

<b>Institution: King's College London</b>
<b>Unit of Assessment: UoA25 (Education)</b>
<b>Title of case study: Post-16 Participation in Mathematics</b>
<p><b>1. Summary of the impact</b></p> <p>This case study describes how research at King's College London directly informed the Government's policy to ensure near-universal participation to age 18 in mathematics education within a decade. This research has shown that (i) England's participation in post-16 mathematics is unusually low internationally, and that (ii) mathematical attainment in England has fallen since the 1970s. This evidence has been cited by government ministers as the basis for their decision to change policy on the study of mathematics in post-16 education. Subsequent research into how other countries achieve high participation has informed the content and implementation of the policy.</p>
<p><b>2. Underpinning research</b> [Numbers in brackets refer to references in Section 3.]</p> <p>Two strands of research underpin this impact, both undertaken by Prof. Hodgen and colleagues at King's. The first relates specifically to participation in upper secondary mathematics education and consists of two international comparative studies funded by Nuffield [1, 2] together with studies funded by the Gatsby Charitable Foundation, examining the supply of mathematics teachers in the UK [3], and the Sutton Trust, examining what mathematics is required in employment [4]. The second strand relates to the mathematical attainment of secondary students in England and consists of research conducted as part of the Increasing Student Competence and Confidence in Algebra and Multiplicative reasoning (ICCAMS) project, a 4.5-year ESRC-funded study [5]. In addition, the ESRC's Targeted Initiative on Science and Mathematics Education (TISME) [6] focussing on translating research findings for policy and practice audiences, has enabled a synthesis of the findings of some of the underpinning research [1, 2 and 5], and has provided access to key policy-makers and politicians, in particular Elizabeth Truss, MP.</p> <p>For the initial Nuffield-funded study, <i>Is the UK an Outlier?</i> [1, 7], the researchers collated and synthesised evidence on 24 countries. This produced a substantial database, verified by national experts, about participation in upper secondary mathematics education in each of these systems. A follow-on study [2] examined policy on participation in mathematics in seven of these countries. This study extended the synthesis and verification of evidence and included a systematic literature review of 743 publications. Research on teacher supply [3], commissioned in response to a Department for Education (DfE) request, consisted of case studies of a purposive sample of nine further education colleges investigating how prepared colleges are for increased post-16 mathematics education participation. The ICCAMS study [5] provided evidence on the current levels of attainment in mathematics using a nationally representative random sample of approximately 7000 students aged 11-14 in 2008/9 and compared this to an equivalent sample from 1976/7. A research review of workplace mathematics [4] provided evidence that mathematical skills in the workforce need to be improved, and that, in post-16 mathematics, more emphasis needs to be placed on modelling and application, alongside multiplicative reasoning and statistics.</p> <p>Taken together, these studies have provided an evidence-based narrative of both the reasons why the UK needs to take action on post-16 participation in mathematics education, and how policy in this area needs to be formulated. The key findings are as follows:</p> <ol style="list-style-type: none"> <li>1. Participation in the study of any mathematics at upper secondary level in England is around 20% (compared to over 50% in almost all other countries). [7, 8]</li> <li>2. Participation in the study of advanced mathematics (to at least an equivalent of AS-level content) in England is low (13%) compared to most other systems (e.g., Scotland: 26%, Korea: 57%, Japan: 85%). [7, 8]</li> <li>3. The UK nations are four of only six of the 24 countries surveyed not requiring compulsory participation in mathematics at upper secondary level. [7, 8]</li> <li>4. High levels of participation are not simply driven by compulsion (i.e. a mandatory requirement</li> </ol>

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to study the subject), particularly in the case of advanced secondary mathematics. Other factors, such as providing appropriate options for *all* students, the breadth of the post-16 curriculum in general, and the specification of mathematics as an entry requirement for HE, are also associated with high levels of participation. [9]

5. Two countries are of particular policy relevance for England: New Zealand and Singapore. Like England, both have 'free-choice' systems of upper secondary education, but, unlike England, both achieve very high participation rates in advanced mathematics (around 40%) and in any mathematics (>65%). [9]
6. The risks to implementation of a policy aimed at near-universal participation to age 18 in mathematics education include: an under-supply of mathematics teachers; the possibility that any new qualification may not be widely available or valued by HE, employers and students themselves; increased social stratification by gender or socio-economic status; and a lack of interest by key stakeholders if the policy is implemented too quickly. [10, 12]
7. Across Key Stage 3, tests show that conceptual understanding of algebra and multiplicative reasoning has declined overall since 1976/7 across the attainment range. [11]
8. Current levels of attainment are not a sufficient preparation for further participation in STEM subjects [4, 5, 6, 11] and the workplace. [10]

### 3. References to the research

#### Supporting grants:

- [1] Hodgen (PI), Pepper & Sturman. (2010). *International Review of Mathematics Education 16-19*. Nuffield Foundation: £12,000 (with NFER). Competitive tender.
- [2] Hodgen. (2012-13). *Towards universal participation in post-16 mathematics*. Nuffield Foundation: £17,000. Commission.
- [3] Hodgen. (2013). *The expansion of post-16 mathematics teaching: issues of teacher supply*. Gatsby Charitable Trust: £4,000. Commission.
- [4] Hodgen (PI) & Marks. (2013). *The mathematics needed for employment and industry: a literature review and scoping study*. Sutton Trust: £6,000. Commission.
- [5] Hodgen (PI), Brown & Coe. (2008-12). *ICCAMS: Increasing Student Competence and Confidence in Algebra and Multiplicative reasoning*. ESRC (ES/F025483/1): £640,000 (with Durham University). Competitive bid.
- [6] Archer (PI), Dillon & Hodgen. (2010-14). *TISME: Targeted Initiative on Science and Mathematics Education*. ESRC (RES-179-34-0001): £220,000. Competitive bid.

#### Research publications (of which 7, 9 & 11 were peer-reviewed): [hard copies available on request]

- [7] Hodgen, J., Pepper, D., Sturman, L., & Ruddock, G. (2010a). *Is the UK an outlier? An international comparison of upper secondary mathematics education*. London: The Nuffield Foundation.
- [8] Hodgen, J., Pepper, D., Sturman, L., & Ruddock, G. (2010b). *An international comparison of upper secondary mathematics education: 24 country profiles*. London: The Nuffield Foundation.
- [9] Hodgen, J., Marks, R., & Pepper, D. (2013). *Towards universal participation in post-16 mathematics: lessons from high performing countries*. London: The Nuffield Foundation.
- [10] Hodgen, J., & Marks, R. (2013). *The Employment Equation: Why our young people need more maths for today's jobs*. London: The Sutton Trust.
- [11] Hodgen, J., Küchemann, D., Brown, M., & Coe, R. (2010). Multiplicative reasoning, ratio and decimals: A 30 year comparison of lower secondary students' understandings. In M. F. Pinto & T. F. Kawaski (Eds.), *Proceedings of the 34th Conference of the International Group of the Psychology of Mathematics Education* (Vol. 3, pp. 89-96). Belo Horizonte, Brazil.
- [12] Kyffin, H., Hodgen, J., & Tomei, A. (2013). *The Supply of Mathematics teachers in the Further Education Sector*. London: King's College London.

### 4. Details of the impact [Numbers in brackets refer to references and sources in Sections 3 & 5.]

Hodgen *et al.*'s research has directly contributed to a shift in policy about participation in mathematics education post-16 from one concerned with *encouraging* 'more young people [to]

continue longer with the study of mathematics' [22, p.13] to one aimed at *ensuring* 'that within a decade the vast majority of pupils are studying maths right through to the age of 18' [Michael Gove: 17]. The impact of the new policy is not limited solely to participation in post-16 mathematics education; it will have a significant widening participation impact. In comparison to other A-levels, participation in mathematics education is skewed towards high attainers, boys and groups with low deprivation, whilst a mathematics qualification (GCSE or A-level) brings significant economic and other social benefits [see evidence cited in 10].

The current government came to power with serious concerns about attainment in school mathematics and the UK's relative performance internationally, but was not then committed to the majority studying mathematics to 18. In his early speeches as Secretary of State for Education, Michael Gove frequently mentioned concerns about mathematics attainment at primary and GCSE levels, but made no mention of post-16 mathematics.

2011-12 was a turning point. At this time four influential reports were published recommending a substantial expansion of post-16 mathematics education. In each of these Hodgen *et al.*'s data on international participation rates was the key evidence cited (and was reproduced in detail in three of the reports [13, 14, 15]):

- In 2011 the Advisory Committee on Mathematics Education (ACME) [13] recommended that 'Policy on mathematics post-16 should ensure that a large majority of young people continue with some form of mathematics post-16' (p.3), and reproduced the participation table from Hodgen *et al.*'s first Nuffield report, *Is the UK an Outlier?* [7] in full to support this recommendation. Established by the Royal Society and the Joint Mathematical Council, ACME is the key national stakeholder body on mathematics education, acting as a 'single voice for the mathematics education community to government' (<http://www.acme-uk.org/about-acme>).
- The Conservative Party's mathematics taskforce [14] made a similar recommendation.
- The House of Lords Select Committee on Science and Technology [15] recommended that 'the Government makes studying maths in some form compulsory for all students post-16'.
- The Wolf Report (2011) [16] recommended that students without a GCSE A\*-C grade in mathematics should be required to continue to study towards GCSE mathematics. Wolf cited the *Is the UK an Outlier?* research [7] as evidence, commenting that it 'examines upper secondary maths provision, with particular attention to vocational programmes, and underlines how extraordinary our policy is and has been. The UK (including England) is effectively unique in not requiring continued mathematics and own-language study for all young people engaged in 16-19 pre-tertiary education' (p.83).

In a speech on mathematics and science education at the Royal Society [17], Michael Gove announced the Government's aspiration that all students should study mathematics to 18, citing the international evidence from the *Is the UK an Outlier?* report [7]. In the following year, Nick Gibb, Minister of State for Schools, reiterated this policy shift [18], citing the evidence from the same report [7] and from the ICCAMS study on attainment [5] to justify the policy.

Since September 2012 when Elizabeth Truss, who as a backbench MP had played a key role in publicising the research findings [e.g., 21, 23], was appointed as Parliamentary Under Secretary of State for Education and Childcare, the focus on implementing this policy has intensified. In five speeches [19] she has restated and elaborated on the policy, citing the participation [7] and attainment [11] evidence, and describing *Is the UK an Outlier?* [7] as a 'blockbuster report' (17/1/13). In addition, the Government has accepted the need for an alternative advanced qualification, as recommended in Hodgen *et al.*'s second Nuffield report, *Towards Universal Participation* [9]. In her keynote speech at the launch of that report, Truss reiterated the Government's intention that all students should study mathematics post-16, agreed the need for an additional 'Maths for All' qualification in advanced mathematics and acknowledged the risks identified in the report (15/1/2013, see also her 17/1/2013 & 7/3/2013 speeches [19]). Additionally, in her lecture on A-Level reforms at the Institute of Education [19], Truss quoted directly from Hodgen *et al.*'s research [9], citing New Zealand's advanced statistics option. The Labour Party (in an article by Kevin Brennan, Shadow Minister for Schools [20]) has also announced its support for the policy, citing the King's research [7, 10]).

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Concurrently, Hodgen was asked by the Department for Education (DfE) to provide confidential advice on the implementation of the policy and specifically the supply of mathematics teachers. As a result, Hodgen, Tomei and Brown provided a detailed commentary on the DfE's (confidential) modelling of mathematics teacher supply [24], drawing on the findings of their previous research [3, 9 and 12]. This commentary reiterates the key risks threatening successful implementation and the need to implement the policy over an extended time period. As a direct result, the DfE are currently exploring a phased introduction of the policy from 2015.

According to Roger Porkess, lead author of the Vorderman report [14], the Nuffield research [7] was 'critical to the direction of national policy. The report was widely read and discussed at the time of its publication and... was cited in two influential reports [13, 14] ... Consequently the findings came to the attention of government ministers and top officials in the DfE, resulting [in] a major change of policy' (personal communication: 26/5/2013). Tim Oates, Chair of the National Curriculum Review Expert Panel, has said that the research has 'identified a serious gap in post-16 provision and ... the strength of the evidence has convinced ministers, subject associations and exam boards ... to address this serious gap' (personal communication: 17/7/13).

### 5. Sources to corroborate the impact

Documents: [hard copies available on request]

[13] ACME. (2011). *Mathematical needs: Mathematics in the workplace and in Higher Education*. London: The Royal Society.

[14] Vorderman, C., Porkess, R., Budd, C., Dunne, R., & Rahman-Hart, P. (2011). *A world-class mathematics education for all our young people*. London: The Conservative Party.

[15] House of Lords Select Committee on Science and Technology. (2012). *Higher Education in Science, Technology, Engineering and Mathematics (STEM) subjects: 2nd Report of Session 2012–13*. London: The Stationery Office.

[16] Wolf, A. (2011). *Review of Vocational Education: The Wolf Report*. London: DfE.

Ministerial speeches: [available at <https://www.gov.uk/government/speeches/> and in hard copy]

[17] Gove, M. (29 June 2011) Speech to the Royal Society on mathematics and science.

[18] Gibb, N. (10 July 2012) Speech at ACME annual conference.

[19] Truss, E. (9 Nov 2012) Speech to National Education Trust; (11 Dec 2012) Speech following publication of TIMSS test results; (17 Jan 2013) North of England Education Conference; (7 March 2013) Institute of Education open lecture on A level reforms; (9 July 2013) Speech at ACME annual conference.

Additional sources: [hard copies available on request]

[20] Brennan, K. (5 July 2013). Why we must make maths compulsory to 18 for all students, *TES*. Retrieved from <http://www.tes.co.uk/article.aspx?storycode=6342661>

[21] Truss, E. (21 June 2013). Press release: Maths to be decoupled from A-levels and made compulsory from 2015. (Circulated with Hodgen's briefing [23] as supporting evidence.)

[22] Smith, A. (2004). *Making mathematics count: The report of Professor Adrian Smith's Inquiry into post-14 mathematics education*. London: DfES.

Research-based briefings and commentaries: [hard copies available on request]

[23] Hodgen, J. (2012). *Attainment, participation and the need for post-16 mathematics education: Findings from the ICCAMS Project*. TISME Summer Conference, DfE, 13/6/13.

[24] Hodgen, J., Tomei, A., & Brown, M. (2013). *The Supply of Mathematics Teachers: Confidential report to DfE*. [Manuscript available on request.]

Individuals:

Parliamentary Under Secretary of State (Education and Childcare). [Impact on Government policy.]  
Chair, National Curriculum Review Expert Panel / Director Of Assessment Research and Development, Cambridge Assessment. [Impact on Government policy.]

Chair, Advisory Committee on Mathematics Education (Royal Society). [Impact on ACME report.]

Vice-Chancellor, University of London; Chair, Inquiry into Post-14 Mathematics Education [22];

Former Chair, Advisory Committee on Mathematics Education (Royal Society). [Policy impact.]

Lead writer of Vorderman Report [14] and ACME committee member. [Policy impact.]