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Reconsidering the rise in A-level mathematics participation

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Abstract

There is growing support for making the study of mathematics to age 18 compulsory for all young people in England. This paper aims to inform this debate through new insights into historic A-level Mathematics participation trends. We analyse full-year cohorts from the Department for Education's National Pupil Database for age-16 students from 2004-2010, a total of just over 4.5 million young people. Using a cohort-tracking approach we aim to better understand the flow of young people through upper secondary mathematics education. Earlier work identified GCSE attainment as the strongest predictor of A-Level Mathematics participation. In this paper we show that the percentage of students progressing to A-Level by GCSE grade has not changed significantly over the period in question, with some exceptions. This implies that the increase in A-level Mathematics numbers is largely explained by the growing proportion of higher GCSE grades. We discuss the implications for policy that this raises, e.g. the possible impact of making GCSE mathematics more demanding.

Introduction

In the run-up to the 2015 UK general election, the main political parties committed to ensuring that all young people continue to study mathematics to 18. In 2011, the then Secretary of State for Education, Michael Gove, signalled the government's intention that "within a decade the vast majority of pupils are studying maths right through to the age of 18" (Gove 2011). Similarly, the Labour Party's 2015 manifesto announced that "**We will make maths and English compulsory to 18** to improve the core skills young people need for future employment and study." (http://www.labour.org.uk/manifesto/education, bold original). Despite the seemingly inexorable drift towards mathematics for all to 18, there are several major obstacles to be navigated including, a) a shortage of teachers, b) contested curricular aims, c) unsuitable qualifications, and d) student attitudes and aspirations.

This policy direction has been strengthening since the CBI (2009) recommendations, and the recent raising of the leaving age to 18 has fuelled the debate around a core curriculum. There is growing awareness of what other international jurisdictions do (Hodgen et al. 2013, Hodgen et al. 2010b), which, when coupled with research on the relationship between mathematical attainment and future earnings (Dolton and Vignoles 2002, Crawford and Cribb 2013, Adkins and Noyes 2015) and employability (Bynner and Parsons 1997), and the importance of mathematics to Science, Engineering and Technology (Roberts 2002, Gago 2004, Smith 2004) and quantitative social science (The British Academy 2012, 2015) is building an increasingly compelling case for this change.

Public debate is less concerned with what mathematics should be studied and the political nature of these discussions (Noyes 2009b, Brown 2011, Gutstein 2009). Various arguments have been put forward (Tikly and Wolf 2000, Gill 2004). Some argue for a greater focus on techno-mathematical literacy (e.g. Hoyles et al. 2010); a greater level of general numeracy (Steen 1990, Heymann 2003); a focus on critical mathematical literacy (Frankenstein 2005), what Gutstein describes as the capacity to 'read and write the world with mathematics' (Gutstein 2006); more statistics and/or applied mathematics (Noyes et al. 2011). In general, for better mathematical competence in the population at large, one might follow the thesis of

Heymann (2003) which, in broad terms privileges much better application of lower level mathematics over advanced content without the capability to apply it. The key policy driver for extended the learning of mathematics is an economic one linked to the increasingly high value of quantitative work in a range of social, commercial, business and scientific endeavours.

The current structure of the school system in England is such that young people complete their GCSEs (General Certificate of Secondary Education) at age 16. Typically, students study 8-10 GCSE qualifications and if they achieve five or more grades C or above they can progress to further academic study. Schools and colleges normally require students to have attained at least a GCSE mathematics grade B before progressing to study A-level mathematics (Matthews and Pepper 2007), though many schools prefer an A* or A grade. Up until 2012, students who progressed to A-level studies followed subject specifications in which AS (Advanced Subsidiary) qualifications could be completed as the first half of the full A-level. This policy has since been disbanded with the A-level course being 'decoupled' from the smaller AS-level qualification and modular programmes being replaced by linear ones in which assessment is synoptic at the end of the course. Concerns about these changes have been widespread in the mathematics education community and the analysis in this paper adds weight to these.

Research funded by the Nuffield Foundation shows that the proportion of England's young people that continue to study advanced mathematics is low compared to other leading jurisdictions (Hodgen et al. 2010b). That said, continuation rates vary greatly by prior attainment with over 80% of students attaining an A* at GCSE completing AS or A-level Mathematics, compared to less than 3% of those with a grade C (Noyes 2009a). One current policy approach to addressing this shortfall is the introduction of Core Maths qualifications which are due to be rolled out in the 2015-16 year. At the time of writing these are in the pilot phase and the potential uptake is unclear. The target cohort (students having a GCSE mathematics grade C or above but who have not chosen A-level mathematics) is estimated to be up to a quarter of a million per cohort.

This paper investigates patterns of A-level mathematics completion over a seven year period, for the GCSE cohorts of 2004-10. The goal is to present an analysis that complements those reported in the media and educational press and which can inform thinking on the challenges of increasing participation in post-16 advanced mathematics. It is important to note that a large group of young people each year do not attain a GCSE grade C and their ongoing mathematical study is also of concern (see Wolf 2011, for the current policy trajectory). However, there is not space to deal with this group herein so the paper is limited to the analysis of those achieving a GCSE mathematics grade C or above, who might then proceed to A-levels in general and A-level Mathematics in particular. Our approach is somewhat different from normal analyses of A-level entry data and we explain this in more detail below.

The Mathematics 'Pipeline'

Three metaphors are used in discussions of upper secondary mathematics engagement: pipeline, pathway and participation. The metaphors are compelling as they align well with the broad thesis of *contemporary metaphor theory* (Lakoff and Johnson 1980, Ortony 1993, Lakoff 1993) and the notion of 'root metaphors' that can be traced back to early sensory-motor experiences: force (c.f. *pipeline*), movement (c.f. *pathway*) and containment (c.f. *participation*). The metaphor of *participation* (for example, Boaler 1999, Noyes 2009a, Brown et al. 2007, Noyes and Sealey 2012, Noyes et al. 2011) speaks of belonging to a community of learners and taking part in the social activity of learning mathematics. The idea of *pathways*, with their associated networks and junctions, denotes movement and, perhaps more importantly, choices. That notion of choice resonates with neo-liberal educational choices (Ball et al. 2000). Thirdly, much has been written about such mathematics *pathways* post-16 (for example, QCA 2008, Noyes et al. 2010, Yeo and Leigh-Lancaster 2010, Noyes et al. 2011).

The metaphor which seems to be more prevalent in the US and is growing in use in England is that of *pipeline* (Jacobs and Simpkins 2006, Steffens et al. 2010, van der Waals 2001, Adamuti-Trache and Andres 2008). This metaphor focuses on the *supply* of suitably qualified mathematicians and scientists to science, industry and commerce (two examples of this notion of 'supply' are Roberts 2002, and DfE 2011). The metaphor implies force. The thing being supplied – in this case students – is pushed (or pulled) along a pipe or channel in order to meet a perceived demand. Here the key concepts are not choice (as in pathways) or interaction (as in participation) and 'leaks from the pipeline' are broadly conceptualised as wasteful with such leaks needing to be plugged. All of this implies that the language used to talk about A-level Mathematics is important because, according to the theory, metaphors have generative power (Schön 1993, Thomson and Comber 2003) and allow certain possibilities and prohibit others (see, for example, Noyes 2006, Parks 2010).

This third metaphor (pipeline) imagines students as flows of human resources. In keeping with this, our approach herein is to better understand the characteristics of this flow. Normally, A-level entries are reported once a year as a single number and these numbers are compared year on year. However, it is not clear who is being counted and compared: are they all of the same age/cohort? Does this include overseas students who have come to the UK for sixth form study? Does it include retaking students? Depending upon the answers to these and other questions, the annual entry statistics might be interpreted differently. In our approach we take cohorts of young people age 16 and track them over the following three years to find out what post-16 mathematics outcomes they achieve. Our analysis subsets the cohort by the strongest predictor of participation, prior GCSE attainment level at age 16 (Noyes 2009a). So, in sum there are two broad approaches:

1. Monitor annual A level mathematics entries/results and observe the changes to build up a picture year on year, but without a clear sense of who is being counted;
2. Follow cohorts of young people, focusing on common initial characteristics, to see whether there is any substantive change in the ways in which they flow through education over time.

The typical approach to reporting student participation (i.e. approach 1) is useful when making certain kinds of claims about the effectiveness of policies or the impact of projects that aim to increase A-level mathematics entries. Given the political importance of the flow in question, alternative, complementary analyses of the data are needed. In what follows we use approach 2 with a series of national cohorts of young people in England, dividing the cohorts primarily by grade at GCSE, but also by gender as there are significant difference in patterns of engagement by gender.

Snapshots of A-level mathematics in the media

Before proceeding we present a few examples of how the rise in A-level mathematics entries has been reported in the media in recent years under 'approach 1'. In 2000, major curricular reforms of A-levels were implemented. The widely cited report Making Mathematics Count (Smith 2004) described that reform as "a disaster for mathematics" because of the impact it had on participation rates. Following recommendations made at that time, A-level mathematics entries turned a corner around 2003/4 and have been rising ever since.

By 2006, the news was sounding more positive with the Guardian newspaper reporting that “Mathematics has become the third most popular A-level subject, with a 5.8% increase in entries and a 22.5% increase in pupils taking further mathematics” (Smith 2006). Three years later, in 2009, Mathematics in Education and Industry (MEI) reported that “something special is happening in mathematics” with a 12.2% increase in those taking A level (Porkess and Lee 2009).

In 2011, with entries for A level mathematics continuing to rise, it was suggested that the phenomena was due in part to ‘the Brian Cox effect’ (Vasagar 2011). Examiners also attributed the rise to the financial recession. One complicating factor is that many students repeated modules making accurate trend analysis, and discussions of causality, difficult. In the same year, Plus Magazine reported, under the title “People keep falling in love with mathematics”:

> Who said that people don't like maths? Numbers of entries to maths A and AS levels across the UK have again increased this year. The number of students taking maths A level has risen by 7.8% compared to last year (from 77,001 to 82,995) and A level further maths entries have risen by 5.2% (from 11,682 to 12,287). At AS level maths has seen an increase of 25.3% compared to last year (from 112,847 to 141,392) and further maths an increase of 24.7% (from 14,884 to 18,555). The number of students taking A level maths is now higher than it has been for almost two decades.
>
> (https://plus.maths.org/content/maths-levels-rise-again)

All of the statistical increases are good news for advocates of greater participation in advanced mathematics. Yet there has been little attempt to thoroughly investigate and explain the changes and understand the underlying patterns.

Three years later in 2014 the Wellcome Trust reported that “Science and maths popularity continues to increase” (August 2014). Elsewhere the Times Educational Supplement reported that “Maths has overtaken English for the first time in more than a decade to become the most popular A-level taken this year…maths has steadily grown in popularity, from 52,788 entries in 2004 to 88,816 this year” (Exley 2014).

These examples are selective but broadly representative. The resounding message over recent years is one of good news. For those championing greater engagement with advanced mathematics these rising numbers are welcome. Sometimes, changes in mathematics numbers are contrasted with other subjects as in the case of English above, but this is about as complex as the analysis gets. The percentages of students doing A-level mathematics still leaves participation post-16 falling very short of the desired ‘vast majority’.

Methodology

The data used in this analysis comes from the Department for Education’s National Pupil Database (NPD). A request was made for the full cohort data for seven consecutive year-11 (age 16) GCSE cohorts from 2004-2010, with linked post-16 A-level data from 2005 through to 2013. This amounts to just over 4.5 million 16-year olds. During this period, the proportion of young people continuing to advanced study (i.e. those that might possibly consider mathematics) rose from around 52% to 63% and similarly, those getting a GCSE C or above in mathematics rose from just under 50% to just under 60% over the period.

A proportion of students take three years to complete their A level studies so it was important to include this later data. It was also the case that not all students certificated at AS level and some were re-examined and so can be double counted in the data. Only by following the cohort and limiting an individual’s inclusion in the working dataset to a single, highest and/or final outcome can we get a clear understanding of what is happening. One of the drawbacks of this approach is the delay in developing a picture of participation patterns by cohort. For example, the entry figures released in August 2015 will include students from the GCSE cohorts of 2012/13/14 but not all of the 2014 cohort will have completed their A level studies until 2017, with the NPD release for this group being January 2018.

The NPD is a tremendously useful dataset but it is very large and, as with many secondary datasets, requires a considerable amount of cleaning and preparation before any analysis can be undertaken. Each cohort of GCSE students comprises around two thirds of a million student records, and there are hundreds of data fields for each student, most of which are irrelevant to our purposes. A number of important issues with the data needed to be addressed. Many students have multiple records in the NPD (particularly post-16) where they have moved institutions, or have repeated qualifications. We removed any duplicate cases by retaining the student record with the highest recorded grade (if applicable) for AS/A level mathematics. For this paper we were not interested in school effects (c.f. Noyes 2013) which would have made this process far more difficult. A very small number of students had A level mathematics qualifications that were not Mathematics or Further Mathematics (e.g. AS-level Use of Mathematics, A-level Statistics). We recoded these alternatives and included them as mathematics qualifications at the appropriate level.

Another data preparation issue that impacts upon the approach we have taken is that some students did not have GCSE mathematics grades (2.7% of those engaged in some form of post-16 advanced study). This is important as GCSE maths is the most important predictor of A level participation. We have omitted these students in this analysis and although it is likely that these grades are not missing at random they comprise a relatively small part of the cohort and don't diminish the analysis. It does mean, however, that the numbers reported below won't sum to the actual entries from the cohort, though they are as accurate as can be expected within each GCSE grade category. In earlier work (Noyes 2009a) with a similar dataset including only student from the Midlands of England, the proportions of students with GCSE grades A*/A/B/C completing some advanced mathematics (i.e. from AS only to A-level Mathematics and Further Mathematics) was 82/53/17/3%. For this reason we present the data in Table 1 by GCSE grade outcome. The issue of missing GCSE grades remains but arguably it is the proportional patterns, rather than the actual numbers which are of greater concern in this current analysis. We assume that the missing students would have had similar trajectories and so the proportions would not be overly affected. A different problem of missingness is that the NPD data only includes those who completed qualifications. It cannot indicate whether a student spent a year studying mathematics but then 'dropped out' (Noyes and Sealey 2012).

After the data was cleaned and organised for analysis we undertook both descriptive and inferential analyses. This paper focuses on the former to survey the general flow patterns seen between these cohorts and the implications that this raises in the context of current reforms and in relation to the claims made about post-16 mathematics up-take.

Analysis and discussion

Table 1 includes outcome data for the GCSE cohorts of 2004, 2007 and 2010. The sample numbers and proportions are given for five different levels of engagement with advanced mathematics post-16: no maths, at least AS-level Mathematics, at least A-level Mathematics, A-level plus some Further Mathematics (either A or AS level) and, finally, A-Level Mathematics plus A-Level Further Mathematics. In effect, the first two of these indicate whether students have done maths or not, and so sum to 100%. The final four categories are (reverse) cumulative. Percentages are rounded to reflect errors in the analytic process and although the totals are reported fully it should be borne in mind that these would vary with different analytic choice trajectories. Figure 1 presents the full seven years of data in a series of charts showing trends in the totals and proportions for student in the A*, A and B GCSE grade groups. The two categories including Further Mathematics are combined in the charts.

It is clear that, in line with the general reporting of A-level Mathematics entries, the numbers of students doing some AS/A-level mathematics has increased considerably across these cohorts (from around 61,000 for the 2004 school leavers to 92,000 for the 2010 year 11 cohort, an increase of around 50%). That said, the numbers not studying any advanced maths (but who were qualified to do so) has also grown from around 202,000 to 234,000, a more modest increase of around 12%. For B/C grade GCSE students the increase in participation is only at AS-level. A-level Mathematics remains the preserve of the 'clever core' (Matthews and Pepper 2007). Of those attaining at least an A-level from the 2010 GCSE cohort, over 90% had attained an A* or A grade at GCSE. The numbers of students within each cohort attaining GCSE grades A* and A, the main groups from which A-level Mathematics students are recruited, has risen by around 34% and 56% respectively over this seven year period.

GCSE Maths Grade	Year	No maths	At least AS maths	At least A-level maths	At least A-level maths and AS further maths	A-levels in maths and further maths	Total
	2004	6204 (23%)	21131 (77%)	19308 (71%)	6136 (22%)	4308 (16%)	27335
A*	2007	4647 (17%)	22719 (83%)	20956 (77%)	7890 (29%)	5504 (20%)	27366
	2010	5474 (15%)	31055 (85%)	27740 (76%)	10023 (27%)	7197 (20%)	36529
	2004	24853 (51%)	23720 (49%)	17185 (35%)	1782 (4%)	902 (2%)	48573
A	2007	29463 (47%)	33889 (53%)	24031 (38%)	2810 (4%)	1440 (2%)	63352
	2010	33454 (44%)	42236 (56%)	26946 (36%)	3266 (4%)	1740 (2%)	75690
	2004	81735 (85%)	14404 (15%)	6294 (7%)	229 (0%)	70 (0%)	96139
B	2007	85276 (85%)	15196 (15%)	6387 (6%)	270 (0%)	76 (0%)	100472
	2010	78752 (82%)	17553 (18%)	5577 (6%)	194 (0%)	85 (0%)	96305
	2004	89247 (98%)	2054 (2%)	414 (0%)	20 (0%)	5 (0%)	91301
C	2007	99333 (99%)	1552 (2%)	369 (0%)	16 (0%)	5 (0%)	100885
	2010	116405 (99%)	1245 (1%)	235 (0%)	14 (0%)	10 (0%)	117650

Table 1: Changing patterns of AS/A level maths participation, by GCSE grade, for year 11 leaving cohorts in 2004, 2007 and 2010. Percentages are included in parentheses. N.B. This includes all students at each GCSE grade, irrespective of whether they progressed to A levels.

The numbers (and proportions) of GCSE grade C students completing any advanced mathematics are relatively small and have fallen by around 40% over the period in question. This decline in numbers occurred despite growth in the number of GCSE grade C students of nearly 30% between the 2004 and 2010 cohorts. The fact remains that around 99% of students achieving a grade C in 2010 did not complete any advanced mathematics over the ensuing three years.

For GCSE grade B students the story is marginally better. The number of B grade students completing some advanced mathematics has risen by over 20%. This is a proportional rise from 15% to 18% of the grade B students. This is all accounted for by a rise in those completing AS mathematics which offsets the decline in those completing at least A-level Mathematics in this B-grade group. It is impossible to say how many of these AS-students set out to complete A-level but then exited early and so 'leaked' out of the pipeline at this point.

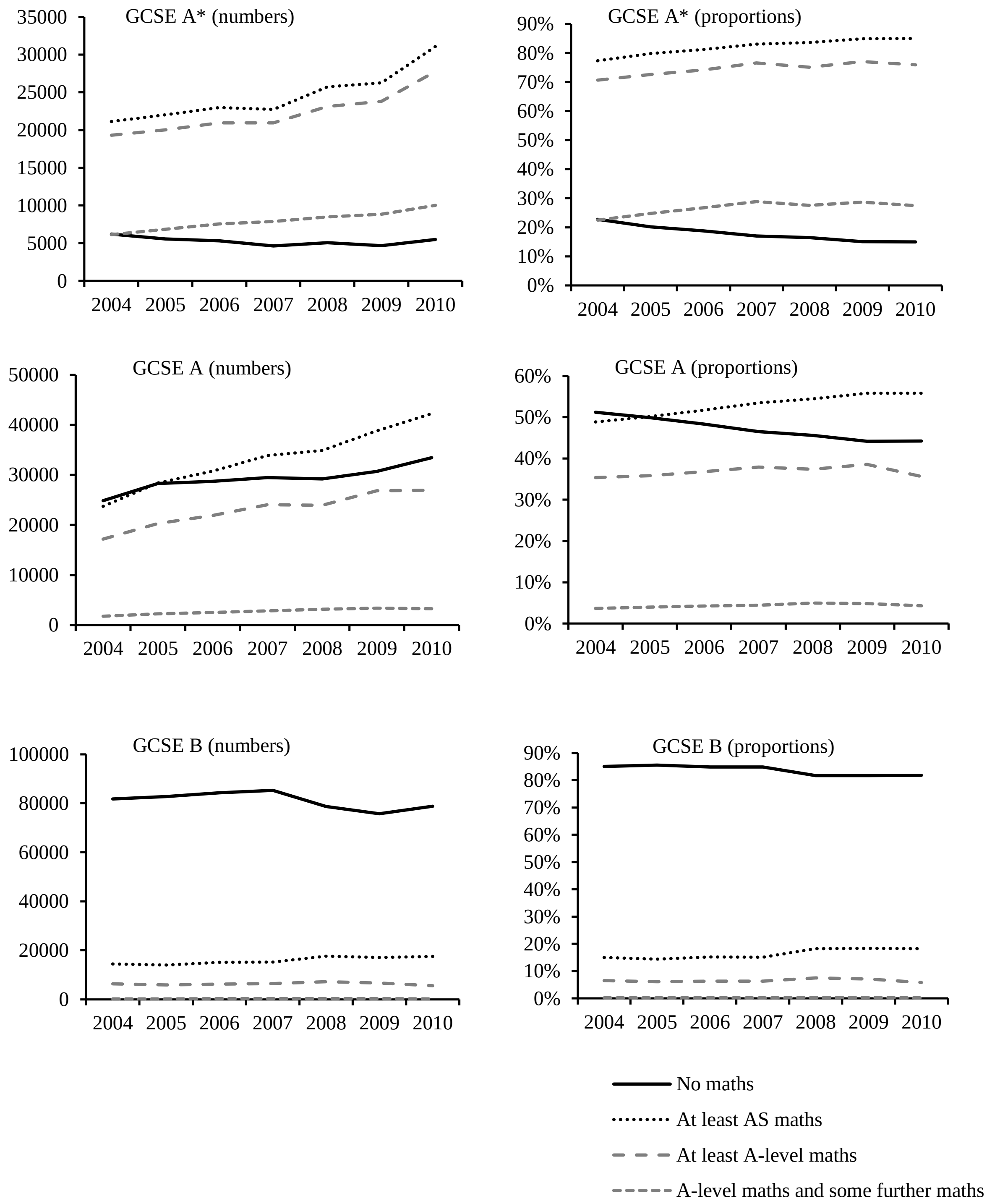

Figure. 1: Numbers and proportions of students from each GCSE Mathematics grade category who subsequently studied advanced mathematics up to different levels.

It is in the A* and A grade GCSE groups where the interesting changes can be seen. For students with GCSE A grade there has been a very small change in proportional engagement with Further Mathematics over time (3.7-4.3%) but the number that completed these further qualifications has risen by over 83% from 1782 to 3266. The small proportional change in Further Mathematics completion is compounded by the A grade GCSE cohort size rising by 56% over the period. The rise in the number of GCSE A grade students completing AS and A-level mathematics has also risen dramatically, but it is only at AS-level where the real proportional growth has taken place. This growth accounts for all of the reduction in the proportion of A grade GCSE students not studying any mathematics. This is a similar counterbalancing effect to that seen for the B-grade students; this highlights the valuable role of AS-level mathematics.

For GCSE A* students, the proportion completing A-level Mathematics plus some Further Mathematics (either AS or A-level) has risen from approximately 22% to 27% (with a peak of 29% in the 2007 GCSE A* cohort). When this proportional growth is compounded with the overarching GCSE A* population growth (of around 34%), the absolute percentage change – from 6136 to 10023 - is over 63% which sounds very impressive. The proportion of A* students completing at least A-level Mathematics has also grown over the period. Indeed it is only in the GCSE A* cohort that there has been a proportional increase of those completing at least A-level Mathematics. Unlike the results for A and B grade GCSE students, the fall in non-maths participation (from 23% to 15%) cannot be explained by the rise in AS-level Mathematics alone.

There is a question of whether any of these increases can be accounted for by the tendency to study more A levels during this period (Noyes 2013, found this to be a predictor of post-16 mathematics engagament). The NPD does include a ‘total entries’ field and analysis of this shows that A* GCSE mathematics students were subsequently entered for 4.26, 4.30 and 4.20 A-levels, on average in 2004, 2007 and 2010 respectively. Similarly, for A grade GCSE mathematics students the numbers are 4.00, 3.95 and 3.86. These change little over time and are very similar when considering those with and without any advanced mathematics, i.e. it appears not to be the case that AS mathematics is more likely to be taken as an additional, fourth, qualification. Given that the GCSE grade acts as a proxy for general attainment, the slight difference between A* and A grade GCSE student number of A-level entries is understandable. What this does show is that the mathematics participation growth for A* GCSE students cannot be attributed to variation in the number of qualifications completed over time.

The role of AS-level Mathematics as either a smaller advanced-level qualification or an exit award is evidently important. This is noteworthy because the current qualification reforms might impact negatively upon AS participation. It is not clear whether students, particularly those with a GCSE B or A grade, will commit to the full two year programme of A-level Mathematics. The evidence suggests that these students are more likely to use AS as an exit award. The current changes would, if this analysis is correct, result in a drop in AS/A level mathematics participation, particularly from amongst A and B GCSE grade students.

Beyond the increased involvement in AS (particularly at GCSE grades A and B), there has been little change in the proportions of students completing at least A level apart for in the GCSE A* category. The student numbers tell a different story. Table 1 suggests that a major contributory factor in the widely reported increased participation in A level mathematics has been the rapid growth of the higher grades at GCSE Mathematics. It is beyond the scope of this paper to discuss the nature of that growth but, suffice to say, there is compelling evidence that GCSE students have not got better at mathematics but rather that there has been some grade slippage (Hodgen et al. 2010a, Coe 2013). Earlier research shows that the relative performance in mathematics at GCSE is an important influence on choice. In other words, if a student has a clutch of GCSE A* grades and yet has an A in GCSE Mathematics, this will tend to mitigate against choosing advanced study (Noyes 2009a). So, a process that has arguably made GCSE less difficult could be a key explanation in the increasing completion of AS/A-level mathematics.

The revisions to GCSE mathematics that will be implemented from 2015 were predicated on the idea of making the qualification more demanding (e.g. Adams 2013) with the inclusion of a new grading system and a new top grade (equivalent to an A**). One possible effect of this move might be to reduce the numbers getting top grades (relative to other subjects) so whilst this might help to address alleged grade slippage, it could also reduce the likelihood of some students choosing advanced mathematics. In a situation where ‘maths to 18’ could become compulsory, the effect would be to push young people away from the more demanding traditional academic pathways of A-level mathematics towards the new, applied Core Maths qualification. Whether this would be politically acceptable is a moot point.

Claims have been made regarding the impact of policies aimed at increasing participation in A-level Mathematics and Further Mathematics, in particular by the Further Mathematics Support Programme (FMSP).

> …it is particularly remarkable that, thanks largely to the efforts of Mathematics in Education and Industry (MEI) an independent educational charity, A level Further Mathematics has been one of the fastest growing mainstream A level subjects in the UK over the past five years.
>
> (MEI, http://www.furthermaths.org.uk/files/FMSP_Media_release_15August2013.pdf)

Whilst the aims of the FSMP are laudable, and it has no doubt made an important contribution to supporting Further Mathematics students and teachers, our analysis shows that there are other factors that have contributed to the growth. We would not want to argue against the rise in Further Mathematics completions being a good thing. Rather, at a time when GCSE is changing (from 2015) and new A-level Mathematics and Further Mathematics qualifications are expected to be introduced from 2017, it is important to have a sound understanding of what drives participation and how curriculum and qualifications reform might impact upon uptake. As mentioned above, the changes of Curriculum 2000 had a huge and negative impact on post-16 participation and there is a chance that the current reforms, which are arguably more extensive, could have similarly unwelcome effects.

From earlier research, it is clear that the school/college attended impacts upon student participation (Noyes 2013), as does gender, ethnicity and social class. We have not focused on these factors herein but want to comment briefly upon gender (see Table 2). The analysis shows that initial proportional differences between boys and girls choice patterns have remained largely unchanged over the period, with a few exceptions. The numbers of boys and girls attaining A* and A grades at GCSE is pretty similar, though the rise in A* grades for girls (38%) is greater than for boys (30%) over the period. Although many of the proportional change patterns are similar, the initial conditions were quite different, so general patterns of engagement have remained. It is striking that many more boys are located towards the right hand side of the table. Of the girls in the 2010 Year-11 cohort that attained a GCSE grade A, 54% completed no advanced mathematics qualification. A greater proportion of A* GCSE students are studying some mathematics over time and despite the fact that many more of the boys in this GCSE category study Further Mathematics, the rate of increase is similar for girls and boys over this period. The proportion of female students completing only AS-level is increasing. One of the explanations for this gender difference is the relative attainment of boys and girls. For example, an analysis of GCSE grade data for 2010 girls with a GCSE A grade in mathematics shows them to have around 10% higher total GCSE points than boys (i.e. the sum of all results where A*=8, A=7, etc). In other words, compared to boys with grade A their other attainment was higher and they probably had more A-level options on offer.

GCSE Grade	Year	No maths	At least AS maths	At least A-level maths	At least A-level maths and AS further maths	A-levels in maths and further maths	Total male	Total female
	2004	16/30	84/70	78/62	29/15	22/09	14493	12842
A*	2007	12/22	88/78	83/70	37/21	27/13	13821	13545
	2010	10/20	90/80	83/68	36/19	27/12	18773	17756
	2004	41/62	59/38	45/26	5/2	3/1	24118	24455
A	2007	37/56	63/44	47/29	6/3	3/1	31210	32142
	2010	34/54	66/46	44/27	6/2	4/1	37761	37929

Table 2: The percentages of Male/Female students with GCSE grades A* and A in the Year 11 leaving cohorts of 2004, 2007 and 2010 who completed particular levels of post-16 mathematics

Concluding comments

The main thrust of this paper has been to use large scale national Department for Education datasets to present some alternative perspectives on patterns of A level mathematics completion over time. Rather than simply looking at the annual reporting of A level entries/outcomes, the study (and the wider project from which is comes) takes a different approach by tracing the flow of student cohorts, and subsections of those cohorts, to see how the flow patterns or pathlines of these groups has changed over time. It is of critical importance to understand these education flows if one is to anticipate the likely impact of current policy and, where necessary, to mitigate any potential unintended consequences.

The analysis demonstrates that different conclusions and/or explanations can arise from adopting the two approaches to presenting participation data discussed earlier. We have chosen to subset the cohorts along the lines of GCSE grade with good reason. Whilst this approach has its own limitations, and might be considered inferior to more advanced statistical techniques, the strong and clear messages from the descriptive analyses of large-scale national datasets such as the NPD are compelling.

If commentators hold to the more triumphalist media reports regarding the growth of A-level mathematics participation, with little understanding of what is driving them, there is a risk that changes to those patterns – which, in our view, are inevitable - will be perceived as threats. The alternative analysis herein highlights the important influence of increased high level GCSE attainment. It also reinforces the problem of engaging GCSE grade C and B students (and to a lesser extent A grade girls) with advanced mathematical study. Whether Core Maths can increase overall participation remains to be seen. If the Core Maths qualifications do help to increase post-16 mathematics participation, they will in all likelihood also draw some students away from AS/A-level Mathematics to the Core Maths pathway. For this reason, it is important to develop rigorous analyses of the current and historical participation patterns in order to avoid the kinds of knee-jerk reactions that have been known to adversely impact upon post-16 maths qualifications (such as in the impact of this report: Educators for Reform 2010). This paper provides such evidence.

The final point to make is that numbers are not everything; the nature of what is being learned is also important. Even if participation levels in post-16 advanced mathematics did include 'the vast majority', it would be of little use if curricula and assessments were not fit for purpose. In particular, with a raft of reforms currently underway and shifts in patterns of participation and student pathways expected, the 'how many?' must continue to be considered alongside the 'what?' Core Maths is currently contributing to that debate and will no doubt expose divisions amongst stakeholders regarding what is valued in mathematics education.

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