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Math Matters!
The Importance of Mathematical and Verbal Skills for Degree Performance

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Math Matters! The Importance of Mathematical and Verbal Skills for Degree Performance[*]

by

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Abstract

We find that mathematics skills have a stronger relationship to university performance than verbal skills. While both are predictive of degree completion and class of degree obtained, mathematics skills have a larger effect, and are particularly predictive of achieving a first-class honours degree and of high achievement in STEM courses.

[*] We are grateful to the Higher Education Authority (HEA) for providing access to the data used in this paper. The conclusions of the paper are those of the authors and do not represent the views of the HEA. Corresponding Author: Judith M. Delaney

1. Introduction

Much research has shown that having a better class of degree has significant payoff in the labour market (Feng and Graetz, 2017; Freier et al., 2015). Recent research by Aucejo and James (2019) shows, using UK data, that verbal skills have a much greater effect on college attendance and graduation probability than mathematics skills and this is true in both science, technology, engineering, and mathematics (STEM) and non-STEM college programmes.[1] However, little is known about whether the findings for college graduation apply to other countries or whether verbal skills are also more important for the class of degree obtained.

In this note, we use administrative data on multiple cohorts of undergraduates to study the relationship between mathematical and verbal skills and degree performance in Irish universities, conditional on enrolment. Building on the literature, we analyse the class of degree obtained in addition to whether the student graduates. Skills may affect graduation probability and class of degree in different ways, so this provides additional perspective on the importance of mathematical and verbal skills. We use mathematics and English grades from the terminal high school examination in Ireland, the Leaving Certificate. This is a high-stakes exam that determines college entry and English and mathematics are compulsory subjects, so these provide high quality measures of mathematical and verbal skills.

In Ireland, the universities grade degrees based on variants of the scale: First-class honours, second-class honours (upper division), second-class honours (lower division), third-class honours/pass. We use two different definitions of degree quality: *Good Degree* (first-class honours or second-class honours (upper division)) and *Great Degree* (first-class honours). Typically, a first-class honours degree is considered to be very high academic achievement. Obtaining at least second-class honours (upper division) is often viewed by

[1] In related Irish work, McCoy and Byrne (2017) study progression from first to second year undergraduate for persons who entered college in 2007. They find that mathematics scores are more important than English scores.

employers as a necessary requirement and is also a minimum standard for many graduate degrees in Ireland and abroad.

2. Data

Our data come from the Higher Education Authority (HEA) data registers that compile information on students in Irish colleges who graduate by 2017. We start with a sample of 82,092 full-time students who enter an honours degree program in a university between 2007 and 2012.[2] Using information on date of birth, we calculate age at entry assuming the programme begins on September 15. People generally sit the Leaving Certificate at ages 17-19 so, to focus on a relatively homogenous group of students who have recently taken the Leaving Certificate, we restrict the sample to persons aged 16 to 20 when starting their university programme (9,485 observations are aged outside this window).

For persons who enter a university, we can determine if they obtain a degree, the year the degree is completed, and the class of degree obtained. The universities report the anticipated (normal) duration of each degree programme, usually 3 or 4 years. When looking at degree completion, we assign students who have graduated within one year of the anticipated length of the programme as degree completers while those who have not graduated within this period are denoted as non-completers. When studying *Good* and *Great* degree outcomes, we restrict the sample to those who graduated within 1 year of the anticipated length of the programme.[3]

[2] The seven universities are University College Dublin (UCD), Trinity College Dublin (TCD), Dublin City University (DCU), Maynooth University (MU), National University of Ireland, Galway (NUIG), University College Cork (UCC), and University of Limerick (UL). Because, in some years, institutions do not report required variables for any students, we have no information on required variables for entrants to UCD for 2007-2009, DCU for 2008-2009, MU for 2007-2008. NUIG for 2007-2008 and for 2011, and UL for 2008.

[3] We restrict the sample to cases where we can see one year or more after the expected graduation. This is not an issue for 3- and 4-year degrees (98% of students) as their anticipated completion year is 2016 or earlier. However, a small number of students do degree courses of 5 or 6 years anticipated duration and we cannot necessarily tell whether these students graduate within one year of anticipated completion (for example, students that start a 5-year degree programme in 2012). We exclude these students from the sample (760 observations are removed).

We drop a further 3,858 observations by restricting the sample to students who attended an Irish secondary school because we require information on the school attended for estimation. We also delete another 3,732 cases where we don't know grades in English or mathematics to arrive at an estimation sample of 64,258 observations. We report descriptive statistics for key variables in Table 1. About 80% of students graduate within one year of the scheduled completion date and, of those, 17% get a *great degree* and 68% obtain a *good degree*.[4]

3. Empirical Methodology

We regress degree outcomes on English and mathematics grades. All regressions include indicators for county of origin, course-by-year indicators, gender, whether a grant recipient, indicators for father's occupation (professional, managerial, non-manual, manual, or unknown), a quadratic in age when starting university, and secondary school fixed effects. By including course-by-year indicators, we control for differing levels of difficulty or varying grading standards across university programmes. On average, in our sample, there are 42 people in a course-year cell (actual course sizes are somewhat larger as we exclude entrants aged 21 or older and foreign students who did not do the Leaving Certificate).

4. Results

Students can take Leaving Certificate subjects either at Higher Level or Lower Level. Our main specification includes indicator variables for the grades obtained. The indicator variables are for scoring, at the Higher Level, 90-100, 80-89, 70-79, 60-69, 50-59, or less

[4] There are a few cases where the degree outcome is reported as "second-class honours". As we don't know whether these are upper division or lower division, we drop these cases when we study *good degree*. Hence, we have fewer observations for *good degree* than we have for *great degree*.

than 50. For subjects taken at Lower Level, we include indicators for scoring 90-100, 80-89, 70-79, or scoring less than 70.[5]

We show the estimates in Figures 1-3. The omitted category is scoring 60-69 at Higher Level so all effects are interpreted relative to scoring 60-69 at Higher Level in that subject. The dots represent point estimates and the bars represent confidence intervals. All estimation is conditional on the student enrolling in university. For college completion, both mathematics and English grades matter. Scoring 90+ in Higher Level English increases the probability of finishing by 4 percentage points compared to scoring 60-69 (the corresponding figure for mathematics is 5 percentage points). Likewise, students who score worse than the omitted category in either subject have lower probabilities of finishing. For *good degree* and *great degree*, the grade effects are much larger. Interestingly, while the effects of English and mathematics are similar for *good degree*, the effects of mathematics grades are much larger for *great degree*. Also, for completion, effects at the bottom of the grade distribution are particularly predictive; for *good degree*, the effect sizes appear similar throughout the distribution; and for *great degree*, the top of the distribution is particularly informative (especially for mathematics grades). Overall, the estimates suggest that, while the differences are small for completion and *good degree*, mathematical skills are more important than verbal skills in predicting a first-class honours degree.

In Table 2, we show results by gender and by university programme type (STEM or non-STEM). To make the results more tractable, we use the mapping from individual grades to admission points used by the universities and report estimates for standardized points in English and mathematics. We find that the effects are similar for men and women, but mathematics scores are particularly predictive of good performance in STEM degrees. In all

[5] Since scoring less than 70 at the Lower Level is uncommon in our sample, we pool all those with less than 70 into one category.

samples and for all outcomes, mathematical scores are more important than English scores and the gap is largest for the probability of obtaining a first-class honours degree.[6]

The findings for graduation contrast with Aucejo and James (2019) who find that, in the UK, verbal skills are more predictive of college graduation than mathematical skills for enrolees in both STEM and non-STEM programmes. The differences between our estimates and theirs may arise because of the different institutional context between the UK and Ireland. However, they may also result from significant differences in the measurement of verbal and mathematical skills in the two papers.[7] In contrast, our findings are consistent with the Irish findings of McCoy and Byrne (2017), who use similar measures to ours and find that mathematics grades are more important than English grades in predicting dropout after the first year of college.

5. Conclusions

While prior research has found that verbal skills are more important than mathematical skills for college completion, we find that mathematical skills are a better predictor of university performance, particularly of obtaining a first-class honours degree and especially in university STEM courses. This may identify one of the mediating channels through which mathematical skills lead to better labour market outcomes (Altonji, 1995; Joensen and Nielson, 2009). A limitation is that our sample only includes college enrolees and, thus, we cannot address the role of verbal and mathematical skills in determining university admission.

[6] Aucejo and James (2019) show that verbal skills are more important than mathematical skills in predicting enrolment in the UK. If this is also the case in Ireland, then estimates that are unconditional on enrolment could be quite different.

[7] Our measures of mathematical and verbal skills are quite different from those of Aucejo and James (2019) who use a complicated latent factor model that generates measures of verbal and mathematical skills using test scores from Key Stage 1 to Key Stage 4 (at ages 7, 11, 14, and 16, approximately). Because many of these subjects are optional, they use selection corrections to deal with the availability of different subject grades for different students. Key stage 4 tests are approximately 2 years prior to starting college; in contrast, the grades we use are based on exams only 3 months before beginning college. Also, the measures we use come from high-stakes exams that determine college entry; the tests they use are from lower-stakes exams.

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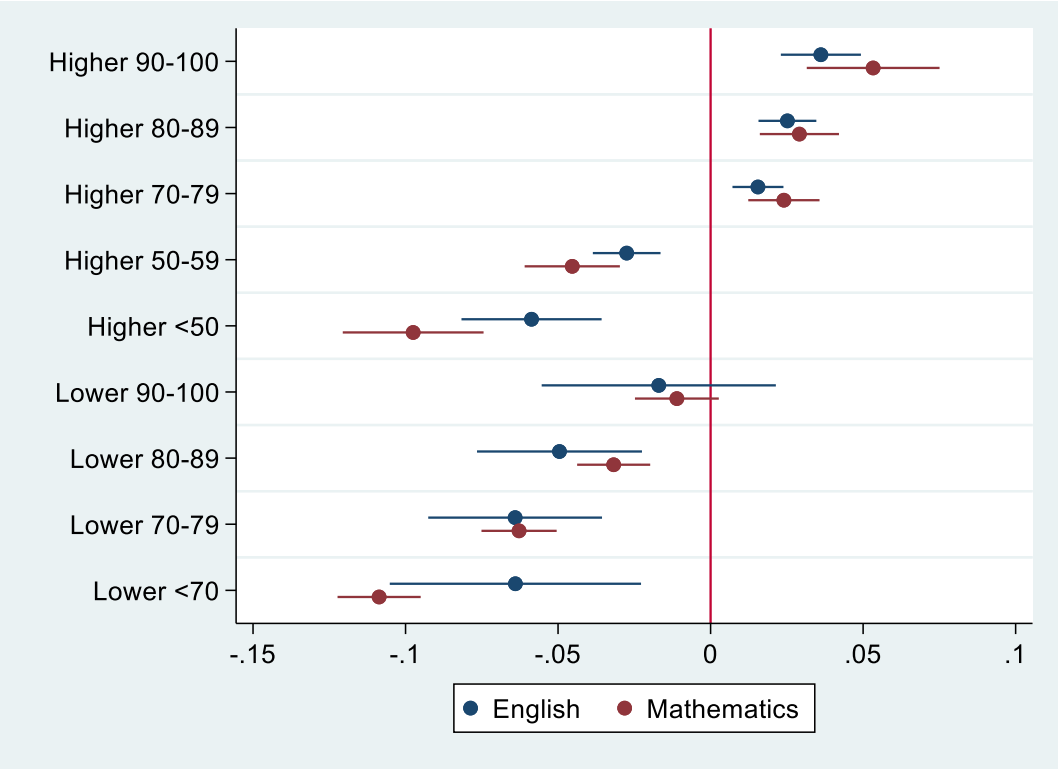
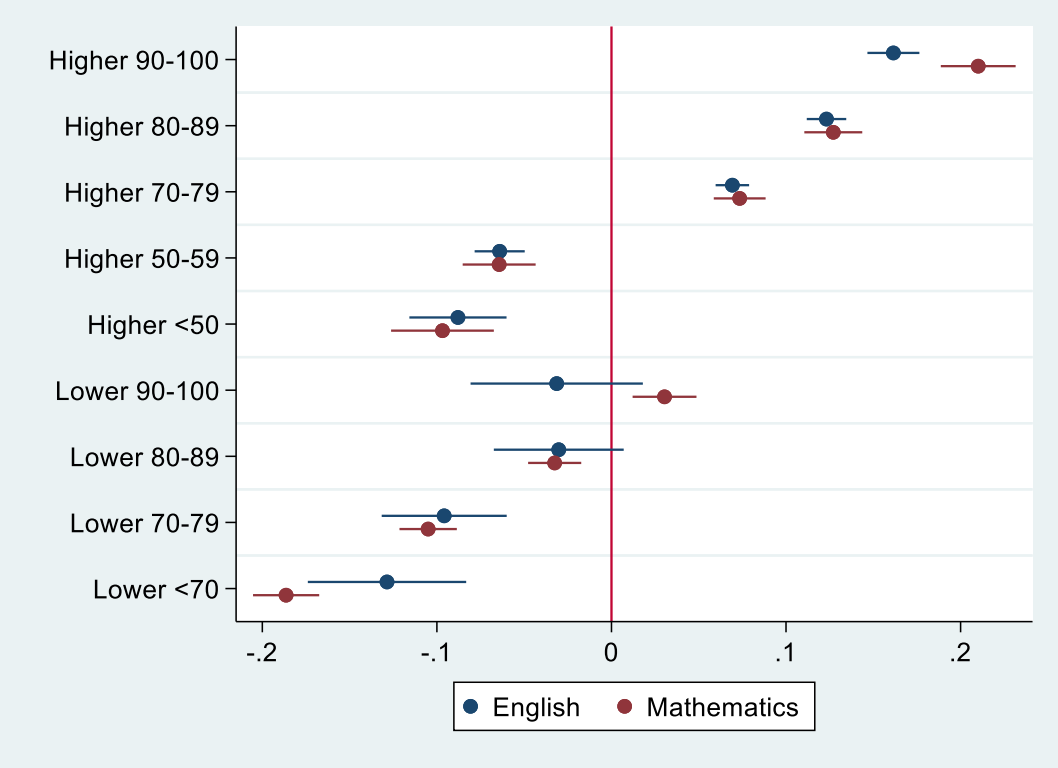
Figure 1: Relationship between English and Mathematics Grades and University Completion



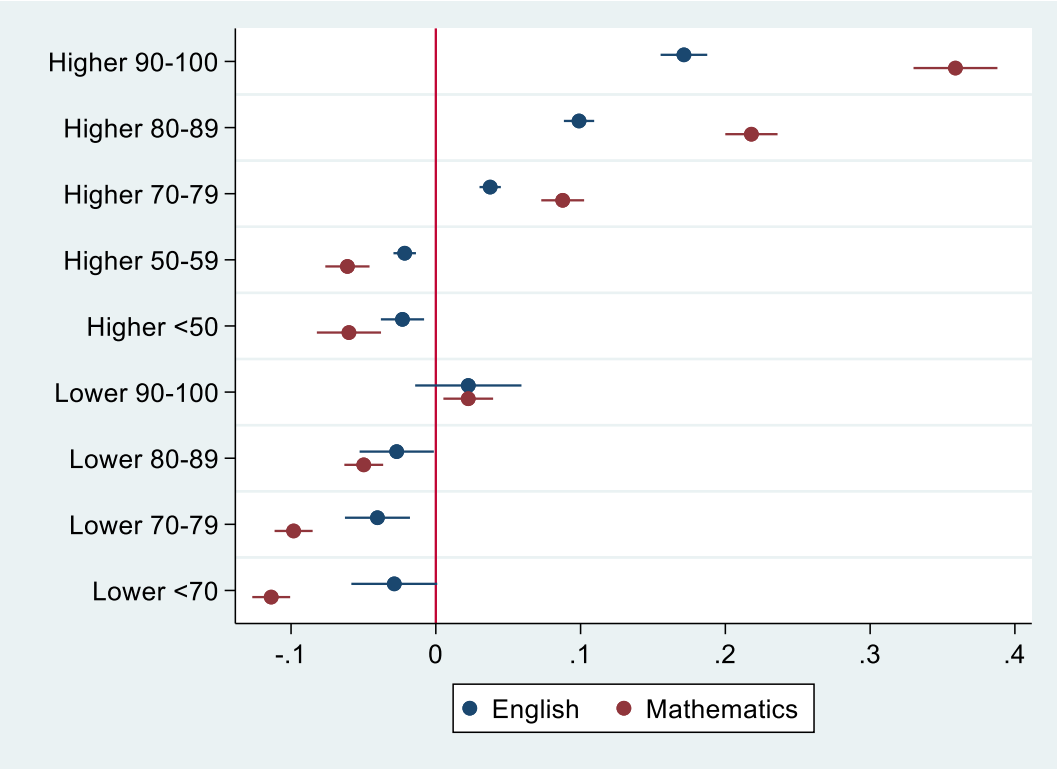
The omitted category is scoring 60-69 at Higher Level. Point estimates and 95% confidence intervals shown.

Figure 2: Relationship between English and Mathematics Grades and Obtaining a *Good Degree*



The omitted category is scoring 60-69 at Higher Level. Effects are conditional on completion. Point estimates and 95% confidence intervals shown.

Figure 3: Relationship between English and Mathematics Grades and Obtaining a *Great Degree*



The omitted category is scoring 60-69 at Higher Level. Effects are conditional on completion. Point estimates and 95% confidence intervals shown.

Table 1: Descriptive Statistics

VARIABLES	(1) N	(2) Mean	(3) Standard Deviation	(4) Minimum	(5) Maximum
Year Started	64,258	2010	1.440	2007	2012
English points	64,258	73.27	14.41	0	100
Mathematics points	64,258	52.98	21.42	0	100
Programme Length	64,258	3.772	0.497	3	6
Age Started	64,258	18.64	0.628	16.24	20.99
Female	64,258	0.537	0.499	0	1
STEM	64,258	0.296	0.457	0	1
Completed Degree	64,258	0.807	0.395	0	1
Good Degree (2.1 degree or better, conditional on completion)	50,113	0.676	0.468	0	1
Great Degree (first-class honours, conditional on completion)	51,860	0.167	0.373	0	1
Standardized Mathematics points	64,258	0	1	-2.473	2.195
Standardized English points	64,258	0	1	-5.086	1.856

Table 2: Relationship between English and Mathematics Grades and University Performance

VARIABLES	(1) All students	(2) Females	(3) Males	(4) STEM	(5) Non-STEM
Completion					
Standardized English points	0.024***	0.015***	0.032***	0.029***	0.021***
	(0.002)	(0.003)	(0.003)	(0.004)	(0.002)
Standardized Mathematics points	0.050***	0.049***	0.050***	0.090***	0.035***
	(0.002)	(0.003)	(0.004)	(0.005)	(0.003)
Observations	64,258	34,513	29,745	19,032	45,226
Mean of Dependent Variable	0.81	0.84	0.77	0.76	0.81
R-squared	0.141	0.148	0.169	0.177	0.132
Good Degree					
Standardized English points	0.076***	0.080***	0.072***	0.061***	0.082***
	(0.002)	(0.003)	(0.003)	(0.004)	(0.003)
Standardized Mathematics points	0.102***	0.099***	0.103***	0.127***	0.093***
	(0.003)	(0.004)	(0.005)	(0.006)	(0.004)
Observations	50,113	27,740	22,373	14,397	35,716
Mean of Dependent Variable	0.68	0.71	0.64	0.67	0.68
R-squared	0.253	0.279	0.273	0.268	0.265
Great Degree					
Standardized English points	0.052***	0.053***	0.051***	0.055***	0.050***
	(0.002)	(0.003)	(0.003)	(0.004)	(0.002)
Standardized Mathematics points	0.104***	0.099***	0.106***	0.152***	0.090***
	(0.003)	(0.003)	(0.004)	(0.006)	(0.003)
Observations	51,860	28,984	22,876	14,437	37,423
Mean of Dependent Variable	0.17	0.16	0.17	0.23	0.14
R-squared	0.205	0.233	0.244	0.243	0.194

All regressions include indicators for county of origin, course-by-year indicators, gender, whether a grant recipient, indicators for father's occupation (professional, managerial, non-manual, manual, or unknown), a quadratic in age when starting university, and school fixed effects. *Good degree* is 1 if the student achieved a 2.1 degree or

better and 0 otherwise. *Great degree* is 1 if the student achieved first-class honours and 0 otherwise. Regressions for *Good Degree* and *Great Degree* are conditional on completion. Robust standard errors in parentheses. *** p<0.01 ** p<0.05 * p<0.1

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