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Who studies STEM subjects at A level and degree in England? An investigation into the intersections between students' family background, gender and ethnicity in determining choice

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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 relationship between student characteristics and choice can be explained by academic disparities, and whether students' background, gender and ethnicity interact in determining university subject choices, rather than simply having additive effects. I use data from more than 4000 students in England from 'Next Steps' (previously the LSYPE) and logistic regression methods to explore the interacting relationships between student characteristics and subject choice. There are four main findings of this study. Firstly, disparities by students' ethnicity are shown to increase when controlling for prior attainment. Secondly, family background indicators are differentially related to uptake for male and female students, with parents' social class and education larger predictors of choice than financial resources. Thirdly, gender, ethnicity and family background interact in determining choices. Particularly, as socio-economic position increases, young women are more likely to choose STEM over other high-return subjects. Finally, associations between student characteristics and subject choices, including interactions, largely persisted when accounting for A-level choices. Implications for policy and future research are discussed.

Keywords: STEM; SES; ethnicity; gender; A level; Degree; subject choice

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) subjects, 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 stakeholders in industry working to further understand the full extent of the problem. The Social Market Foundation has identified an

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existing shortage of up to 40,000 workers with STEM skills, and considering trends in industry it is predicted that 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 the study of STEM subjects (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 General Certificate of Education (GCE) Advanced Level (A level) typically earn higher salaries later in life (Dolton & Vignoles, 2002; Greenwood *et al.*, 2011). Despite this, the problem of low uptake seems a particularly large concern in the UK, which has one of the lowest shares of 15-year-olds aspiring to pursue STEM careers of OECD countries (OECD, 2012). In the interests of the promotion of social mobility and equality of opportunity, it is important that individual benefits are not restricted by a student's social background, gender or ethnicity. Recent policy changes have led to an increase in post-compulsory mathematics qualifications available (Department for Education, 2014), which may contribute to increased basic skills in maths, however, they may not necessarily lead to an increase in participation at degree level. It is therefore important to understand which students do not study STEM subjects, and why particular groups have lower participation.

Prior research in the area has considered reasons for decreased participation in STEM subjects for all students, often with particular focus on gender disparities. Reasons put forward for lack of engagement include students' values, perceptions of the importance and relevance of STEM, shortages of maths and science teachers, perceptions that STEM subjects are more difficult or 'boring' compared with other subjects (Wynarczyk & Hale, 2008), and teaching methods and styles (e.g. Gilbert, 2006; Pampaka *et al.*, 2012a,b). In response to decreasing participation, a large research initiative—the Targeted Initiative on Science and Maths Education (TISME)—was set up in the UK. Key findings from five large-scale projects included that the perception of ability and knowledge of usefulness of STEM appeared to drive issues with uptake, rather than interest in or enjoyment of science (TISME, 2013). Furthermore, science capital in families was an important driver of choice; students whose parents were engaged with STEM or worked in STEM careers were more likely to study STEM further (Archer *et al.*, 2012). There is less research, however, on how these mechanisms relate specifically to student characteristics, especially in respect to students' background and ethnicity. An important prerequisite to understanding exactly which mechanisms lead to decreased engagement amongst particular groups is to fully understand which student characteristics are associated with choice, and how.

Family background, gender, ethnicity and subject choice

Family background is a key predictor of students' academic progress; a strong association persists between income and achievement across subjects in the UK (see The Royal Society, 2008). In consideration of this relationship, there is a growing literature detailing how this translates into access inequalities in Higher Education (HE) (e.g. Gayle *et al.*, 2003; Blanden & Gregg, 2004; Anders, 2012), however, the question of subject choices is relatively under-researched in the UK. The Royal Society

identified prior attainment as the strongest predictor of subject choice (The Royal Society, 2008), and considering there are large differences in attainment by students' background, it is possible that disparities in uptake by social position reflect these academic disparities.

Research in the UK reveals some association between family background and subject choice. Van de Werfhorst *et al.* (2003), using the 1958 British Birth Cohort Study, found that social class was related to choice of prestigious fields of study, including medicine and law, at university. Focusing on STEM subjects directly, Gorard *et al.* (2008) showed a clear disparity in numbers of students choosing to study STEM subject post-16 by Free School Meal (FSM) status (a measure of disadvantage based on students' family income; students whose parents earn below a certain threshold are eligible for free school lunches in the UK). Although lower attainment amongst students eligible for FSM was shown to be an important reason why they may be more reluctant to study STEM, the authors argue that this does not fully explain disparities by levels of advantage. Research into students' background and science participation has shown that students' social class is associated with science capital, which would lead us to expect students' background to be positively related to participation (Archer *et al.*, 2012). It is clear, however, that the relationship between background and uptake, given prior attainment, has yet to be fully unpicked.

Sociological theory offers some insight into why educational inequalities by students' social background emerge. According to Boudon's (1974) model of relative risk aversion, extended formally by Breen and Goldthorpe (1997), individuals will aim for a social position that is at least as good as their parents', with the key motivation of avoiding downward mobility (Breen & Yaish, 2006). The theory's implications for vertical stratification are clear; students from higher socio-economic status (SES) backgrounds would be more likely to attend university, as this will be necessary for maintaining their social position. For horizontal stratification, however, the picture is less clear. On the one hand, students from higher SES groups may be more concerned about choosing subjects with higher returns upon graduation (including STEM subjects). For students from more working-class backgrounds, or with parents having few qualifications, by studying any subject at A level or university they will be moving up the social ladder. In accordance with this interpretation, Davies *et al.* (2013) found that students from higher socio-economic backgrounds were more concerned with financial returns when making educational choices. Conversely, the theory could suggest that more disadvantaged students will be *more* concerned with returns to subjects than their peers. For students from lower SES groups, there may be more risks associated with the study of arts and humanities subjects. More advantaged students will usually have more networks to draw on after graduation, and may be able to receive more financial help from parents when gaining additional work experience (for example, through unpaid internships), and therefore be inclined to choose subjects that return more social capital. In line with this interpretation, Ma (2009) shows that in a US sample, when accounting for prior attainment, lower SES students were more likely to study technical and business majors.

There are also 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 sectors in the UK held by women (Kirkup *et al.*, 2010).

HESA statistics show that in 2013–2014, female students made up 48.3% of STEM undergraduates compared with 56.2% of students overall, and in engineering and technology subjects less than 10% of students were female (Equality Challenge Unit, 2014). For A levels, female students are less likely to study maths, physics and chemistry than male students, and more likely to study biology (Joint Council for Qualifications, 2014).

Unlike inequality in participation by students' family background, prior attainment cannot explain disparities by gender. There is a wealth of research considering difference in ability as the cause of gender disparities, however, this has been largely dismissed (Linn & Hyde, 1989) and it is widely accepted that in general, women and men are similar in abilities (Hyde, 2005). After conditioning on attainment, gender remains the largest predictor of uptake of maths at university (Noyes, 2009). 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 in other subjects, and therefore have more choice. Wang *et al.* (2013) show that students in a US college with high maths and verbal test scores were less likely to be working in STEM fields than those with high maths scores and average verbal scores. In consideration of these findings, the study presented considers the relationship between students' grades in maths, science and English individually, and whether English ability has a negative association with uptake.

The relationship between ethnicity and participation in particular subjects is complex, and strongly intertwined with family background, gender and prior attainment in the UK. In terms of academic capabilities, Strand (2007) studied Next Steps to understand the extent of differences in student attainment by ethnicity, showing that 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. Differences in attainment generally even out by GCSE exams, with Black and Minority Ethnicity (BME) students having progressed at a faster rate than their White peers (Strand, 2014).

Disparities in subject choice do not follow predicted patterns, given the relationship between attainment, family background and uptake of STEM subjects. Previous research looking across characteristics and using the Youth Cohort Study (YCS), the Labour Force Survey (LFS) and the Higher Education Statistics Agency (HESA) statistics showed that Chinese and Indian students were most likely to participate in Science, Engineering and Technology (SET) occupations, whilst African and Caribbean students, and Bangladeshi girls, were notably under-represented (Jones & Elias, 2005). The most recent data from HESA shows that 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 maths (Boaler *et al.*, 2011). It is likely that BME participation in STEM subjects will increase when taking into account students' prior attainment.

The reasons behind the increased uptake of STEM subjects amongst BME students are unclear. Research into biases in education point to numerous institutional disadvantages, particularly for black students. For example, there are particularly low representations of black individuals in science textbooks (Frost *et al.*, 2005), and Black Caribbean students, given their attainment, are more likely to be put into lower ability groups (Strand, 2007). The latter is of particular concern in STEM subjects, where ability grouping is most often used (Kutnick *et al.*, 2005). This may explain why black students appear least likely to study STEM subjects when compared with other minority ethnicity students, however, it does not explain why white students also appear to be under-represented. The relatively high ethnic diversity in STEM subjects is mirrored by a relative lack of diversity in arts and humanities subjects. It is possible that BME students are rejecting arts and humanities subjects, leading to higher proportions choosing STEM. Recent work has highlighted the issues of diversity in university curricula in the UK (Mirza & Joseph, 2013; Peters, 2015), especially considering the lack of representation of BME individuals in philosophy, literature and history education.

Following a review of the literature in research detailing the relationship between ethnicity and attainment, Warikoo and Carter (2009) argue that 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. The current paper aims to address this by considering how student characteristics interact to influence their choices. For example, although gender and family background may both be negatively associated with choice, the magnitude and direction of the relationship between subject choice and student background may differ when we look within genders. There is a strong tradition in qualitative study of looking at the intersections between individuals' characteristics; at how individuals' experiences, given their characteristics, interact in more complex ways in producing disparities in outcomes (e.g. Crenshaw, 1989). Recent quantitative research looking into academic disparities has shown evidence for interactions (e.g. Dekkers *et al.*, 2000; Kingdon & Cassen, 2010; Strand, 2014).

Research questions

- What is the relationship between students' family background, gender and ethnicity with choice of STEM study at A level and university?
- Can disparities in uptake be explained by students' prior academic attainment?
- Do students' characteristics interact in determining choices?

This paper proceeds as follows. The first section describes, under 'methodology', the data used for analysis, relevant variables and analytical strategy. The second section quantifies the proportions of students studying STEM at A level by students' gender, ethnicity and family background, and interactions between these characteristics. The third section considers HE subject choices. The fourth section concludes with a discussion of results and possible implications for policy and research.

Methodology

Data

I use Next Steps, previously the Longitudinal Study of Young People in England (LSYPE), a representative panel dataset including interviews, surveys and demographic information for young people and their parents or carers in England. The longitudinal nature of the data allowed me to compare student characteristics collected at age 14, with choices at age 18–19, eliminating the possibility that subject studied would influence the reporting of characteristics.

The study started in 2004, with the most recent wave of data collected in 2010. The sampling strategy for the study was twofold. Firstly, schools were sampled, with a focus on oversampling schools in deprived areas. Secondly, pupils within schools were sampled, with a focus on oversampling students from BME backgrounds. Owing to practical considerations, home-educated students, boarding students, students in schools with very small class sizes and students in the UK only for educational purposes were excluded from the study. Whilst the first four waves were collected via face-to-face interviews with young people and their parents or carers, the next three waves also employed telephone and Web-based survey methods. Full specifications of the sampling procedures employed in the study, and methods of data collection, can be found in the LSYPE user guide (Department for Education, 2011). The data has been linked with the National Pupil Database (NPD), giving detailed information on students' academic attainment across school years.

For key variables including the outcome (subject choice), ethnicity and gender, analysis is only carried out for individuals who gave valid responses. To retain adequate sample sizes, and avoid losing rich information on students who may have missing responses on a few variables, multiple imputation methods using chained equations were used for all other variables. It was not, however, considered meaningful to model students' ethnicity and gender based on other variables in the dataset. A total of 8494 students participated in Wave 1 and Wave 7 data collection (from which I draw my data), of which 4165 students had studied A levels and 4172 students were studying in HE, and gave valid responses for subject studied. Three students refused to report ethnicity, and a further 34 students from the A-level sample, and 37 from the degree sample, did not report sex. The final sample, therefore, was 4128 students studying A levels and 4132 students studying in HE. Table 1 further illustrates how the final samples were reached.

Table 1. Final sample size for this study compared with initial sample

Sample	Number of students	
	A level	Degree
Participated in Waves 1 and 7	8494	8494
Studied A levels, or in HE, and reported subject choices	4165	4172
Reported subject choices, gender and ethnicity	4128	4132

In consideration of issues relating to attrition, weights provided and calculated by the UK data services (Department for Education, 2011) have been used for analysis. Weights for final analysis took into account the probability of students being in the initial sample (design weights) and the probability of response based on key variables (estimated through logistic regression methods). For Wave 7, variables associated with attrition included: gender, ethnic group, housing tenure, interview month, HE application status, and some behavioural traits. The purpose of using weights is to ensure that the sample remains representative of the population, and reduce the probability of bias due to differences in response rates. It is acknowledged that calculating weights is a complex process for longitudinal data, and that weights can only be applied based on students observed, and not unobserved characteristics. It is possible that there are unobserved characteristics, such as motivation, which may be associated with attrition, student characteristics and subject choice.

Key variables

Subject choice. Students' choice of 'at least one STEM A level', compared with studying no STEM subjects at A level, was modelled as a binary choice. STEM subjects at A level included maths, further maths, physics, chemistry and biology. Students in England typically study between three and four A levels, so their A-level choices may tell us less than HE choices about their future outcomes and careers. There remains a considerable financial return, however, to the study of STEM A levels, independent of HE subject choice [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 two or more) for entry.

Students' subject choices at university were modelled as a categorical choice with three levels: STEM subjects; arts and humanities subjects; Social Sciences, Law and Business & administrative (SLB) subjects. STEM subjects in HE included: medicine and dentistry; subjects allied to medicine; biological sciences; veterinary sciences, agriculture and related; physical sciences; mathematical and computer sciences and engineering and technologies. 38.4% of students studied a STEM subject. All subjects considered under the broad umbrella of science were included in the STEM category during analysis, following research into STEM uptake also including biological and medical science (e.g. Botcherby & Buckner, 2012; Equality Challenge Unit, 2014). Whilst it is acknowledged that the largest gender disparities in uptake occur in physical sciences, and for biological and medical sciences this disparity isn't as large (see Boaler *et al.*, 2011; Equality Challenge Unit, 2014), there remain large disparities in uptake of medicine and biological science by students' ethnicity and family background (van de Werfhorst *et al.*, 2002; Equality Challenge Unit, 2014). Furthermore, it is clearly of policy interest to increase uptake of medical and biological sciences.

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 identified individually. Instead, I included an indicator for students studying social studies (including economics), law and business & administrative studies, making up 29.9% of students. Remaining subject choices included: architecture, building and planning; linguistics, European languages; Eastern literature; history and philosophy; creative arts; education.

Family background. For initial analysis considering which family background indicators explain variation in subject choice, mothers' and fathers' highest academic qualification (degree and higher, A level and some HE, GCSEs and below), parents' NS-SEC occupational class (secretarial, intermediate, working class, long-term unemployed)¹ and students' gross family income² were included in all models.

Following prior research into family background differences in academic outcomes (e.g. Chowdry *et al.*, 2011), an individual score was computed for each student to determine their socio-economic position (SEP) based on the following variables: how well the household is managing on finances; highest qualification of parents (whichever was highest); family's NS-SEC class and household tenure. I use polychoric principal components analysis (PCA) to identify a factor score and rank for each student. Although PCA is typically only appropriate for continuous variables, polychoric PCA has been shown to be an appropriate method for combining ordinal variables (see Kolenikov & Angeles, 2004). For the A-level and HE sample, the PCA factor explains 66% and 64%, respectively, of the variation in these indicators. In contrast to much prior research, 'eligibility' for FSM status was not used as a measure of economic status. 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 models. This follows research suggesting that independent-school students are more likely to study STEM and traditional subjects (e.g. CaSE, 2014). It is important to note that in Next Steps, independently educated students are under-represented; 3.4% of students in the initial sample were independently educated compared with around 7% across England.

Attainment. Students' attainment was taken from NPD records; students' capped GCSE scores and individual scores in KS2 maths, science and English were included in the analysis. When splitting students into two attainment groups, above median attainment or below, large differences in participation by attainment are observed. Table 2 compares descriptive proportions of students in the high-attaining half of students by subject group. 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% of students taking a STEM A level achieved above median scores. In line with A-level choices, students studying STEM subjects in HE are more likely to have higher scores across all indicators of attainment, except KS2 English, and those studying SLB have the lowest scores on average on all indicators except KS2 maths.

Table 2. Proportions of students scoring above average (compared with other cohort members) participating in each degree subject group, and for those taking at least one STEM subject at A level

Subject	Take at least one 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%

Analytical strategy

I first present raw descriptive statistics for students' choice of STEM A level, and of STEM and SLB subjects in HE, comparing proportions of students choosing each group of subjects by ethnicity and family background across genders. To understand which characteristics are most important in explaining students' subject choices, and how students' family background, gender and ethnicity interact in determining choice, I use logistic regression models. Regression methods identify the unique associations of each predictor variable with students' choices, thus allowing identification of which student characteristics explain the largest proportion of variance in choice, whilst other predictors are held constant.

Models are built up in three stages. Model 1 predicts students' subject choices based on their characteristics only. For A-level choices this is choice of at least one STEM A level compared with no STEM A levels. For degree subject choice, this is choice of STEM, SLB or arts and humanities subjects. Model 2 controls for prior attainment across subjects, and Model 3 includes interaction terms. For degree choices an additional fourth model is run, which also includes indicators for whether students studied STEM subjects at A level, to assess whether associations between student characteristics and degree choices are significant over and above their relationship with A-level choices.

The motivation for including all characteristics in the first model, rather than looking at raw proportions, is that student characteristics are strongly correlated. For example, students' SEB 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 claiming FSM (Bhattacharyya *et al.*, 2003) or in relative income poverty (Kenway & Palmer, 2007). For this reason, it is likely that models not taking account of both student characteristics will under or over-estimate the diversity of uptake of STEM subjects. In the samples used for analysis, there are large differences in students' family background by their ethnicity. Table 3 outlines the proportions of students claiming FSM by ethnicity, which broadly reflect the proportions reported by Bhattacharyya *et al.* (2003). Students' attainment is also related to characteristics; students from lower SEBs especially are more likely to have lower levels of prior attainment, so it would be expected that some of the differences in subject

Table 3. Differences in proportions of students claiming FSM by ethnicity¹

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%

¹Taken from the sample attending university; results were similar for the A-level sample.

choice (especially choice of STEM subjects, which are considered ‘harder’ than other subjects) would reduce when accounting for attainment.

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

Students typically study between three and four A levels, and given university entrance requirements it is unlikely that students who do not study at least one STEM A level will study a STEM subject at university. Proportions of female and male students from each ethnic group studying STEM A levels in the Next Steps sample are shown in Figure 1. As predicted, male students are more likely to study at least one STEM A level. Overall, Indian, Pakistani and ‘other ethnicity’ students are more likely to study STEM A levels than students from other ethnicities. White, Black African and Black Caribbean students have particularly low levels of relative uptake. There appear to be gender differences in uptake across the majority of ethnicities, with the exception of mixed ethnicity and Black Caribbean students, where there are no gender differences. Female students of mixed ethnicity and Black Caribbean ethnicity are more likely to study STEM A levels than white female students, whereas Black Caribbean male students are less likely to study STEM than white male students. For Bangladeshi students there is a particularly large gender disparity in proportions of students studying STEM, with just over 20% of young Bangladeshi women choosing STEM subjects at A level compared with over 50% of young Bangladeshi men.

Table 4 illustrates the relationship between students’ family background, gender and subject choice. Male students taking at least one STEM A level are more likely to be in higher income bands, and all students choosing STEM A levels are more likely to have parents with higher educational achievements and in higher occupational classes than students who were not studying any STEM subjects. They are also more likely to be attending independent schools, and to be in the highest SEP group.

Regression models of A-level subject choices

Logistic regression results of the relationship between students’ characteristics and subject choices are shown in Table 5. The first model includes students’ ethnicity, family background indicators and school type. The second model additionally

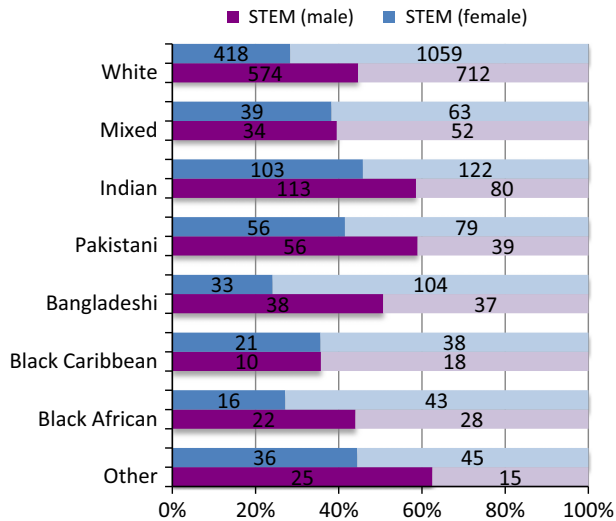


Figure 1. Raw proportions of students who completed at least one STEM A level by ethnicity [Colour figure can be viewed at wileyonlinelibrary.com]

Table 4. Family background characteristics of female (male) students completing at least one STEM A level¹

Subject	Take at least 1 STEM subject	No STEM subject
Median income band	£28,600–£31,200 (£31,200–£33,800)	£28,600–£31,200 (£28,600–£31,200)
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%)

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

includes students' prior academic attainment and the third model includes interaction terms. Figure 2 illustrates differences in students' odds of choosing at least one STEM A level by ethnicity, with the blue dots illustrating odds before conditioning on attainment (taken from Model 1) and the purple dots illustrating odds after conditioning on attainment (taken from Model 2). Differences in choices by ethnicity broadly reflect raw associations, however, Figure 2 shows that with the addition of prior attainment to the regressions, differences in uptake increase substantially. This suggests that the full extent of disparities in choice by ethnicity is suppressed by attainment differences, which influence choices in the opposite direction.

Table 5. Results of logistic regression of choice of STEM A level.¹ Odds ratios are shown with standard errors in parentheses

Variables	Model 1		Model 2		Model 3	
	OR	SE	OR	SE	OR	SE
Female	0.533***	0.041	0.499***	0.050	0.494***	0.055
Ethnicity (Ref: White)						
Mixed	1.389	0.307	1.468	0.438	1.056	0.535
Indian	2.570***	0.344	3.793***	0.665	3.747***	1.011
Pakistani	2.749***	0.497	5.260***	1.155	5.281***	1.639
Bangladeshi	1.424*	0.274	1.792**	0.434	3.283***	1.215
Black Caribbean	1.717*	0.536	3.877***	1.243	2.116	0.968
Black African	1.079	0.255	2.278***	0.716	1.867	0.924
Other	3.425***	0.868	3.914***	1.161	4.543***	2.559
Independent school	1.192	0.165	0.836	0.179	0.825	0.176
Mother Highest Qual. (Ref: GCSEs or lower)						
Degree or higher	1.172	0.136	0.676**	0.103	0.664***	0.102
A levels or some HE	0.957	0.092	0.752**	0.087	0.751**	0.087
Mum not present	0.393**	0.150	0.441**	0.166	0.442**	0.166
Father Highest Qual. (Ref: GCSEs or lower)						
Degree or higher	2.016***	0.252	1.541***	0.233	1.715***	0.289
A levels or some HE	1.216*	0.129	1.105	0.144	1.168	0.157
Dad not present	0.957	0.131	0.991	0.156	0.916	0.159
Social Class (Ref: Working class)						
Managerial	1.244*	0.146	1.007	0.142	1.051	0.156
Intermediate	1.119	0.145	1.173	0.175	1.195	0.181
Unemployed	0.817	0.209	0.901	0.287	0.858	0.296
Income	1.002	0.003	0.999	0.004	1.000	0.004
Attainment						
GCSE			3.354***	0.272	3.371***	0.274
KS2 math			2.278***	0.187	2.283***	0.189
KS2 science			1.248***	0.103	1.253***	0.103
KS2 English			0.537***	0.039	0.538***	0.039
Female × SEP					0.958	0.098
Ethnicity × SEP						
Mixed × SEP					0.715	0.215
Indian × SEP					0.813	0.155
Pakistani × SEP					1.002	0.213
Bangladeshi × SEP					0.691*	0.139
Black Caribbean × SEP					1.070	0.248
Black African × SEP					1.104	0.248
Other × SEP					1.008	0.197
Ethnicity × Sex						
Mixed × Female					1.818	1.121
Indian × Female					1.028	0.346
Pakistani × Female					0.946	0.382
Bangladeshi × Female					0.591	0.264
Black Caribbean × Female					2.037	1.147
Black African × Female					0.984	0.609
Other × Female					0.689	0.418
Constant	0.447***	0.063	0.506***	0.082	0.479***	0.082
Observations	4128		4128		4128	

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

¹Model 1 includes student's family background indicators; Model 2 includes student's prior academic attainment.

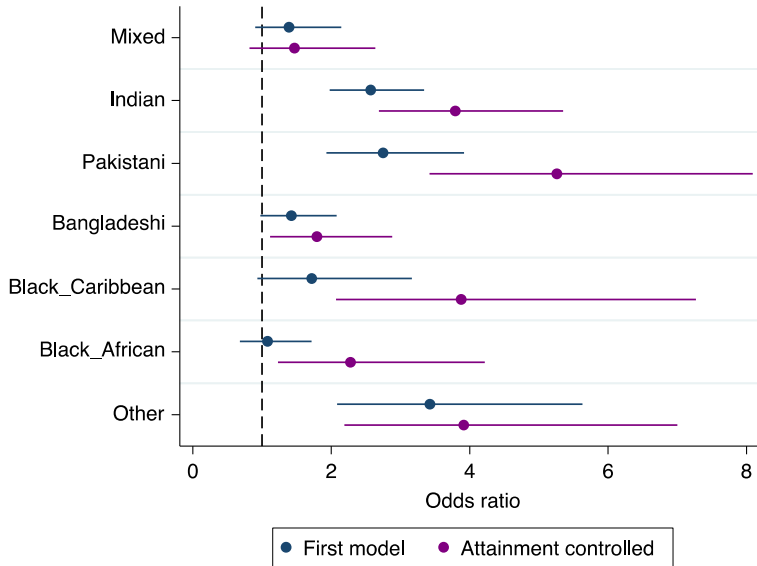


Figure 2. Students' odds of studying at least one STEM A level by ethnicity. The reference category is white students [Colour figure can be viewed at wileyonlinelibrary.com]

One possible reason why BME students may be more likely to choose higher-return STEM 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 that an increase in these attitudes and behaviours does not lead to proportionately higher academic attainment, they could influence student choices.

Students' social class and parents' education are both uniquely related to choices. Students whose parents work in managerial occupations are more likely to study STEM than students with parents in working-class occupations. The relationship is, however, fully explained by prior attainment. Students from higher social classes are more likely to achieve higher grades, which in turn predicts participation in STEM A levels. Parents' education levels have differing associations with STEM study, which persist when conditioning on attainment. Students whose mothers have a degree are less likely to study STEM A levels, whilst students whose fathers have a degree are more likely to study STEM A levels. Figure 3 illustrates this relationship between students' family background and choice of STEM A levels with all student characteristics, attainment measures and interaction terms controlled, showing how the association between both parents' education and choices persists, whilst other background characteristics are no longer significantly associated with choices.

Compared with other family background characteristics, parental income and whether students attended independent school are not associated with participation in STEM. This suggests that relationships between type of school and participation are driven by students' parents' education and social class, rather than differences in schooling.

Overall, students' prior attainment is positively associated with choice, with the exception of KS2 English attainment. This is in line with research by Wang *et al.*

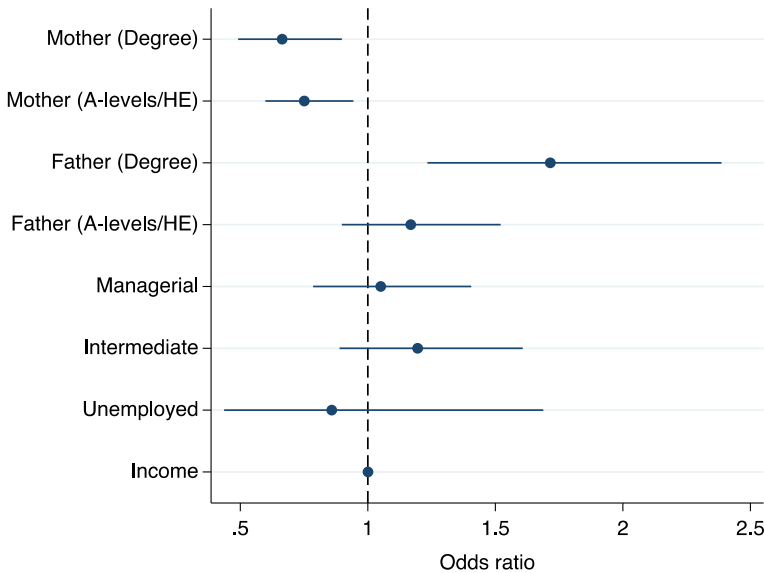


Figure 3. Students' odds of studying at least one STEM A level by family background characteristics. The reference category is students from working-class backgrounds whose parents do not have qualifications higher than GCSE [Colour figure can be viewed at wileyonlinelibrary.com]

(2013), and suggests that students who do well in English are choosing to pursue other subjects. It is noted that due to the issue of multicollinearity, care should be taken when interpreting the odds ratios on attainment scores; scores are likely to be highly correlated and therefore exact values would change considerably with the addition or subtraction of indicators in the model. As it stands, we can only confidently ascertain direction of association and the cumulative effect of attainment indicators on other associations.³

Overall, there are few interactions between student characteristics and A-level choices, the only exception being that more advantaged Bangladeshi students are less likely to pursue STEM subjects at A level.

How do student characteristics interact in determining HE subject choice?

There are well-established differences in choice 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 of ethnicity, HESA data covering students across the UK also reveals that overall, students from BME backgrounds are more likely to study STEM and SLB subjects and less likely to study arts and humanities subjects, although there is large heterogeneity between ethnic groups and subjects (Equality Challenge Unit, 2014). The Next Steps data also indicates that there are large differences in participation by students' gender and ethnicity, as shown in Figure 4. White students are least likely to study high-return SLB subjects, whilst Asian students are most highly represented, and this increase in uptake is mirrored by very low uptake of arts and humanities subjects. Black Caribbean and Black African students stand out as being particularly under-represented in STEM.

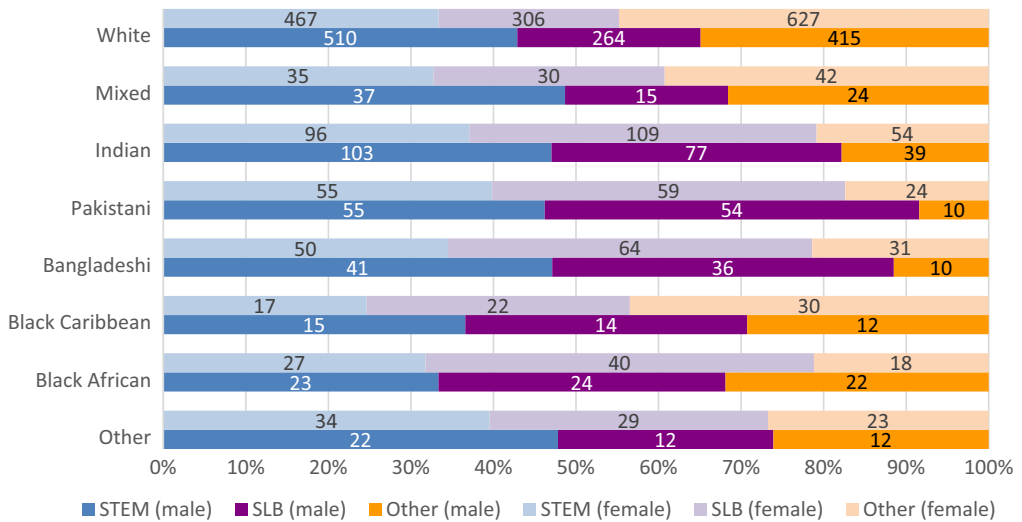


Figure 4. Raw proportions of students studying STEM, SLB or other subjects at university by gender and ethnicity [Colour figure can be viewed at wileyonlinelibrary.com]

Table 6 illustrates the raw relationships between family background, gender and subject choice. There are small differences in average income of students in each subject group. Female students studying SLB subjects have the lowest median family incomes, whereas young men studying either SLB or arts and humanities subjects have the lowest family incomes. Students studying STEM and arts and humanities subjects are most likely to have parents with a degree or higher, and in service-class occupations, compared with students studying SLB subjects. In contrast, SLB subjects 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.

Regression models of HE subject choices

Table 7 presents results from multinomial logistic regressions of the relationship between subject studied and students’ characteristics. Like A-level choices, regression models were built up in stages, with the first model including only student characteristics and school type, the second model conditioning on attainment and the third model including interaction terms. A fourth model is run, including indicators for whether students studied STEM at A level.

Differences in choice by ethnicity are strikingly large. The first model shows that, even after accounting for family background, students from BME backgrounds are less likely to study arts and humanities subjects, and more likely to study SLB subjects, than STEM subjects. Black Caribbean students and students of mixed ethnicity, however, are most similar to white students in their choices, and are no more likely to study STEM (see Figure 5).

Table 6. Family background characteristics of female (male) students choosing STEM, SLB or other degree subjects¹

Subject	STEM	SLB	Other
Median income band	£28,600–£31,200 (£31,200–£33,800)	£26,000–£28,600 (£26,000–£28,600)	£28,600–£31,200 (£26,000–£28,600)
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%)
Managerial class	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%)

¹Incomes are at 2003 prices, measured in Wave 1 data collection. ‘Service class’ includes parents in higher and lower managerial and professional occupations; parent with ‘at least some HE’ includes parents with some HE and those with a degree qualification or higher.

In line with raw associations and prior research, differences in uptake of STEM and other subjects are observed by students’ family background (Gorard *et al.*, 2008; The Royal Society, 2008). Whilst social class and family income are not significantly associated with choices, parental education (particularly mothers’ highest qualification) is. Students whose mothers have a degree are more likely to study arts and humanities than STEM subjects, even when prior attainment differences are taken into account. Students whose fathers have a degree are more likely to study STEM than SLB subjects, however, this relationship is fully explained by attainment differences (see Figure 6).

It might be expected, given that STEM and SLB subjects offer higher financial returns, that family income would be associated with choices, for example students from higher-income families may be more concerned with financial returns after study (e.g. Davies *et al.*, 2013). Alternatively, students from lower-income families may be more inclined to avoid more risky subjects when considering outcomes (e.g. Breen & Goldthorpe, 1997) and choose ‘easier’ subjects. Despite this, and raw statistics indicate otherwise, when taking account of other student characteristics, family income is not related to subject studied. In terms of schooling, there is an indication that independently educated students, all else held equal, are more likely to study high-return SLB subjects over STEM subjects.

Interactions are observed between students’ social background and gender, and between ethnicity and gender. As students’ SEP increases, young women are less likely to choose SLB subjects and more likely to choose to study STEM subjects. This suggests that young women from more deprived backgrounds may be particularly vulnerable to factors driving students away from STEM. Black African female students, however, are much more likely to choose STEM over arts and humanities.

Model 4 shows that when including indicators for whether students studied one STEM A level or two or more STEM A levels, results are largely similar. Students studying STEM at A level were considerably more likely to study STEM subjects at degree over both arts and humanities, and SLB subjects. Taking account of A-level choices did affect some ethnic differences in participation, for example Indian students who studied STEM at A level were not significantly more likely to choose

Table 7. Results of multinomial logistic regression of degree choice

Variables	Social sciences, business and law															
	Arts and humanities						Social sciences, business and law									
	Model 1		Model 2		Model 3		Model 4		Model 1		Model 2		Model 3		Model 4	
	RRR	SE	RRR	SE	RRR	SE	RRR	SE	RRR	SE	RRR	SE	RRR	SE	RRR	SE
Female	1.538***	0.131	1.330***	0.122	1.393***	0.146	1.065	0.124	1.211**	0.112	1.194*	0.120	1.191	0.146	0.917	0.121
Ethnicity (Ref: White)																
Mixed	0.978	0.229	0.943	0.226	1.125	0.393	1.149	0.439	1.276	0.336	1.261	0.342	0.836	0.356	0.860	0.385
Indian	0.490***	0.089	0.451***	0.084	0.509**	0.152	0.888	0.339	1.497***	0.214	1.417**	0.209	1.345	0.289	2.272***	0.653
Pakistani	0.235***	0.058	0.202***	0.049	0.186***	0.075	0.326**	0.142	1.426*	0.275	1.304	0.258	1.556*	0.387	2.713***	0.695
Bangladeshi	0.406***	0.110	0.369***	0.100	0.234***	0.107	0.345**	0.174	1.676***	0.332	1.648**	0.332	1.377	0.473	2.000*	0.733
Black Caribbean	0.928	0.314	0.667	0.263	0.675	0.310	0.662	0.310	1.304	0.443	1.124	0.387	1.311	0.584	1.250	0.576
Black African	0.671	0.170	0.499**	0.135	0.925	0.347	0.878	0.366	1.952***	0.464	1.683**	0.423	1.899*	0.729	1.842	0.721
Other	0.450***	0.130	0.450***	0.131	0.624	0.267	1.407	0.554	0.794	0.210	0.839	0.221	0.758	0.318	1.594	0.714
Independent school	1.472	0.376	1.458	0.382	1.438	0.369	1.288	0.337	1.781**	0.455	1.745**	0.449	1.754**	0.454	1.586*	0.412
Mother Highest Qual. (Ref: GCSEs or lower)																
Degree or higher	1.103	0.142	1.286*	0.176	1.294*	0.178	1.407**	0.217	0.785	0.120	0.882	0.138	0.881	0.139	0.955	0.167
A levels or some HE	0.947	0.101	1.010	0.110	1.012	0.111	0.929	0.111	0.995	0.117	1.035	0.123	1.038	0.124	0.960	0.125
Mum not present	0.850	0.340	0.806	0.316	0.782	0.307	0.672	0.272	1.041	0.401	1.008	0.393	1.039	0.409	0.932	0.369
Father Highest Qual. (Ref: GCSEs or lower)																
Degree or higher	0.875	0.123	1.011	0.148	0.981	0.186	1.320	0.269	0.702**	0.115	0.773	0.128	0.779	0.159	1.024	0.222
A levels or some HE	1.040	0.129	1.115	0.143	1.104	0.165	1.247	0.203	0.992	0.136	1.035	0.144	1.048	0.167	1.189	0.202
Dad not present	1.090	0.155	1.088	0.162	1.140	0.209	1.118	0.220	1.062	0.164	1.053	0.164	1.020	0.195	0.983	0.204
Social Class (Ref: Working class)																
Managerial	0.968	0.128	1.010	0.138	1.008	0.140	1.019	0.156	0.921	0.131	0.962	0.138	0.975	0.142	0.991	0.158
Intermediate	1.226	0.177	1.244	0.184	1.240	0.185	1.388**	0.230	1.124	0.170	1.138	0.173	1.145	0.176	1.279	0.212
Unemployed	1.274	0.377	1.267	0.383	1.315	0.410	1.293	0.417	0.855	0.237	0.850	0.234	0.845	0.246	0.833	0.253

Table 7. (Continued)

Variables	Arts and humanities				Social sciences, business and law											
	Model 1		Model 2		Model 3		Model 4		Model 1		Model 2		Model 3		Model 4	
	RRR	SE	RRR	SE	RRR	SE	RRR	SE	RRR	SE	RRR	SE	RRR	SE	RRR	SE
Income	1.000	0.004	1.002	0.004	1.001	0.004	1.006	0.004	1.001	0.004	1.002	0.005	1.002	0.005	1.006	0.005
Attainment																
GCSE			0.779***	0.061	0.775***	0.061	1.174**	0.093			0.732***	0.058	0.728***	0.058	1.089	0.094
KS2 math			0.677***	0.053	0.678***	0.054	0.877	0.076			1.039	0.092	1.041	0.093	1.314***	0.125
KS2 science			0.886	0.070	0.888	0.070	0.995	0.088			0.787***	0.067	0.786***	0.067	0.874	0.081
KS2 English			1.404***	0.119	1.405***	0.120	1.153*	0.097			1.296***	0.111	1.304***	0.111	1.094	0.097
Female × SEP					1.004	0.104	1.021	0.112					0.790**	0.087	0.798*	0.093
Ethnicity × SEP																
Mixed × SEP					1.276	0.270	1.517*	0.326					1.185	0.252	1.387	0.289
Indian × SEP					0.638**	0.134	0.666	0.167					0.880	0.144	0.917	0.165
Pakistani × SEP					1.072	0.233	1.072	0.239					1.203	0.238	1.225	0.236
Bangladeshi × SEP					0.985	0.214	1.079	0.259					0.814	0.177	0.867	0.196
Black Caribbean × SEP					0.998	0.295	0.980	0.295					0.906	0.238	0.878	0.251
Black African × SEP					0.976	0.209	0.916	0.218					1.184	0.246	1.125	0.255
Other × SEP					1.150	0.273	1.386	0.349					0.917	0.228	1.084	0.309
Ethnicity × Female																
Mixed × Female					0.828	0.391	0.965	0.478					2.047	1.133	2.369	1.331
Indian × Female					0.760	0.271	0.862	0.363					1.111	0.311	1.260	0.418
Pakistani × Female					1.168	0.577	1.295	0.666					0.813	0.293	0.883	0.308
Bangladeshi × Female					1.949	0.976	2.105	1.121					0.899	0.350	0.941	0.365

Table 7. (Continued)

Variables	Arts and humanities				Social sciences, business and law								
	Model 1		Model 2		Model 3		Model 4						
	RRR	SE	RRR	SE	RRR	SE	RRR	SE					
Black Caribbean × Female			0.976	0.694	1.382	0.979			0.637	0.409	0.859	0.566	
Black African × Female			0.290**	0.152	0.360*	0.202			0.985	0.475	1.203	0.627	
Other × Female			0.607	0.338	0.521	0.289			1.041	0.575	0.914	0.557	
Studied one STEM A level					0.268***	0.037					0.343***	0.049	
Studied two or more STEM A levels					0.034***	0.006					0.052***	0.009	
Constant	0.845	0.132	0.800	0.126	1.462**	0.271	0.618***	0.106	0.579***	0.102	0.568***	0.107	1.004
Observations	4135		4135		4135		4135		4135		4135		4135

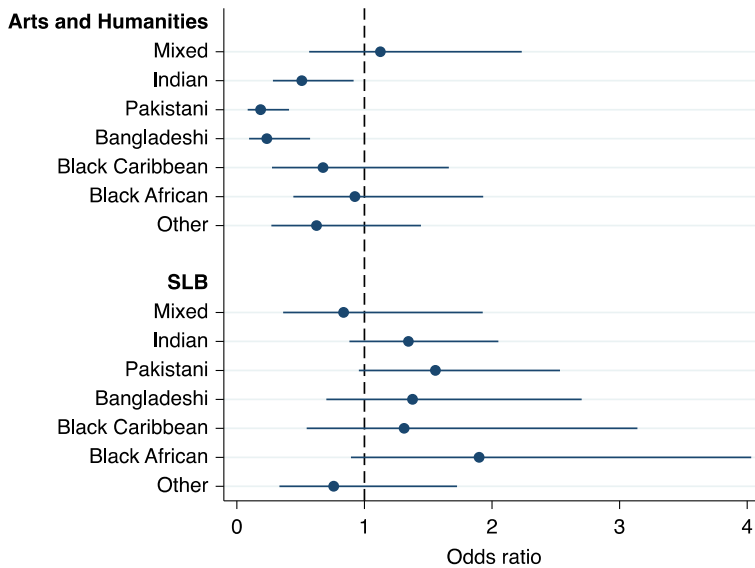


Figure 5. Students' odds of studying arts and humanities or SLB subjects over STEM subjects at university by ethnicity. The reference category is white students. Results from the final model are shown (including attainment and interaction effects) [Colour figure can be viewed at wileyonlinelibrary.com]

STEM over arts and humanities than white students who also studied STEM A levels. In contrast, when accounting for A-level choices, Pakistani and (to a lesser extent) Bangladeshi students were more likely to choose SLB over STEM compared with white students. The social background disparities persisted and increased somewhat, with students whose mothers had a degree remaining more likely to study arts and humanities than students with lower levels of education. The interactions between gender and SEP, and between Black African ethnicity and gender in determining uptake, also persisted.

Discussion

This paper aimed to describe disparities in students' 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 A level and HE because these subjects have high levels of disparity in uptake across student characteristics, as well as numerous benefits of study to both individuals and society. For HE choices this was compared with uptake of two other groups of subjects: SLB subjects, which offer higher returns on graduation to individuals, and arts and humanities subjects. Although research into educational achievement disparities has started to look at how student characteristics interact to produce outcomes, rather than simply how they additively lead 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 students' ethnicity, and whether patterns of choice differed for male and female students, or across socio-economic groups.

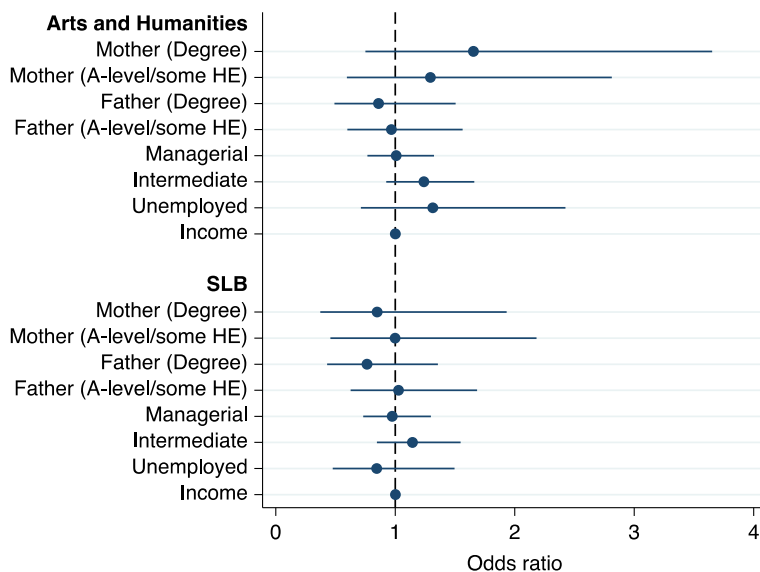


Figure 6. Students' odds of studying arts and humanities or SLB subjects over STEM subjects at university by family background. The reference category is students from working-class backgrounds whose parents do not have qualifications higher than GCSE. Results from the final model are shown (including attainment and interaction effects) [Colour figure can be viewed at wileyonlinelibrary.com]

The findings complement a growing literature profiling disparities in uptake of STEM subjects (e.g. Gorard *et al.*, 2008; Boaler *et al.*, 2011; Botcherby & Buckner, 2012). In the Next Steps sample, students of almost all minority ethnic groups were more likely to study STEM and SLB subjects given family background, and this association increased when taking account of their prior attainment. Although generally there were similar patterns of uptake by students' ethnicity across genders, the interaction between Black African ethnicity and gender suggests that Black African women are more likely to study STEM than arts and humanities. This is in contrast to raw data suggesting that Black African and Caribbean students are less likely to study STEM subjects when family background is not accounted for (Boaler *et al.*, 2011). It is possible that the underlying reasons for these differences, whether driven by cultural differences or biases (institutional or individual), are affecting young women and men differently. The findings offer additional evidence of the relative lack of ethnic diversity in arts and humanities subjects, where white students are disproportionately represented compared with all other ethnic groups. In terms of theories of relative risk aversion, given that there appear to be some additional barriers within HE and upon graduation for BME students, they may be making very rational choices to study subjects which have more secure prospects and higher financial returns. For example, research figures show that in the UK, minority ethnicity students are less likely to receive high degree classifications and are more likely to be unemployed after graduation (Runnymede Trust, 2014).

This paper adds to the literature by considering a more comprehensive range of indicators for students' family background, including income, parents' education,

occupational status and type of school attended. It appears that parental education, but not social class or financial resources, influence students' choices. Students studying STEM A levels are more likely to have fathers with a degree, and less likely to have mothers with a degree. At degree level, students whose mothers have a degree are most likely to study arts and humanities. It is possible that this relationship is related to the subject parents are educated in, and relative 'science capital' in the family (Archer *et al.*, 2012). As mothers are more likely to have non-science degrees than fathers, they may influence their children to study other subjects. Because the LSYPE data does not include subjects studied by parents, this isn't something that could be explored further in the current study.

The interaction between students' family background and gender suggests that young women from more advantaged backgrounds are more likely to choose STEM subjects, whilst those from relatively deprived backgrounds are more likely to study SLB subjects, which—although they offer high individual returns—are not considered 'difficult' compared with STEM subjects. In accordance with the theory of relative risk aversion, more advantaged female students may be choosing more 'risky' high-return subjects compared with their less advantaged peers.

As with ethnicity, there isn't sufficient evidence that young women have an innate difference in ability to young men, and much research has profiled the many institutional biases that may push young women away from STEM subjects. STEM subjects are stereotypically seen as more 'masculine' domains, and in school, girls with the same academic attainment as boys are less likely to be rated as high achieving in maths by teachers (Campbell, 2015) and less likely to receive positive reinforcement from teachers (Mujtaba & Reiss, 2012), which may affect self-efficacy beliefs. Although the reasons are unclear, girls are less likely to be interested in science, and more likely to be interested in people, than boys (Collings & Smithers, 1984). What sets this work apart is the finding that disparities are not constant, but differ by students' family circumstances. 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. Students from lower SEPs may be more likely to feel constrained by their gender and to feel that they have less control over their future, which may in turn be related to uptake (e.g. Mau *et al.*, 1995).

It could also be that students' family background is related to parents' attitudes and behaviours, which mediate the relationships observed. If mothers with higher education levels have more egalitarian views of gender roles (Crompton & Lyonette, 2005), these views may be transmitted to their children (Kulik, 2002; Antill *et al.*, 2003) and thus directly or indirectly influence young women's interests and values when choosing courses. Future research could focus specifically on whether student and parental attitudes and behaviours mediate the relationship between students' characteristics, SEP and subject choices.

There are various 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 included a rich set of student family background characteristics to draw evidence from, and the longitudinal nature of the dataset allows me to assess whether student circumstances at age 13–14 can

predict later subject choices. Despite these strengths, there remain some limitations to the study. 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 to both non-participation and subject choice. In addition, the majority of indicators (with the exception of student attainment) are based on self-report from students and parents, which may lead to some measurement error. Recent policy changes, such as the increase in the student fees cap 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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NOTES

- ¹ Taken from the family member with the highest income, or responsible for paying rent/mortgage.
- ² Gross family income was initially grouped into 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.
- ³ To test whether models were more robust when including only one measure of attainment, models were run with GCSE attainment indicators only, however, changes in coefficients on other variables were negligible.

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