social class												
Higher managerial	-0.498	(0.361)	-0.851**	(0.360)	-0.812**	(0.377)	0.155	(0.419)	-0.005	(0.411)	0.082	(0.417)
Lower managerial	-0.794**	(0.343)	-1.096***	(0.338)	-0.866**	(0.353)	-0.022	(0.392)	-0.183	(0.380)	-0.060	(0.391)
Intermediate	-1.108***	(0.391)	-1.228***	(0.391)	-1.346***	(0.404)	-0.526	(0.457)	-0.612	(0.446)	-0.573	(0.453)
Small employer	-0.688*	(0.371)	-0.896**	(0.366)	-0.877**	(0.383)	0.282	(0.419)	0.145	(0.405)	0.217	(0.413)
Lower supervisor	-1.060***	(0.406)	-1.277***	(0.406)	-1.283***	(0.442)	0.053	(0.441)	-0.064	(0.429)	0.004	(0.438)
Semi-routine	-0.984**	(0.393)	-1.073***	(0.389)	-1.107***	(0.418)	-0.143	(0.436)	-0.149	(0.418)	-0.099	(0.430)
Reference: Routine												
Unemployed	-0.592	(0.586)	-0.860	(0.600)	-0.761	(0.535)	0.084	(0.622)	-0.060	(0.610)	0.009	(0.605)
Mother has a degree	-0.149	(0.168)	-0.338*	(0.174)	-0.391**	(0.185)	-0.198	(0.203)	-0.310	(0.207)	-0.330	(0.209)
Father has a degree	-0.172	(0.178)	-0.272	(0.183)	-0.380*	(0.196)	-0.304	(0.211)	-0.381*	(0.218)	-0.410*	(0.219)
Income	0.009*	(0.005)	0.006	(0.005)	0.003	(0.005)	0.001	(0.006)	-0.002	(0.006)	-0.002	(0.006)
Independent School	-0.090	(0.361)	-0.039	(0.378)	0.146	(0.337)	0.359	(0.402)	0.366	(0.428)	0.385	(0.426)
Prior attainment												
GCSE score			0.448***	(0.099)	0.103	(0.117)			0.167	(0.107)	0.027	(0.109)
KS2 Math			0.274***	(0.101)	0.170	(0.117)			0.208*	(0.117)	0.011	(0.108)
KS2 Science			0.264***	(0.101)	-0.106	(0.114)			-0.085	(0.111)	0.175	(0.110)
KS2 English			-0.349***	(0.096)	0.028	(0.108)			-0.015	(0.110)	-0.147	(0.101)
Choose STEM A-level					2.099***	(0.171)					0.450**	(0.200)
N	1,846 (806/ 496)											

* p < 0.10, ** p < 0.05, *** p < 0.01

*Model 1 includes student's family background indicators, in Model 2 student's prior academic attainment is included and Model 3 includes an indicator for choice of at least one STEM A-level.

Figures 8 & 9: Increase in the relationship between ethnicity and STEM degree choice, when conditioning on academic attainment*

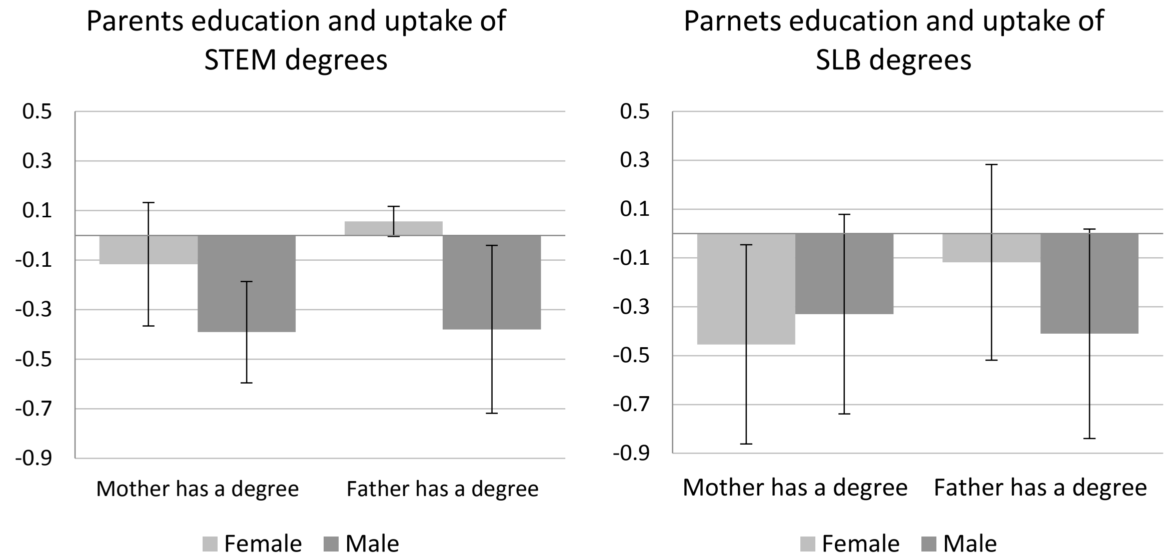


For female students, having a father with a degree or higher is not strongly associated with choice (there is a small positive association with choice of STEM degree before conditioning on attainment). Mothers' highest educational qualification is, however, associated with choice of SLB degree. For SLB subjects there is a clear negative relationship between mothers' education and uptake; students are around 45-50 percentage points less likely to study SLB if their mother has a degree. Overall, accounting for prior attainment does not reduce associations substantially. This is in contrast with findings from A-level choice, where accounting for attainment did reduce the influence of parents' education for young women. This suggests there are family background influences over and above those on attainment, exerting additional influence on female students' choices to continue studying STEM subjects from A-level to degree, but not for choosing STEM A-levels.

Associations differ for male students, where both fathers' and mothers' education level is associated with choice. Male students whose parents have a degree or higher qualification are less likely to study STEM than arts and humanities. The association between mothers' education and uptake is only significant once prior attainment is included in the models. When accounting for A-level choice the association between mothers' education and uptake increases, and the association between fathers' education and uptake becomes significant. This suggests that although there are family background differences in male students choice over and above that exerted on academic attainment and A-level subject choice. For both male and female students there appears to be an additional 'leak in the pipeline' when considering degree choice for girls with mothers with lower education levels, and boys with parents with higher education levels.

* The base category is white students. The first bar represents odds before controlling for prior academic attainment, given family background. The second bar represents odds after attainment is included in the model. Marginal effects and 95% confidence intervals are shown.

Figures 10 & 11: Gender differences of students' likelihood of studying a STEM or SLB degree by parents' highest education qualification after controlling for students prior attainment and A-level choice.*



It might be expected, given STEM and SLB subjects offer higher financial returns, family income would be associated with choice. Students from higher income families may be more concerned with financial returns after study (e.g. Davies *et al.*, 2013). Conversely, students from lower income families may be more inclined to avoid more risky subjects when considering outcomes (e.g. Breen and Goldthorpe, 1997). It is also possible that students' family income is associated with knowledge of relative returns of different degree subjects. Despite this, and raw statistics indicating otherwise, when taking account of other student characteristics family income is not related to subject studied. There is indication independently educated girls are less likely to study STEM degree by around 70 percentage points, and although not statistically significant independently educated boys in this sample are more likely to choose SLB subjects.

There are clear gender differences in the association between prior attainment and degree choice. Whilst female students are only around 15 percentage points more likely to study STEM subjects with each standard deviation increase in GCSE score, boys are 46 percentage points likely to choose STEM. Prior attainment in KS2 maths seems to have a strong association with uptake of both STEM and SLB subjects and Science KS2 scores are associated with males' choice of STEM but not females. For all students English had a negative association with uptake of STEM subjects.

* The base category is students whose fathers or mothers have no qualifications. Marginal effects are given after students other family background; ethnicity and prior academic attainment are controlled. 95% Confidence intervals are shown.

How do patterns of uptake differ by students' family background?

In contrast to A-level choices, gender and ethnicity differences in uptake differ across SEP groups. Tables 10 and 11 show that gender differences in uptake of both STEM and SLB subjects are largely driven by differences between low SEP young men and women. Low SEP men are 7 percentage points more likely to be studying a STEM degree, and 6 percentage points less likely to study SLB, than women. For the high SEP students there is no difference in uptake. The interaction between ethnicity and SEP, however, goes in the opposite direction. Low SEP BME students were no more likely to study STEM subjects than white students, however for middle and high SEP students differences in uptake of STEM between white and BME students is 10 percentage points. For SLB subjects, for all SEP groups BME students' have higher uptake. This would be expected given that family background has an association with degree choice after controlling for academic attainment.

Tables 10 & 11: Results of logistic regression of choice of at least one STEM A-level, stratified by students SEP. Separate models for choice of STEM or LEM degrees. Marginal effects are shown with standard errors in parenthesis.*

STEM degree	**Low SEP**	**2nd SEP**	**High SEP**
Male	0.072**	0.063**	0.027
	(0.032)	(0.032)	(0.032)
BME	0.031	0.064	0.100**
	(0.031)	(0.040)	(0.046)
GCSE	0.084***	0.047	0.070***
	(0.020)	(0.031)	(0.025)
KS2 Math	0.068***	0.068***	0.028
	(0.023)	(0.024)	(0.028)
KS2 Science	-0.007	0.031	0.104***
	(0.021)	(0.024)	(0.027)
KS2 English	-0.057***	-0.052**	-0.110***
	(0.021)	(0.024)	(0.026)
N (N STEM degree)	1,539 (562)	1,289 (485)	1,307 (540)

SLB degree	**Low SEP**	**2nd SEP**	**High SEP**
Male	-0.060**	0.017	0.033
	(0.030)	(0.030)	(0.027)
BME	0.128***	0.100***	0.068**
	(0.026)	(0.033)	(0.030)
GCSE	-0.039**	-0.028	-0.025
	(0.018)	(0.020)	(0.019)
KS2 Math	0.017	0.054**	0.023
	(0.021)	(0.023)	(0.021)
KS2 Science	0.015	-0.085***	-0.054***
	(0.020)	(0.022)	(0.021)
KS2 English	0.005	0.030	0.020
	(0.020)	(0.022)	(0.018)
N (N SLB degree)	1,539 (513)	1,289 (348)	1,307 (294)

* p < 0.10, ** p < 0.05, *** p < 0.01

* 22.7% of the most advantage students were BME compared with 30.1% in the middle group and 56% of the most disadvantaged students.

5. Discussion

This paper aimed to both describe disparities in student's subject choices by their family background, ethnicity and gender, and to unpick the more complex relationships between these characteristics. I focused specifically on uptake of STEM subjects at degree and A-level, thought have high levels of disparities in uptake across student characteristics and numerous benefits to both individuals and the UK as a whole. For degree level choices this was compared with uptake of another group of subjects, SLB subjects, known to offer higher returns on graduation to individuals, and with arts and humanities subjects. Although research into educational achievement disparities have started to look at how student characteristics interact to produce outcomes, rather than simply looking at them as additively leading to deficit in attainment, studies of students subject choices have not yet considered more complex models. The study addressed this by looking at whether family background could explain disparities in uptake by student's ethnicity, whether patterns of choice differed for male and female students, or across socio-economic groups.

The findings compliment a growing literature profiling disparities in uptake of STEM subjects (e.g. Boaler, Altendorff and Kent, 2011; Botcherby and Buckner, 2012; Gorard, See and Smith, 2008). Female students are less likely to choose STEM subjects in this large, representative sample of students studying in England. Students of minority ethnic groups were more likely to study STEM and SLB subjects given family background, and this association increased considerably when taking account of students' prior attainment. Although there were similar patterns of uptake by students' ethnicity across genders, there are large differences between Black African and white female, but not male, students in choices. This is in contrast to raw data suggesting Black African and Caribbean students are less likely to study STEM subjects when family background is not accounted for (Boaler, Altendorff and Kent, 2011). It is possible the underlying reasons for these differences, whether driven by cultural differences or biases (institutional or individual), are affecting girls rather than boys.

Research into institutional biases in STEM subjects points to particularly low representations of Black individuals in school text books (Frost *et al.*, 2005). Furthermore, ability grouping has been identified as a possible cause of decreased uptake in STEM subjects particularly (grouping is more prevalent in these subjects) and research has shown Black Caribbean students, given attainment, are more likely to be put into lower sets (Strand, 2007). Despite these biases, given attainment and family background black African and Caribbean students, particularly girls, are much more likely to study STEM A-levels. This suggests there are other factors, possibly relating to family and cultural attitudes towards STEM and SLB subjects, which overcome any institutional biases. A full understanding for the reasons behind the increased ethnic diversity in STEM and SLB subjects is beyond the scope of this paper.

The paper adds to the literature by considering a more comprehensive range of indicators of student's family background including family income, parent's education and occupational status, and type of school attended. There are some interactions between student's gender and family background; for male students social class is associated with degree choice but not with A-level choice. Parents' education is positively related to STEM A-level choice, and negatively related to degree choice (given A-level choices). For female students, fathers' education is positively related to choice of STEM A-levels but not degrees, and mothers' education is related to degree choices. Associations between degree choices and mothers' education persists when accounting for A-level choices, suggesting a leak in the pipeline for female students with parents who do not have a degree. If policy makers are interested in aiming interventions at increasing participation in STEM degree subjects, overall it appears encouraging higher attainment for low SEP students will have a large impact on uptake, however given the additional associations between uptake and parents education level especially, it seems that this would not close the gap entirely. Further research is required to fully understand why students with similar attainment profiles but differing family backgrounds are choosing different subjects, and why the gaps increase between A-level and degree subject choice.

It remains unclear why parents' education would have a larger positive impact for young women' choice of STEM subjects, after considering A-level choices. As with ethnicity, there are some institutional biases in STEM subjects observed by gender. Girls with the same academic attainment as boys are less likely to be rated as high achieving in maths by teachers (Campbell, 2013). Given the institutional factors at play throughout students' lives, it may be that the processes involved in overcoming stereotypes are also associated with students' background. In contrast, students from lower SEPs may be more likely to feel constrained by other characteristics (such as gender or ethnicity) and to feel they have less control over future which may in turn be related to uptake (e.g. Mau, Domnick and Ellsworth, 1995). Future research could focus on the relationships between students' personal characteristics, parental attitudes and behaviours, and disparities in uptake. Overall, this paper highlights the importance of considering interactive, rather than additive, relationships between students' background and uptake.

There are many strengths to the analysis presented. Based on observable characteristics, the LSYPE is generally representative of the population, and weights are applied where this is not the case. This is a recent sample, and students' subject choices in 2008 – 2010 are analysed. Furthermore, I have a rich range of student family background characteristics to draw evidence from, and the longitudinal nature of the dataset allows me to assess whether student circumstances at 13-14, can predict later subject choices. Despite these strengths, there remain some limitations to the study presented. Although weights have been applied to ensure the data are representative, these could only be modelled on observed characteristics, and it is possible that there are some unobserved characteristics related both with non-participation and subject choice. In addition, the majority of variables (with the exception of student attainment) are based on self-report from students and parents, which may lead to some measurement error (for example, social desirability considerations may affect participants' responses). Recent policy changes, such as the increase in the student fees cap from just over £3,000 per year, to £9,000 per year from 2012 may have an effect on students' subject choices, something that cannot be assessed in the current next steps cohort.

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