

Subject Choice or Academic Attainment?

What is the relative importance of subject choice Vs academic attainment in predicting university outcomes in STEM subjects?

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Research Questions

To what extent is subject choice at A-level associated with academic attainment at university in STEM subjects?

How do any associations compare between A-level subjects and to prior attainment (as assessed by the top three A-level grades)?

Similar work

Widening access through admissions policy, Hoare and Johnston, 2010

Effects of A-level subject choice and tariff, King and Aves, 2011

Welsh Baccalaureate Qualification – Taylor 2013 and Yhnell et al. 2016

Predictive validity of level 3 qualifications, Cambridge Assessments, 2014

Curriculum reform

All the data presented here is pre-reform, however

Content changes to many STEM A-levels have been modest.

Data Set Summary

- 2014/15 & 2015/16 graduates from England and Wales
- Holding 3 or more A-levels
- Containing 122,799 STEM graduates
- JACS 3 Subject Areas 1-9
 - JACS 3 Principle Subjects A0-J9



Outcome Measure

Degree classification – binary logistic regression models examine 1st:2:1 Vs 2:2 3rd as well as individual degree classifications

Variables

Gender (male female), age (young/mature students), ethnicity (White, Non White), school funding type (private, state, other), year of graduation (2015, 2016), prior attainment (tariff of top 3 A-levels), A-level subjects, Welsh Baccalaureate Qualification, university mission group.

A-level subject proportions by JACS code (%)

%	Biol	Chem	Physic	ComSci	Engi	Psyc	Geog	Maths	FMATH
All STEM degrees	45.3	42.6	29.4	8.1	0.8	24	13.9	54.5	11
Biological Sciences	57.9	35.2	7.2	3.6	0.1	49.5	11.5	29.9	1.1
Mathematical Sciences	16	32.1	46.7	6.3	0.3	6.9	5.3	99.2	50.1

Degree Outcomes

%	1st + 2:1	First	Upper Second	Lower Second	Third	Total Number
All STEM degrees	80.5	31.6	48.9	16.6	3.0	122799
Biological Sciences	81.7	25.1	56.7	16.1	2.2	37340
Mathematical Sciences	73.2	36.4	36.8	20.9	5.9	11768

Exclusions

- Unclassified degrees – mostly clinical subjects
- Disability – (8.6%)
- Fluent Welsh Speakers (0.9%)

Collinearity

- POLAR data with School Type
- Welsh Baccalaureate and Welsh Domiciled

Variation between HEIs

- Taylor et al. (2013) divided the sector into more selective and less selective HEIs (Tariff)
- Separating into quintiles produces a variable that is collinear with prior attainment
- Mission group (including reinstating 1994 group) produces a variable that is no longer collinear with prior attainment but in which there are apparent differences between the outcomes of graduates between mission groups – a proxy for HEI diversity?

Results – All STEM degrees – 1st/2:1 Vs 2:2/3rd

Good Degree = 98,842 Nagelkerke pseudo R ² = 0.114		N	Wald	Sig.	Odds Ratio (Exp(B))	95% C.I.for EXP(B)	
						Lower	Upper
Gender	Male	61,308					
	Female	61491	484.4	0.000	1.445	1.398	1.493
Age Marker	Young	116,203					
	Mature	6,596	106.0	0.000	1.427	1.334	1.527
Ethnicity	Majority Group	86,906					
	Minority Group	35,893	1286.0	0.000	0.545	0.527	0.563
School Funding Type	State	98,986	101.5	0.000			
	Private	13,328	70.4	0.000	0.807	0.768	0.848
	Other	10,485	44.1	0.000	0.834	0.790	0.880
Academic Year	2014/2015	60,764					
	2015/2016	62,035	36.1	0.000	1.094	1.063	1.127
Prior Attainment	Top 3 Tariff		4374.9	0.000	1.010	1.010	1.011
	Per grade				1.230		
Welsh Bacc	No	120,903					
	Yes	1,896	15.1	0.000	0.797	0.710	0.894
Maths A Level	None	55,891	615.7	0.000			
	Single	53,378	14.2	0.000	1.075	1.035	1.116
	Further	13,530	362.6	0.000	0.555	0.522	0.589
STEM A Level Subjects	Biology	55,578	173.2	0.000	1.268	1.224	1.313
	Chemistry	52,337	1.3	0.246	1.021	0.986	1.058
	Physics	36,108	5.0	0.026	1.047	1.006	1.089
	Psychology	29,430	23.5	0.000	1.109	1.064	1.157
	Geography	17,095	16.0	0.000	1.100	1.050	1.153
Mission Group	None	37,204	294.0	0.000			
	Russell Group	46,725	95.6	0.000	0.803	0.769	0.839
	1994 Group	9,370	5.6	0.018	0.929	0.873	0.988
	University Alliance	22,574	94.5	0.000	1.233	1.182	1.287
	Million+ Group	6,926	62.1	0.000	1.292	1.212	1.377
	Constant			1374.7	0.000	0.185	

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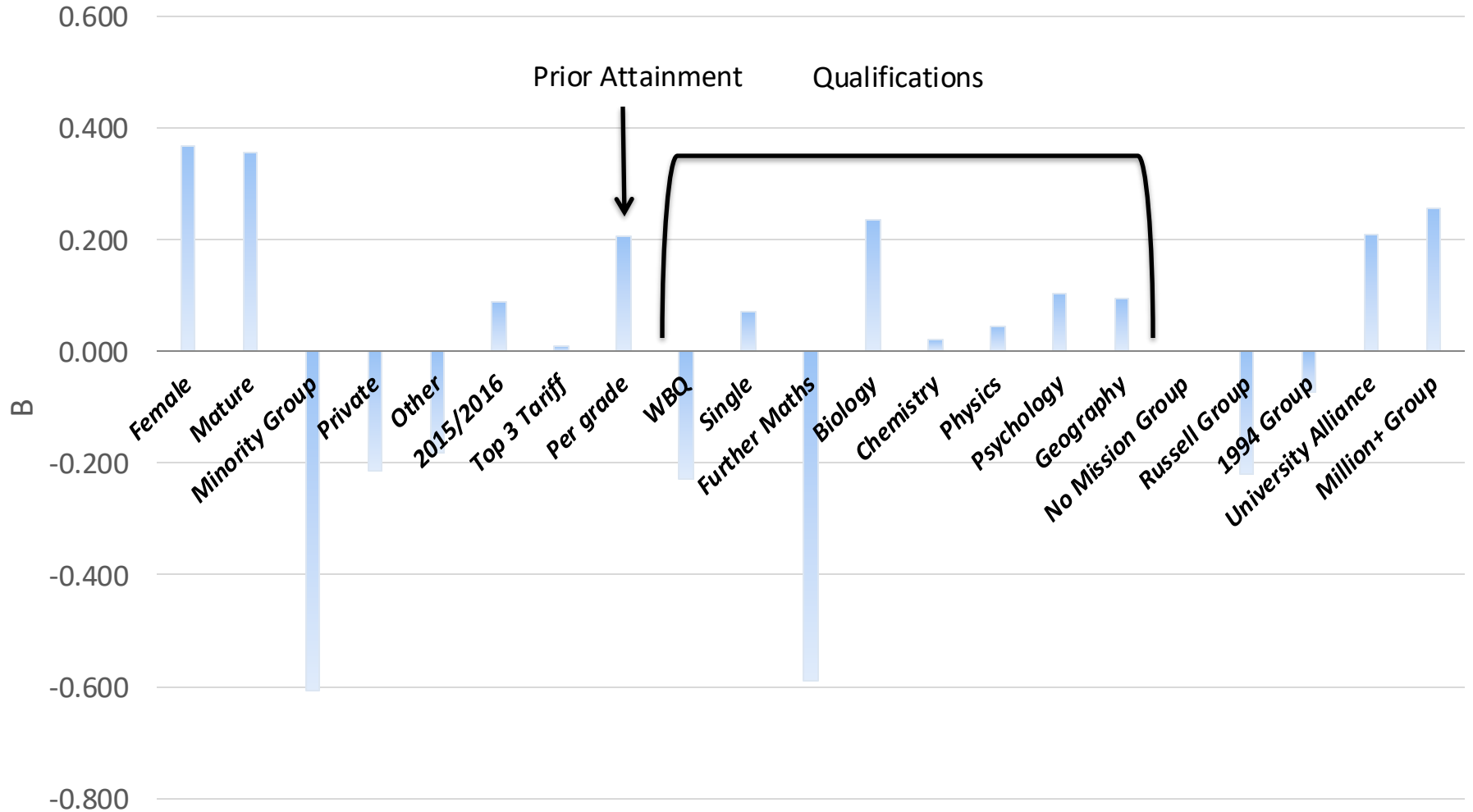
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	Psychology	29,430	23.5	0.000	1.109	1.064	1.157
	Geography	17,095	16.0	0.000	1.100	1.050	1.153

Points of interest

- The A-level contributing most to the fit of the model and with the highest odds ratio is Biology
 - Biological Sciences has the greatest number of students in HE STEM areas (by JACS code)
- The contribution of biology A-level is vastly outweighed by prior attainment and the impact of 1 or 2 A-level grades outweighs subject area. biology is also outweighed by gender, and ethnicity.
- Learners holding A-levels in mathematics and Further Mathematics appear to attain less well in HE than those without any mathematics A-levels

Results – All STEM degrees – 1st/2:1 Vs 2:2/3rd

All STEM - 1st/2:1 Vs 2:2/3



Results – All STEM degrees – Obtaining a 1st

1 st Class = 38,793 Nagelkerke pseudo R ² = 0.105		Wald	Sig.	Odds Ratio (Exp(B))	95% C.I. for EXP(B)	
					Lower	Upper
Gender	Male					
	Female	80.294	0.000	1.137	1.105	1.169
Age Marker	Young					
	Mature	635.877	0.000	2.041	1.931	2.157
Ethnicity	Majority Group					
	Minority Group	1223.894	0.000	0.571	0.553	0.589
School Funding Type	State	364.270	0.000			
	Private	355.677	0.000	0.666	0.638	0.695
	Other	26.145	0.000	0.878	0.835	0.923
Academic Year	2014/2015					
	2015/2016	50.779	0.000	1.095	1.068	1.123
Prior Attainment	Top 3 Tariff	5059.582	0.000	1.010	1.010	1.011
	Per grade			1.226		
Welsh Bacc	No					
	Yes	23.858	0.000	0.766	0.688	0.852
Maths A Level	None	220.652	0.000			
	Single	139.127	0.000	1.214	1.175	1.254
	Further	1.730	0.188	0.966	0.916	1.017
STEM A Level Subjects	Biology	16.018	0.000	1.063	1.032	1.095
	Chemistry	5.431	0.020	1.036	1.006	1.068
	Physics	117.219	0.000	1.207	1.167	1.249
	Psychology	174.238	0.000	0.780	0.752	0.809
	Geography	96.133	0.000	0.821	0.789	0.854
Mission Group	None	1584.037	0.000			
	Russell Group	728.513	0.000	0.610	0.589	0.633
	1994 Group	27.758	0.000	0.872	0.829	0.918
	University Alliance	310.851	0.000	1.415	1.361	1.470
	Million+ Group	252.667	0.000	1.652	1.553	1.758
	Constant	7302.430	0.000	0.022		

Results – All STEM degrees – Obtaining a 1st

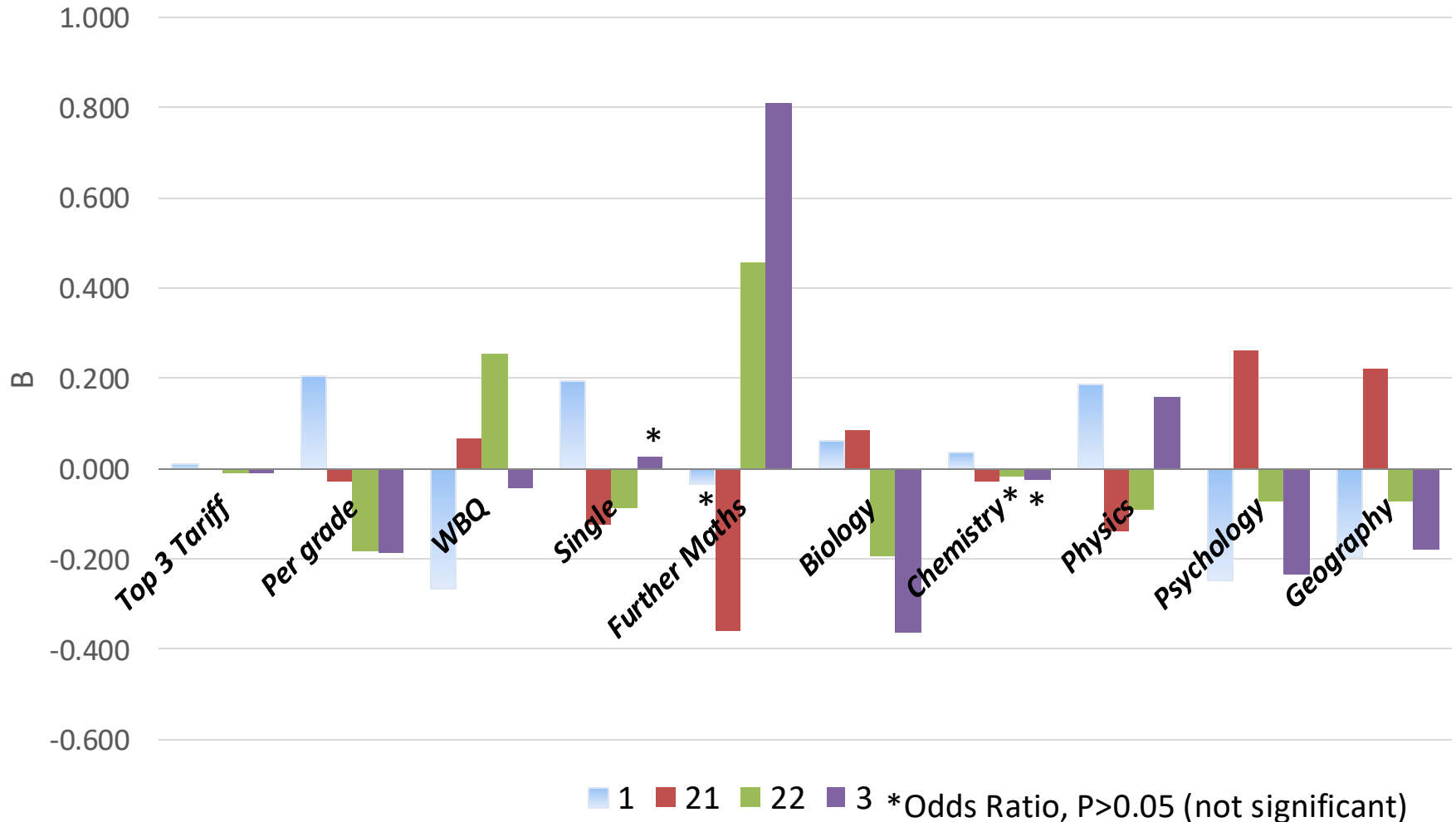
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					Lower	Upper
Prior Attainment	Top 3 Tariff	5059.582	0.000	1.010	1.010	1.011
	Per grade			1.226		
Maths A Level	None	220.652	0.000			
	Single	139.127	0.000	1.214	1.175	1.254
	Further	1.730	0.188	0.966	0.916	1.017
STEM A Level Subjects	Biology	16.018	0.000	1.063	1.032	1.095
	Chemistry	5.431	0.020	1.036	1.006	1.068
	Physics	117.219	0.000	1.207	1.167	1.249
	Psychology	174.238	0.000	0.780	0.752	0.809
	Geography	96.133	0.000	0.821	0.789	0.854

Points of interest

- Chemistry has become significant at the 95% confidence interval, but still less so than biology
- Learners with Further Mathematics now do not perform significantly differently to those without a mathematics A-level

Results – All STEM degrees

All STEM - Degree Outcomes



Next Questions:

- Could these results be due to variation between subject areas?
- Biological sciences is the largest JACS code by student number
 - entry onto these courses frequently requires either biology or chemistry A-levels, or the presence of both.
 - would the impact of biology or chemistry be greater in this subject area?
- Would we still see an impact of mathematics A-level in the Biological Sciences?

Results – Biological Sciences 1st/2:1 Vs 2:2/3rd

Good Degree = 30,519 Nagelkerke pseudo R ² = 0.169		N	Wald	Sig.	Odds Ratio (Exp(B))	95% C.I. for EXP(B)	
						Lower	Upper
Gender	Male	12962					
	Female	24378	384.167	0.000	1.809	1.705	1.919
Age Marker	Young	36198					
	Mature	1142	10.510	0.001	1.290	1.106	1.506
Ethnicity	Majority Group	28399					
	Minority Group	8941	368.409	0.000	0.538	0.506	0.574
School Funding Type	State	31935	34.708	0.000			
	Private	3700	18.057	0.000	0.803	0.726	0.889
	Other	1705	19.748	0.000	0.747	0.657	0.849
Academic Year	2014/2015	18230					
	2015/2016	19110	45.877	0.000	1.214	1.148	1.284
Prior Attainment	Top 3 Tariff		1765.458	0.000	1.014	1.013	1.014
	Per grade				1.313		
Welsh Bacc	No	36758					
	Yes	582	2.174	0.140	0.848	0.681	1.056
Maths A Level	None	26191	25.817	0.000			
	Single	10738	13.777	0.000	1.141	1.064	1.223
	Further	411	8.883	0.003	0.648	0.488	0.862
STEM A Level Subjects	Biology	21612	145.405	0.000	1.472	1.382	1.567
	Psychology	18477	26.526	0.000	1.189	1.113	1.270
	Geography	4311	9.148	0.002	1.158	1.053	1.273
Mission Group	None	13309	124.455	0.000			
	Russell Group	10351	43.496	0.000	0.725	0.659	0.798
	1994 Group	3312	19.598	0.000	0.775	0.692	0.867
	University Alliance	7176	24.400	0.000	1.209	1.121	1.303
	Million+ Group	3192	37.975	0.000	1.358	1.232	1.497
	Constant			946.485	0.000	0.060	

Results – Biological Sciences 1st/2:1 Vs 2:2/3rd

Good Degree = 30,519 Nagelkerke pseudo R ² = 0.169		N	Wald	Sig.	Odds Ratio (Exp(B))	95% C.I. for EXP(B)	
						Lower	Upper
Prior Attainment Top 3 Tariff			1765.45	0.000	1.014	1.013	1.014
Per grade			8		1.313		
Maths A Level	None	26191	25.817	0.000			
	Single	10738	13.777	0.000	1.141	1.064	1.223
	Further	411	8.883	0.003	0.648	0.488	0.862
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	Psychology	18477	26.526	0.000	1.189	1.113	1.270
	Geography	4311	9.148	0.002	1.158	1.053	1.273

Points of interest

- Biology and chemistry are collinear, biology is used here due to a greater odds ratio and pseudo R²
- The odds ratio of a one to two grade difference in prior attainment is higher than that for any individual subject
- Mathematics and Further Maths trends still present

Results – Biological Sciences 1st/2:1 Vs 2:2/3rd

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Prior Attainment Top 3 Tariff			1765.45 8	0.000	1.014	1.013	1.014
Per grade					1.313		
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	Single	10738	13.777	0.000	1.141	1.064	1.223
	Further	411	8.883	0.003	0.648	0.488	0.862
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	Psychology	18477	26.526	0.000	1.189	1.113	1.270
	Geography	4311	9.148	0.002	1.158	1.053	1.273

With Chemistry Rather than Biology R² = 0.165

Prior Attainment Per grade		1.311					
Maths A Level	None	26191	31.406	0.000			
	Single	10738	16.362	0.000	1.154	1.077	1.237
	Further	411	11.115	0.001	0.617	0.464	0.820
STEM A Level Subjects	Chemistry	13146	39.031	0.000	1.247	1.164	1.336
	Psychology	18477	12.546	0.000	1.128	1.055	1.206
	Geography	4311	11.097	0.001	1.176	1.069	1.294

Results – Biological Sciences obtaining a 1st

1st = 9,364 Nagelkerke pseudo R ² = 0.134		Wald	Sig.	Odds Ratio (Exp(B))	95% C.I. for EXP(B)	
					Lower	Upper
Gender	Male	82.823	0.000	1.293	1.223	1.366
	Female					
Age Marker	Young	106.694	0.000	2.080	1.810	2.390
	Mature					
Ethnicity	Majority Group	240.353	0.000	0.596	0.559	0.637
	Minority Group					
School Funding Type	State	112.033	0.000			
	Private	109.248	0.000	0.631	0.578	0.688
	Other	6.490	0.011	0.848	0.747	0.963
Academic Year	2014/2015	45.027	0.000	1.184	1.127	1.244
	2015/2016					
Prior Attainment	Top 3 Tariff	1992.750	0.000	1.013	1.013	1.014
	Per grade			1.307		
Welsh Bacc	No	9.387	0.002	0.716	0.578	0.886
	Yes					
Maths A Level	None	24.971	0.000			
	Single	20.765	0.000	1.147	1.081	1.217
	Further	1.750	0.186	0.859	0.686	1.076
STEM A Level Subjects	Biology	256.820	0.000	1.609	1.518	1.705
	Psychology	48.363	0.000	0.808	0.761	0.858
	Geography	2.999	0.083	0.933	0.863	1.009
Mission Group	None	648.482	0.000			
	Russell Group	329.421	0.000	0.509	0.473	0.547
	1994 Group	47.740	0.000	0.718	0.654	0.789
	University Alliance	95.136	0.000	1.430	1.331	1.536
	Million+ Group	136.560	0.000	1.867	1.681	2.073
	Constant	3096.063	0.000	0.005		

Results – Biological Sciences obtaining a 1st

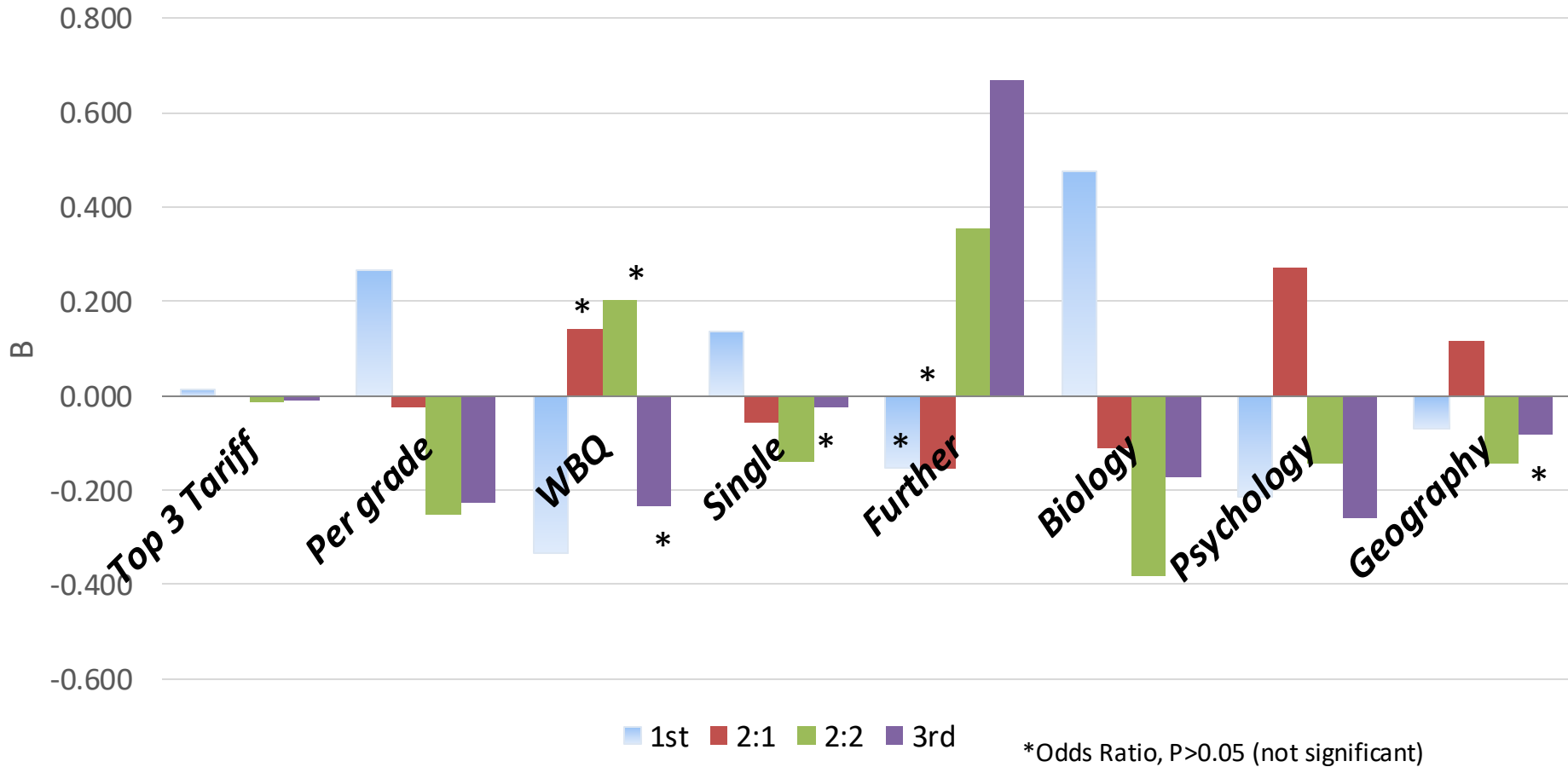
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					Lower	Upper
Prior Attainment	Top 3 Tariff	1992.75	0.000	1.013	1.013	1.014
	Per grade			1.307		
Maths A Level	None	24.971	0.000			
	Single	20.765	0.000	1.147	1.081	1.217
	Further	1.750	0.186	0.859	0.686	1.076
STEM A Level Subjects	Biology	256.820	0.000	1.609	1.518	1.705
	Psychology	48.363	0.000	0.808	0.761	0.858
	Geography	2.999	0.083	0.933	0.863	1.009

With Chemistry Rather than Biology R² = 0.130

Prior Attainment	Per grade			1.303		
Maths A Level	None	26.902	0.000			
	Single	20.359	0.000	1.146	1.080	1.216
	Further	3.309	0.069	0.812	0.649	1.016
STEM A Level Subjects	Biology	152.602	0.000	1.469	1.382	1.562
	Psychology	53.997	0.000	0.793	0.746	0.844
	Geography	0.224	0.636	0.981	0.907	1.062

Results – Biological Sciences

Biological Sciences - Degree Outcomes



Associations

- Odds ratios for biology A-level are higher than other STEM subjects
- A difference of 2 grades at A-level produces a greater change in odds ratio than any individual subject
- Graduates with Further mathematics are less likely to obtain 1st and 2:1 Biological Science degrees and more likely to obtain 2:2 and 3rd class degrees than those without any mathematics A-levels

Next Questions

- Would we still see an impact of mathematics A-level under Mathematics Sciences JACS 3 code?

Results – Mathematical Sciences 1st/2:1 Vs 2:2/3rd

Good Degree = 8,612 Nagelkerke pseudo R ² = 0.096		N	Wald	Sig.	Odds Ratio (Exp(B))	95% C.I. for EXP(B)	
						Lower	Upper
Gender	Male	7060					
	Female	4708	55.317	0.000	1.414	1.291	1.550
Age Marker	Young	11497					
	Mature	271	4.844	0.028	1.378	1.036	1.832
Ethnicity	Majority Group	7444					
	Minority Group	4324	125.120	0.000	0.577	0.524	0.635
School Funding Type	State	9168	48.311	0.000			
	Private	1096	34.288	0.000	0.647	0.559	0.748
	Other	1504	23.455	0.000	0.706	0.613	0.813
Academic Year	2014/2015	5900					
	2015/2016	5868	0.520	0.471	1.032	0.948	1.123
Prior Attainment	Top 3 Tariff		443.396	0.000	1.011	1.010	1.012
	Per grade				1.246		
Welsh Bacc	No	11615					
	Yes	153	3.832	0.050	0.699	0.488	1.000
Maths A Level	None	84	0.712	0.399	1.258	0.738	2.145
	Single	5788	46.199	0.000			
	Further	5896	44.848	0.000	0.718	0.651	0.791
STEM A Level Subjects	Biology	1879	0.171	0.679	1.027	0.906	1.164
	Chemistry	3782	6.665	0.010	1.133	1.030	1.245
	Physics	5491	5.621	0.018	0.893	0.814	0.981
Mission Group	None	2673	124.182	0.000			
	Russell Group	6477	33.602	0.000	0.700	0.621	0.790
	1994 Group	1128	0.001	0.979	1.002	0.850	1.181
	University Alliance	1380	58.452	0.000	1.883	1.601	2.215
	Million+ Group	110	9.649	0.002	1.980	1.287	3.047
	Constant			187.287	0.000	0.107	

Results – Mathematical Sciences 1st/2:1 Vs 2:2/3rd

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Per grade					1.313		
Maths A Level	None	84	0.712	0.399	1.258	0.738	2.145
	Single	5788	46.199	0.000			
	Further	5896	44.848	0.000	0.718	0.651	0.791
STEM A Level Subjects	Biology	1879	0.171	0.679	1.027	0.906	1.164
	Chemistry	3782	6.665	0.010	1.133	1.030	1.245
	Physics	5491	5.621	0.018	0.893	0.814	0.981

Points of interest

- A single mathematics A-level is now the comparator
- The odds ratio for those with Further Mathematics is less than one and significantly different to learners with a single mathematics A-level
- Those without mathematics represent a very small and probably unusual proportion of learners (<1%)

Results – Mathematical Sciences obtaining a 1st

Good Degree = 4,287 Nagelkerke pseudo R ² = 0.115		Wald	Sig.	Odds Ratio (Exp(B))	95% C.I. for EXP(B)	
					Lower	Upper
Gender	Male					
	Female	22.978	0.000	1.228	1.129	1.335
Age Marker	Young					
	Mature	2.048	0.152	1.222	0.929	1.609
Ethnicity	Majority Group					
	Minority Group	118.587	0.000	0.589	0.536	0.648
School Funding Type	State	93.411	0.000			
	Private	78.390	0.000	0.520	0.449	0.601
	Other	27.363	0.000	0.679	0.588	0.785
Academic Year	2014/2015					
	2015/2016	0.271	0.603	0.979	0.905	1.059
Prior Attainment	Top 3 Tariff	591.570	0.000	1.013	1.012	1.014
	Per grade			1.291		
Welsh Bacc	No					
	Yes	1.471	0.225	0.801	0.560	1.146
Maths A Level	None	0.325	0.569	0.864	0.522	1.430
	Single	10.509	0.005			
	Further	10.348	0.001	0.864	0.790	0.944
STEM A Level Subjects	Biology	1.282	0.257	1.068	0.953	1.197
	Chemistry	15.918	0.000	1.191	1.093	1.299
	Physics	0.261	0.610	0.978	0.896	1.067
Mission Group	None	287.855	0.000			
	Russell Group	108.310	0.000	0.557	0.499	0.622
	1994 Group	1.004	0.316	1.080	0.929	1.256
	University Alliance	94.308	0.000	2.154	1.845	2.515
	Million+ Group	19.507	0.000	2.802	1.774	4.427
	Constant	671.981	0.000	0.011		

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Points of interest

- A single mathematics A-level is the comparator
- There is a ~50/50 split between those holding a single mathematics A-level and those holding Further Mathematics
- The odds ratio for those with Further Mathematics is less than one and significantly different to learners with a single mathematics A-level
- Those without mathematics represent a very small proportion of learners (<1%)

Key findings and future steps

Key Findings

- Possessing STEM A-level subjects appears to be positively associated with STEM degree outcomes.
- The effect of chemistry A-level does not outweigh that of Biology A-level
- Prior attainment appears to outweigh the impact of A-level subject choice at 1 to 2 grade points
- While possessing a single mathematics A-level is associated with higher degree classifications, possessing further mathematics does not.
- Models assessing 1st/2:1 Vs 2:2/3rd outcomes and 1st class degree outcomes generally have more predictive value but all pseudo R² values are <0.2

Next Steps

- Qualitative work
 - Interviews of students graduating in STEM subjects
 - A very small number completed in Biological Sciences
- Examining the attainment of STEM learners throughout their student lifecycle
- Interactions between A-level subjects
- Polychoric correlations
- International Baccalaureate

Questions?