Addressing low attainment

Proposer: Jeremy Hodgen, Increasing Confidence and Competence in Algebra and Multiplicative Structures (ICCAMS)

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Summary of policy idea

In order to increase participation and attainment in mathematics and STEM generally, we call for an increased focus on low attaining students in mathematics. Specifically, we believe the education system should:

- Offer low attaining students an engaging and challenging mathematics curriculum tailored to their learning needs.

This may seem an obvious and uncontentious proposal. However, the majority of low attaining students are currently offered the very antithesis of this, an unengaging, repetitive and remedial mathematics curriculum that discourages further participation and does little to raise mathematical attainment and understanding. In order to achieve this aim, there is a need to:

- Improve the evidence base on 'what works' for low attaining students in secondary mathematics and in particular provide convincing evidence to schools and teachers of the efficacy of such an approach for low attainers.
- Develop resources to support teachers and schools to offer an appropriately challenging curriculum to low attaining students.

Rationale

Mathematics is a 'gatekeeper' subject for STEM participation in both academic and vocational education. The ICCAMS study indicates that the problem of low attainment in England has got significantly worse since the 1970s despite a plethora of initiatives designed to address the problem. Too often low attaining students are offered a repetitive and remedial curriculum, although there is little evidence to support this approach. Indeed, this approach appears to discourage students from continuing with mathematics (and STEM) post-16 (e.g., Brown et al, 2008). Currently, a great deal of policy attention is focused on increasing mathematics provision in 16-19 education (e.g., Wolf, 2011). However, for this supply-side policy to be successful, we also need to increase the demand for mathematics from young people by convincing them of the value of studying mathematics (e.g., Hodgen et al, 2013). There is a danger that the revised National Curriculum will further entrench a remedial approach to low attainment in mathematics and that, contrary to the intentions of policy-makers and politicians, low attainment and participation in mathematics may get worse.

Evidence base

In Phase 1 of the ESRC-funded Investigating Confidence and Competence in Algebra and Multiplicative Structures (ICCAMS) project we conducted a representative national survey of mathematical understanding in algebra and multiplicative thinking in Key Stage 3 in England (Hodgen et al, 2010). The survey was undertaken in 2008/9 and used tests of Algebra, Decimals and Ratio developed in the Concepts in Secondary Mathematics and Science (CSMS) study (Hart, 1981), thus allowing a unique comparison of students' understandings over time.

The results showed that, in comparison to the original survey in 1976/7, at the end of Year 9, the average facility of items in all three areas had declined. This decline is supported by the findings of a number of recent studies at secondary (Shayer & Ginsberg, 2009), at primary (Brown et al, 2008) and amongst 16 to 18 year olds (OECD, 2013). Considerable political and media attention has focused on our finding of a general decline in understanding (e.g., Truss, 2013). However, we believe that our findings about low attaining students are of even greater concern:

- At the end of Year 9, the proportion of students whose responses failed to reach even the lowest defined level of performance appeared to have doubled in Algebra and Ratio to more than 15% of the cohort.[1] The increase in the very lowest attaining group in the Decimals test is smaller, but nevertheless the proportion is more than 10% of the cohort. (See Figure 1 and Table 1.) These secondary students have difficulty answering even basic questions about core ideas from *primary* mathematics.
- Further, looking beyond the very lowest attaining group, the proportion of students who do not appear to have mastered the most basic mathematical ideas in the *secondar*y curriculum by the end of Key Stage 3 is also worryingly high. (See Table 2.) For example, almost two-thirds of the cohort has difficulty with ratios involving simple non-integer multipliers.
- The attainment gap appears to widen considerably during Key Stage 3. (See Table 3.)

Studies of setting show that lower sets in mathematics are characterised by low expectation, a restricted and fragmentary curriculum and a slow pace (e.g., Boaler et al, 2000; Hallam & Ireson, 2005). The research evidence base on low attainment in secondary mathematics is limited[2], but there is little evidence to support this remedial approach. For example, the only recent research synthesis examining the effects of teaching interventions directed specifically at low attainment (Baker et al, 2002) suggests a more engaging and targeted approach based on feedback, peer tutoring and explicit teaching. Indeed, there is some evidence to suggest that providing low attainers with such a 'rich' curriculum increases both their attainment and the likelihood of participation in non-compulsory mathematics (e.g., White et al., 1996; Burris et al, 2006).

In the ICCAMS study, we developed an approach to mathematics that provided appropriate challenge using formative assessment, which was piloted with a group of 20 teachers and Year 8 mathematics classes from 10 schools. The results show that students who received ICCAMS made greater progress than a matched control group. For the ICCAMS students, the rate of learning doubled over the course of an academic year: standardized growth rate, 0.33, compared to control, 0.14. Although students across the attainment range made significant learning gains in ICCAMS, many teachers were reluctant to fully implement the approach with their low attaining classes. This suggests that a similar, but more complete and better-targeted, implementation would result in greater learning gains for the low attainers.

[1] In the 1970s analysis, items were empirically selected from each test to form a series of levels (4 for Algebra & Ratio; 6 for Decimals). Students were judged to be successful at a specific level if they successfully answered two-thirds or more of the items at that level. The lowest attaining group consists of students who did not achieved two-thirds of Level 1 items.

[2] For example, the Sutton Trust-Education Endowment Foundation Teaching and Learning Toolkit (Higgins, 2013) contains surprisingly little evidence explicitly addressing low attainment as opposed to raising attainment in general. Baker et al (2002) identified only 15 studies directed at mathematical low attainment that met their inclusion criteria on rigour and quality. There are more such interventions at primary (Dowker, 2010), although, even at primary, the research base is very limited.

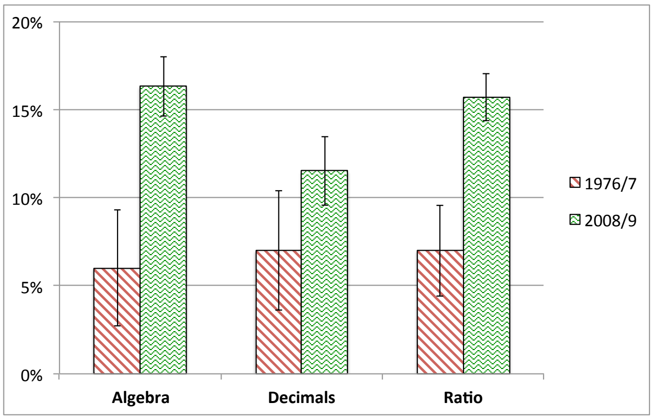

Figure 1: Proportions of students at the lowest level of attainment in 1976/7 and 2008/9 in Algebra, Decimals and Ratio at the end of Year 9 / Key Stage 3.

	1976/7	**2008/9**	**Change between 1976/7 & 2008/9**	
	Facility (SE)	*Facility (SE)*	*Difference (SE)*	*Significant change?*
Algebra	**6.0%** (3.28%)	**16.3%** (1.68%)	**10.3%** (3.69%)	UP
Decimals	**7.0%** (3.40%)	**11.5%** (1.94%)	**4.5%** (3.92%)	n.s.
Ratio	**7.0%** (2.59%)	**15.7%** (1.34%)	**8.7%** (2.91%)	UP

Table 1: Proportions of students at the lowest level of attainment with standard errors and change over time in Algebra, Decimals and Ratio at the end of Year 9 / Key Stage 3.

Topic	Key idea	Example	Proportion of Year 9 (age 14) who do **not** achieve 'basic' idea
Algebra	Some understanding of syntax	*If m = 3n + 1, and n = 4, what is m?*	41%
Decimals	Relating adjacent decimal places	*Multiply 5.14 by 10*	31%
Ratio	Non-integer multipliers	*x 1.5 in context*	65%

Table 2: The proportion of students in Year 9 in 2008/9 who have not mastered the most basic mathematical ideas in the key secondary topics of algebra, decimals and ratio.

	Percentile							Increase in 'gap': 10th → 90th percentiles
	5th	10th	25th	50th	75th	90th	95th	
Algebra	0.08	0.17	0.51	0.68	0.59	0.59	0.59	**0.42**
Decimals	0.03	0.06	0.23	0.34	0.23	0.29	0.23	**0.23**
Ratio	0.11	0.11	0.21	0.32	0.53	0.63	0.48	**0.53**

Table 3: Effect sizes estimates (Cohen's d) of growth in learning end Year 7 to end Year 9 across the attainment range.

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