Nuffield Foundation

Grants for Research and Innovation

Front page summary

Rethinking the Value of Advanced Mathematics Participation (REVAMP)

The level of participation in advanced mathematics courses has been raising concerns for several years. Recent international comparisons show England to have one of the lowest levels of post-16 mathematics engagement. This, together with sustained pressure from stakeholders, has led to the Secretary of State's call for most young people to be studying mathematics up to 18 by the end of the decade.

This project weaves together four strands of quantitative analysis to understand the current and changing attitudes to, participation in, and value of A level mathematics. The project will utilise high-quality secondary datasets and includes a large-scale survey of 17-year-olds' understandings of the value of mathematics in their educational and life choices and aspirations.

The four quantitative strands of the project are

1. Updated research on the 'economic return' to A level mathematics;
2. An investigation of the nature of changing participation in A level mathematics from 2005-13;
3. Modelling of the relationship between A level mathematics and outcomes in a range of science and social science degree level programmes;
4. A large-scale survey of 17-year-olds.

These quantitative studies will be interwoven with a policy trajectory analysis that traces the value(s) attributed to A level mathematics, in particular its economic value. The project will produce a thorough and timely account of the state of attitudes to, and participation in, advanced mathematics just prior to the introduction of EBCs, reformatted A levels and new level-3 mathematics qualifications in 2015.

Rethinking the Value of Advanced Mathematics Participation (REVAMP)

Mathematics education – particularly at the interface between school, university and/or employment – is arguably the most scrutinised, debated and contested curriculum area due to its importance to a range of political, educational and economic issues. This has probably never been more so than now, with on-going and extensive debate taking place about 16-19 mathematics participation, curriculum and assessment. This project will bring up-to-date research evidence to bear on these discussions, looking at the same problem from several different angles, mainly through the use of secondary datasets. It will 1) reconsider the economic return to advanced (A level) mathematics, 2) examine the changing patterns of A level completion 3) investigate the benefits of A level to a range of undergraduate degree programmes, 4) trace the policy history in post-16 mathematics and 5) survey the latest attitudes to post-16 advanced mathematical study.

Background

The number and proportion of young people participating in advanced[1] mathematics in England's schools has been subject to a great deal of scrutiny for many years (DfE, 2011; Hawkes & Savage, 1999; Royal Society, 2008) and debates about the value of advanced mathematical study continue unabated (Norris, 2012; Noyes, Drake, et al., 2010; Smith, 2004). This project will extend previous research (Noyes, 2009, 2012; Noyes & Sealey, 2012) to reconsider the *value* of advanced level mathematics at a critical time in the development of mathematics education policy, curriculum and assessment in England, when the calls for learners to do both more and harder mathematics have never been louder.

In the build-up to Curriculum 2000, Dolton and Vignoles' (1999) analysis of the 1958 National Child Development Study concluded that the 'economic return' to A level mathematics was unique and significant (potentially around a 10% increase in earnings). This finding has subsequently seeped into educational thinking (e.g. Wolf, 2002) and policy discourses (e.g. Kounine, Marks, et al., 2008) and has been taken up by a variety of stakeholders and think tanks in their recommendations (e.g. Vorderman, Budd, et al., 2011; Wolf, 2011); school teachers even use it to recruit A level mathematics students (see Harris, 2012). The assumption of a causal relationship from that study of the baby-boomer generation, convenient though it might be for mathematics community, needs re-examining, firstly by analysing more recent datasets and secondly because of the different times in which we now live.

It is impossible to know the extent to which Dolton and Vignoles' econometric research has influenced the remarkable increase in A level completion since 2005 (around 60%[2]), but this pattern needs to be investigated in order to understand whether the current growth trajectory will help to address some of the longstanding concerns of the Science, Technology, Engineering and Mathematics (STEM) community. For example; are more girls doing maths/science? Can A level maths become a requirement on certain mathematically-demanding HE programmes? Etc. The recent DfE analysis (2011) of mathematics and science A level participation is very detailed but does not answer some of these trend questions, nor does it explore the significant variance in participation between schools/colleges highlighted in recent work (Noyes, 2012).

The furore that followed Curriculum 2000 (see Smith, 2004) has been influential in building the Secretary of State's intention to "set a new goal for the education system so that within a decade the vast majority of pupils are studying maths right through to the age of 18" (Gove, 2011). The argument depends in part on the findings from international comparison studies

[1] 'Advanced' includes any NQF Level 3 mathematics qualifications, current or proposed, and can be thought of as the mathematics available to those who have already obtained a GCSE grade C

[2] http://www.jcq.org.uk/media-centre/news-releases/entry-trends-2012-a-as-aea-tables

that show England to have one of the lowest rates of post-16 mathematics participation (Hodgen, Pepper, et al., 2010; OECD, 2010). It is also being driven by calls for improved quantitative skills in a wide range of degree programmes (e.g. British Academy, 2012). There is an assumption that the level of mathematics studied (i.e. as evidenced by completing A level) rather than student ability/potential (as evidenced in GCSE attainment) is what is important, but this connection needs further probing.

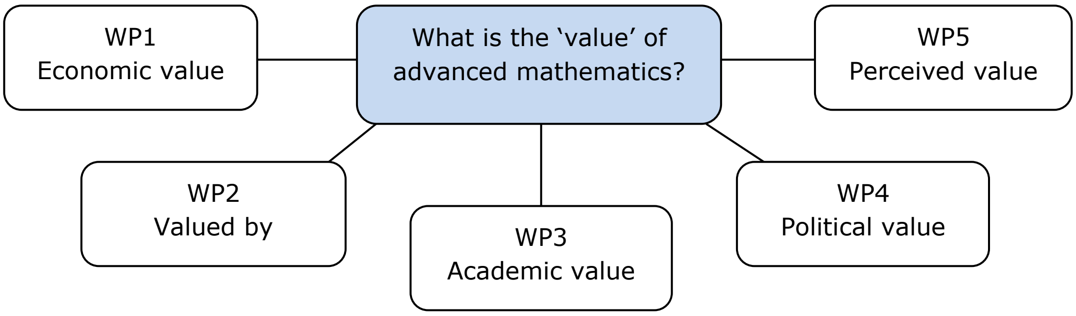
At the same time that A level numbers are rising, there remains a need to provide relevant alternative pathways for post-16 learners, ones that are driven less by the needs of HE and more by the desire to engage a broad constituency of level 3 learners (ACME, 2012; Noyes, Wake, et al., 2011; Williams, Wake, et al., 2008). The value of mathematics for these young people is not necessarily the delayed gratification of supposed future earning potential, the relationship of mathematics' to SET (Roberts, 2002) or the utilitarian value of mathematics for accessing related HE courses (Williams, 2012). The hegemony of economic drivers that are currently prominent in global policy discourses (Gutstein, 2009) need understanding and critique. Furthermore, the nature and extent of students' motivations, as well as the values they attribute, to studying post-16 mathematics needs investigating at this critical time. If current ministerial ambitions are realised, the end of this proposed project will coincide with the introduction of new post-16 mathematics courses and incentives designed to encourage take-up (ACME, 2012). This research will therefore inform the enactment phase of this policy process: the on-going development of curriculum, support and Information, Advice and Guidance that can better meet the range of students' needs.

Aims and research questions

Given this background, this project will interweave various quantitative analyses of three secondary datasets in order to provide different perspectives on the value of advanced level mathematics. Alongside this, we will undertake a policy trajectory analysis of 14-19 mathematics education since Curriculum 2000, and will also conduct a large-scale survey of 17-year-olds (i.e. Year 12) in order to understand their evolving attitudes towards post-16 mathematical study. The project's umbrella research question - what is the value of A level mathematics today? - is explored in a number of intersecting strands. These five strands are outlined in the table as *work packages* with key questions, data sources and issues:

WP	*Research Questions*	*Dataset*
1	Is there still a 'return' to A level mathematics and, if so, how great is it? Do Dolton and Vignoles' findings hold in more recent datasets?	1970 British Cohort Study
2	Who is doing A level Mathematics now? How have participation patterns changed; by social category, by school type, etc?	National Pupil Database; A level cohorts 2005-2013, matched to prior attainment and census data
3	What is the relationship between A level participation and attainment and degree outcomes?	2012 HESA outcomes data, matched to prior qualifications
4	How have mathematics education reports/policy/etc, taken up the economic and other value discourses since Curriculum 2000?	New dataset comprising all relevant papers, reports, policy documents.
5	What do 17 year olds think is the value of post-16 advanced mathematical study and how does it relate to their current and future choices and aspirations?	New dataset from large scale survey

The work packages offer five perspectives on this question of value:



Methodology

This section details the methodology for each of the five work packages:

WP1 Economic value: *Returns to A level mathematics*

This strand of the work is essentially a replication study with more up-to-date national panel data. There are three major panel surveys currently hosted by the Centre for Longitudinal Studies[3]: the 1958 National Child Development Study (NCDS); the 1970 British Cohort Study (BCS) and the Millennium Cohort Study (MCS). Dolton and Vignoles' work combined the use of the 1958 NCDS with data on a sample of 1980 graduates. Their report "The economic Case for Reforming A levels" provides the template for our analysis of the 1970 BCS. The BCS age 42 data will become available in the middle of 2013. Given that Dolton and Vignoles found that the 'return' did not become clear until the age 30 data, using the 1970 BCS offers a more up-to-date dataset of adults at the middle of their working lives. The MCS participants are too young for any analysis of earnings. The analysis will use regression modelling to investigate the relationship between A level mathematics completion and later salary.

Following Dolton and Vignoles, these econometric models will account for mathematical ability bias (i.e. that those who choose A level are already known to be successful mathematicians) through the inclusion of prior attainment in any regression analysis. The models will also explore the relevance of background variables (i.e. whether family history, advice and support are important), and whether individuals completed higher qualifications and in what subject. All of these methodological points have been rehearsed by Dolton and Vignoles so the methodology is clear.

With regards to the dataset, conversations with database managers at the Centre for Longitudinal Studies (CLS) have confirmed that the NCDS has appropriate data for this replication study. The age 30 data sweep compiled detailed information on qualifications undertaken since age 16 so we will not need to supplement the NCDS with graduation data (c.f. Dolton and Vignoles). The A level categories are in raw form and I have recommended a possible coding framework to the CLS so that the dataset is ready for this research. This strand of the work should be completed in the first full year of the project, on the condition that the release of data from the Age 42 sweep is not delayed.

[3] http://www.cls.ioe.ac.uk/

WP2 Valued by whom? *Understanding changing patterns of participation*

There is a considerable amount of work to do to prepare this large dataset for analysis. Previous research (Noyes, 2009) has detailed the process of cleaning and preparing these datasets and how sequences of analytical choices need to be recorded and their influence on final analyses understood (see, for example Gorard, 2008). A preliminary 'in-principle' request has been made to the DfE National Pupil Database for 2005-2012 Key Stage 5 data; all matched to prior attainment and social background. Given the increase of around 60% in A level completion numbers over this period, this WP will explore this trend in more depth. Initially, this will be through the use of descriptive statistics to present various analyses of this growth and how it is constituted. Important factors here are social background variables (e.g. ethnicity, gender, proxies for class – free school meal eligibility (FSM), income deprivation affecting children index (IDACI)), prior attainment (e.g. is gain largely from A grade GCSE students?), level of A level mathematics participation (e.g. AS, A level, further mathematics).

Following the descriptive statistical work, logistic regression models will be developed for A level mathematics completion (binary response) and level of participation and outcomes (multinomial response). Dummy variables for such things as school type and region will enable us to identify any patterning in the changing participation/attainment patterns over this time. Earlier work (Noyes, 2012) indicated the significant role of schools/colleges in the unusually high level of between-institution variance in A level participation and this analysis using multilevel logistic modelling (Goldstein, 2003; Rasbash, Steele, et al., 2005) will be repeated and extended to explore whether this has been reduced as uptake has increased. Here, as in other WPs, care will be taken to account for missing data (Graham, 2012) through use of proprietary software (e.g. REALCOM-IMPUTE, see Goldstein, 2011).

Another important element of this strand of the project is to map out the changing combinations of A levels. One snapshot of this has recently been undertaken (Gill, 2012) but this project will explore the trends over time. This is important in HE discussions regarding entry requirements to mathematically-demanding degree programmes, and in the debate about embedding more mathematics in other A levels (SCORE, 2012). Earlier work (Matthews & Pepper, 2007) identified common subject combinations. Here we look across patterns of participation and also focus in on specific science and social science subjects (e.g. chemistry, economics and psychology).

WP3 Academic value: *Predicting degree outcomes*

There are some legal complications with matching the NPD and HESA datasets required for this strand of the work. I have been in lengthy discussion with HESA and DfE about resolving this matter and understand that the situation is currently being redressed. HESA can provide data that includes A level qualifications but in order to investigate the predictive value of A level mathematics, prior attainment at GCSE is also required. This WP seeks to answer questions like the following. Consider several 16 year olds who achieve the same GCSE results and are socially similar, who then make different A level choices (some including mathematics) and all complete a degree in, say, psychology at University X. Is there any statistical association between the degree outcomes and their participation in A level mathematics and if so what is the effect size?

One element of this work package will be to investigate whether there is now sufficient data to explore whether the Use of Mathematics qualification has been beneficial in the learning trajectories of those young people who have taken it (Hutcheson, Pampaka, et al., 2011; Noyes, et al., 2011). At this stage we do not know the numbers involved and therefore what analyses would be possible.

This WP will focus on the development of single and multi-level regression models that calculate the academic value of having an A level in mathematics (including the level of the qualification) upon degree outcomes, given prior GCSE performance and background variables. There are a considerable range of possible undergraduate programmes that could be of interest so the analysis will include a representative sample of institutions and will pay particular attention to the disciplines that are central to the current HEA project 'Skills in Mathematics and Statistics in the Disciplines and Tackling Transition'[4]: chemistry, economics, psychology, computing, sociology, geography and business.

WP4 Political value*: Policy and public discourses of the value of mathematics*

There have been numerous reports from government departments, charities, learned societies and think tanks since Curriculum 2000 that have tried to understand and/or offer recommendations on how to tackle the challenge of increasing mathematics uptake post-16. This work package aims to explore the changing discourses in these literatures in order to understand how the current policy discussions are framed. We will begin by compiling an exhaustive database of reports, statements, press releases, media coverage, government papers and the like, that pertain – directly or indirectly - to upper secondary school mathematics (14-19). Content analysis (Krippendorff, 2012; Schreier, 2012) of this database will then be undertaken in order to map out the discourses of post-16 mathematics participation, to look for particular trends and silences. The analysis will be undertaken using open source content analysis software (e.g. Yoshikoder[5]). A dictionary of key terms will be developed and used to explore the genesis, development and resilience of particular ideas and how these relate to the developing policy-scape for post-16 mathematics.

A particular focus in this WP is the growth of economic discourses in the framing of debates about post-16 mathematics participation and, related to this, the growing influence of international comparisons (e.g. TIMSS and PISA) upon national discussions (Ball, 2012; Grek, 2009; Rizvi & Lingard, 2009). This WP will draw upon policy sociology to develop a critical interpretation of the trends in post-16 mathematics education policy and advisory work. By tracing these discourses over the last dozen years it aims to understand how the key influencers (including what Stephen Ball terms the policy 'interlockers') and influences have framed the debates and likely future of Post-16 mathematics.

WP5 Perceived value: *student attitudes and ascription of value*

This survey will be undertaken in the first half of the 2014/15 academic year with 17-year-olds in the six months following completion of their GCSEs. This is just prior to when it is expected that new post-16 mathematics qualifications will become available. The online survey will be distributed as widely as possible through schools and colleges. The use of unique institutional URLs will enable us to match the survey data to the trend analysis from WP2. The survey will be developed and trialled in 4 institutions during 2013/14. Some items will be drawn from recent attitudinal surveys (e.g. from the ESRC-funded GMAP[6] and Transmath[7] projects as well as other relevant published studies (e.g. Brown, Brown, et al., 2008)) in order to replicate that work at a larger scale for 17-year-olds. New items will be included to enable us to understand attitudes to the changing qualification landscape, the introduction of new post-16 mathematics qualifications and the 'ABacc' (Paton, 2012), should it come to fruition. We will explore young peoples' perception of the 'use' and 'exchange' value (Williams, 2012) of advanced

[4] The PI is a member of the steering group for this project: http://www.heacademy.ac.uk/resources/detail/project
[5] http://www.yoshikoder.org/index.html
[6] Further information about the ESRC-funded Geographies of Mathematical Attainment and Participation project can be found at http://www.esrc.ac.uk/my-esrc/grants/RES-061-25-0035/read
[7] http://www.education.manchester.ac.uk/research/centres/lta/ltaresearch/transmaths/

mathematics and the extent to which their perceptions of the value of advanced mathematics align with those of government and other stakeholders.

Support for the design and delivery of the survey is provided by an external consultant with expertise in large-scale survey design and delivery. The survey will be constructed using the latest version of SNAP and will lead to the production of a cleaned SPSS data file. A full range of analysis will be conducted, including multilevel models that will allow us to explore between-school variation in attitudes to mathematical study. Although students will be anonymous, the inclusion of school level identifiers will allow us to match to the analyses conducted in WP2. This will enable us to marry up school-level performance and participation rates with attitudinal data from students, offering a unique opportunity to understand some of the patterning that we expect to see in WP2. This will also help in the weighting of cases in order to produce more reliable statistical inferences.

WP5 presents one of the highest risks in the project due to the challenge of securing good response rates. The reason for conducting this survey is that schools/colleges will at that time be faced with the impending challenge of having to offer post-16 mathematics to many more students than had previously been the case. This will provide some leverage for engagement with the survey and by seeking access through head teachers/principals we will get high-level support for the survey. It is important that the survey is not just targeted at existing choosers of mathematics so we will work with local head teachers to develop an effective strategy for maximising the chances of a good response rate, seeking the support of head teacher unions and other organisations (e.g. the National College for School Leadership) in disseminating the survey invitation.

Communication, engagement and outcomes

This proposal articulates strongly with the following agendas and projects:

- The Government's emerging strategy for increasing post-16 mathematics participation;
- ACME's post-16 mathematics project (ACME, 2012);
- The Higher Education Academy's STEM project: Skills in Mathematics and Statistics in the Disciplines and Tackling Transition;
- The work of SCORE to strengthen mathematics in A level science assessment (SCORE, 2012);
- Efforts by the ESRC[8], The Nuffield Foundation[9], HEFCE[10] and The British Academy[11] to raise the level of quantitative skills in Higher Education.

The project timeline overlaps with my membership of the Royal Society's Advisory Committee on Mathematics Education. I have been centrally involved in ACMEs work on post-16 mathematics and will be involved in future advisory work in this area. This provides an unusual opportunity to feed research into the policy implementation process. In addition, my membership of the steering group of the HEA project, which will come to an end in the summer of 2013, allows for the connection of this proposed research to what arises from the recommendations that will come from that project. The proposed study sits at the interface of DfE and BIS responsibilities and my existing networks allow for engagement across these policy spaces.

One of the goals of the project is to contribute to scholarship in this area of advanced mathematics participation. We will therefore publish a range of papers in peer reviewed journals. However, the more important goals of the project are to ensure that the research a)

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[8] http://www.esrc.ac.uk/funding-and-guidance/tools-and-resources/research-resources/initiatives/qmi.aspx

[9] http://www.nuffieldfoundation.org/quantitative-methods-programme

[10] https://www.hefce.ac.uk/whatwedo/crosscutting/sivs/qss/

[11] http://www.britac.ac.uk/policy/Quantitative_Skills.cfm

impacts on the developing policy-scape and implementation process, b) feeds into the kinds of literatures analysed as part of WP4, and, related to these c) helps to develop strategies by which the education research community might more effectively bridge the research-policy divide. In order to achieve this we will produce a range of shorter, accessible outputs for dissemination to non-academic audiences. Given the Nuffield Foundation's expertise in this type of work we will make use of opportunities available through their staff and networks.

The project steering group will meet in London. This is a strategic decision as we aim to connect with what Ball has termed 'policy interlockers' (Ball & Exley, 2010) and given the concentration of such workers in and around London, it is important to plan for successful engagement with these people. The steering group will also provide avenues for a wider range of dissemination activity. It will meet every 6 months and have a broad constituency such as the PI, RA, academics with research experience in post-16 mathematics participation, relevant members of learned societies and advisory groups, a statistician, government department officials (if possible) and the Nuffield Foundation. We will take advice from Nuffield as to how this group might be best constructed to achieve the research and dissemination goals.

We will present findings at the annual conference of the British Educational Research Association at the mid and end point of the project and costs for this have been included. There will be a project dissemination seminar in the late summer of 2015 which we will ask the Nuffield Foundation to host, so have not included costs for that below. The project will also have web presence as part of the Centre for Research in Mathematics Education.

Timeline

The following timeline gives an indication of when various elements of each WP will be undertaken. These are necessarily front loaded and give space for extended data preparation/cleaning, statistical analysis and preparation of reports and dissemination products.

	'Year' 1	Year 2			Year 3		
	Jun-Sept 2013	**Oct-Dec 2013**	**Jan-April 2014**	**May-Aug 2014**	**Sept-Dec 2014**	**Jan-April 2015**	**May-Sept 2015**
Project management	Appoint RA Establish Steering Group Produce detail project timeline	SG1 Establish RA	SG2	SG3	SG4 Consider follow-on research	SG5	
Work Pack. 1	Request dataset	Prepare dataset	Analysis	Report preparation			
WP2	Request dataset	Data cleaning and production of dataset for analysis	Data cleaning and production of dataset for analysis	Exploratory analyses Consider adding 2013 data	Analysis	Analysis	Report preparation
WP3	Request dataset	Match data	Data cleaning and production of dataset for analysis	Analysis	Analysis	Report preparation	
WP4	Compile dataset	Compile dataset	Prepare dictionary	Analysis	Report preparation		
WP5		Consider existing surveys. Lit review to inform new items	Develop survey	Pilot survey	Survey	Analysis	Analysis
Reporting and Dissemination			Interim report 1: focus on WP1		Interim report 2: focus on WP3&4 BERA conference	Synthesis WP analyses and prepare papers, pamphlets, etc	Final report Bera Conference Nuffield Seminar

References

ACME (2012). *Post-16 Mathematics: a strategy for improving provision and participation*. London: Advisory Committee on Mathematics Education/Royal Society.

Ball, S. (2012). *Global Education Inc.: New Policy Networks and the Neoliberal Imaginary*. London: Routledge.

Ball, S., & Exley, S. (2010). Making policy with 'good ideas': policy networks and the 'intellectuals' of New Labour. *Journal of Education Policy, 25*(2), 151-169.

BERA (2011). *Ethical guidelines for educational research*. London: British Educational Research Association.

British Academy (2012). *Society Counts: quantitative skills in the social sciences and humanities*. London: BA.

Brown, M., Brown, P., & Bibby, T. (2008). "I would rather die": reasons given by 16-year-olds for not continuing their study of mathematics. *Research in Mathematics Education, 10*(1), 3-18.

DfE (2011). *Maths and science education: the supply of high achievers at A level*. London: Department for Education.

Dolton, P., & Vignoles, A. (1999). *The economic case for reforming A levels (CEPDP, 422)*. London: Centre for Economic Performance, London School of Economics and Political Science.

Gill, T. (2012). *Uptake of two-subject combinations of the most popular A levels in 2011, by candidate and school charactersitics*. Cambridge: Cambridge Assessment.

Goldstein, H. (2003). *Multilevel Statistical Models, 3rd Edition*. London: Hodder Arnold.

Goldstein, H. (2011). REALCOM-IMPUTE: multiple imputation using MLwin Available from http://www.bristol.ac.uk/cmm/software/realcom/imputation.pdf

Gorard, S. (2008). Who is missing from higher education? *Cambridge Journal of Education, 38*(3), 421-437.

Gove, M. (2011). Michael Gove speaks to the Royal Society on maths and science Retrieved 17th December, 2012, from http://www.education.gov.uk/inthenews/speeches/a00191729/michael-gove-speaks-to-the-royal-society-on-maths-and-science

Graham, J. (2012). *Missing Data: Analysis and Design*. London: Springer.

Grek, S. (2009). Governing by Numbers: the PISA 'effect' in Europe. *Journal of Education Policy, 24*(1), 23-37.

Gutstein, E. (2009). the politics of mathematics education in the United States: dominant and counter agendas. In B. Greer, S. Mukhopadhyay, A. Powell & S. Nelson-Barber (Eds.), *Culturally Responsive Mathematics Education* (pp. 137-164). Abingdon: Routledge.

Harris, J. (2012). *Rational Numbers: investigating compulsion for mathematics study to 18*. London: The Pearson Think Tank.

Hawkes, T., & Savage, M. (1999). *Measuring the mathematics problem*. London: The Engineering Council.

Hodgen, J., Pepper, D., Sturman, L., & Ruddock, G. (2010). *Is the UK an Outlier?* London: Nuffield Foundation.

Hutcheson, G., Pampaka, M., & Williams, J. (2011). Enrolment, achievement and retention on 'traditional' and 'use of mathematics' AS courses. *Research in Mathematics Education, 13*(2), 147-168.

Kounine, L., Marks, J., & Truss, E. (2008). *The Value of Mathematics*. London: Reform.

Krippendorff, K. (2012). *Content analysis: an introduction to its methodology* (3rd ed.). London: Sage Publications Ltd.

Matthews, A., & Pepper, D. (2007). *Evaluation of Participation in A level Mathematics: final report*. London: Qualifications and Curriculum Authority.

Norris, E. (2012). *Solving the maths problem: international perspectives on mathematics education*. London: RSA/OCR.

Noyes, A. (2009). Exploring social patterns of participation in university-entrance level mathematics in England *Research in Mathematics Education, 11*(2), 167-183.

Noyes, A. (2012). The effective mathematics department: adding value and increasing participation? *School Effectiveness and School Improvement, in press*.

Noyes, A., Drake, P., Wake, G., & Murphy, R. (2010). Evaluating Mathematics Pathways: Final Report, December 2010 Available from https://www.education.gov.uk/publications/standard/publicationDetail/Page1/DFE-RR143

Noyes, A., & Sealey, P. (2012). Investigating participation in Advanced level mathematics: a study of student drop out *Research Papers in Education, 27*(1), 123-138.

Noyes, A., Wake, G., & Drake, P. (2011). Widening and increasing post-16 mathematics participation: pathways, pedagogies and politics. *International Journal of Science and Mathematics Education, 9*, 483-501.

OECD (2010). *PISA 2009 Results: What students know and can do: student performance in reading, mathematics and science (Volume I)*. Organisation for Economic Cooperation and Development.

Paton, G. (2012, 17th October). New 'ABacc' to be added to school league tables*. The Telegraph*. from http://www.telegraph.co.uk/education/educationnews/9615628/New-ABacc-to-be-added-to-school-league-tables.html.

Rasbash, J., Steele, F., Browne, W., & Prosser, B. (2005). *A User's Guide to MLWin (version 2.0)*: Centre for Multilevel Modelling, University of Bristol.

Rizvi, F., & Lingard, B. (2009). *Globalizing Education Policy*. London: Routledge.

Roberts, G. (2002). *SET for success: The supply of people with science, technology, engineering and mathematics skills*. London: Department for Education and Science.

Royal Society (2008). *Science and mathematics education 14-19: A 'state of the nation' report on the participation and attainment of 14-19 year olds in science and mathematics in the UK*. London: The Royal Society.

Schreier, M. (2012). *Qualitiative content analysis in practice*. London: Sage Publications Ltd.

SCORE (2012). *Mathematics within A-level science examinations*. London: Science Community Representing Education.

Smith, A. (2004). *Making Mathematics Count*. London: The Stationery Office.

Vorderman, C., Budd, C., Dunne, R., Hart, M., & Porkess, R. (2011). A world-class mathematics education for all our young people. Retrieved from http://www.tsm-resources.com/pdf/VordermanMathsReport.pdf

Williams, J. (2012). Use and exchange value in mathematics education: contemporary CHAT meets Bourdieu's sociology. *Educational Studies in Mathematics, 80*(1), 57-72.

Williams, J., Wake, G., Black, L., Davis, P., Hernandez-Martinez, P., Hutcheson, G., et al. (2008). TLRP Research Briefing No 38: Keeping open the door to mathematically demanding programmes in Further and Higher Education. Retrieved from http://www.lta.education.manchester.ac.uk/TLRP/Research%20Briefing.pdf

Wolf, A. (2002). *Does Education Matter? Myths about education and economic growth*. London: Penguin.

Wolf, A. (2011). Review of Vocational Education - the Wolf Report. Retrieved from https://www.education.gov.uk/publications/eOrderingDownload/The%20Wolf%20Report.pdf