THE MATH WARS: TENSIONS IN THE DEVELOPMENT OF SCHOOL MATHEMATICS CURRICULA

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I make no attempt to conceal my own philosophy of mathematics education and beliefs about effective and desirable teaching approaches. I am commited to mathematics teaching for all, rather than for the interests of an elite social group; a view that mathematics is far from a value-free or neutral subject; and a belief in a pedagogy based on a problem-solving approach rather than a transmission model of teaching. It is perhaps not surprising, therefore, that I became interested in Boaler's (2006, 2008) research, conducted in three high schools in California between 2000 and 2004. Boaler notably concluded that the collaborative problem-solving approach used at Railside High School, known as *Complex Instruction,* led to higher levels of attainment and more equitable test outcomes than the two other schools in the study. Students at Railside also exhibited much higher levels of *relational equity,* by showing positive attitudes towards the contributions and learning of fellow students.

Searching the internet for further information on the project, I came across what I will refer to as the *counter article,* entitled *A close examination of Jo Boaler's Railside report* (Bishop *et al.,* 2008), devoted entirely to criticisms of Boaler's findings. The authors of the counter article include R. James Milgram, professor emeritus in the department of mathematics at Stanford University, where Boaler was based when she carried out her research. It struck me as odd that an academic should dedicate so much time and energy towards undermining the research findings of a colleague in the same institution. Exploring the background to Boaler's research and the counter article revealed a (to me) remarkable story concerning the recent development of school mathematics in the US. Despite little of this story being widely known in England [1], I believe it provides valuable insights for those engaged in the debate over the future of mathematics education in England and worldwide.

The aggressive stance taken by Bishop *et al.* (2008) in the counter article needs to be set against a background of political tensions and power struggles in the world of mathematics education in the US, particularly prevalent in California, centred on the approach to mathematics teaching that should be adopted in schools. Because of the extreme positions and mutual hostility of two rival groups, the *reformers* and the *traditionalists*, this conflict has become commonly known as the *Math Wars* (Schoenfeld, 2004; Jackson, 1997a, 1997b).

A deeper understanding of the underlying issues and causes of the Math Wars in the US can help to explain similar, albeit less overt, tensions over mathematics education in England. These issues are discussed with reference to Ernest's typology of ideologies of mathematics education and associated teaching approaches (Ernest, 1991). Consideration is given to how these ideologies have influenced the development of mathematics education policy in schools, both in England and the US, and to how they explain the reaction of the authors of the counter article.

Ideologies and philosophies of mathematics education

Ernest (1991) proposes a typology of five ideologies of mathematics education: industrial trainer, technological pragmatist, old humanist, progressive educator and public educator. He describes an ideology as "an overall, value-rich philosophy or world-view, a broad inter-locking system of ideas and beliefs" (Ernest, 1991, p. 6). An ideology combines both epistemological and moral value positions; thus, ideologies of mathematics education are influenced significantly by views of mathematics. The first four of Ernest's ideologies are based on an *absolutist* view of mathematics, in which mathematics is based on a series of unquestionable truths. Only the public educator ideology is based on the increasingly influential fallibilist view, in which mathematics is socially constructed and constantly changing. Ernest describes how ideologies bind people together into interest groups with competing belief systems, expressed through different and often conflicting aims of mathematics education.

The *old humanist* ideology is based on a desire to maintain the abstract and rigorous nature of mathematics. Once typified by the interests of the aristocracy and gentry, it is nowadays more prevalent amongst mathematicians than mathematics educators. The *technological pragmatist* ideology, common amongst representatives of commerce and industry, is accompanied by a utilitarian approach to teaching mathematics, characterised by the promotion of skills useful in the workplace and necessary for economic growth. The *industrial trainer* ideology is based upon extending the practices of business and industry to education, for example, through the promotion of selection and marketisation in schools. Both old humanist and industrial trainer ideologies are associated with a conservative teaching approach, characterised by an authoritarian, transmission model of teaching. The *progressive educator* ideology sees the primary purpose of mathematics education as the nurturing of the individual and the acquisition of skills and concepts appropriate to the needs of the learner. It is relatively common amongst teachers and educationists and is associated with a progressive approach to teaching mathematics, typified by the promotion of practical activities and personal exploration. The *public educator* ideology is exemplified by a greater commitment towards equity and social justice. It is reflected in a critical approach to teaching mathematics, that aims to develop an awareness of the nature of the subject and to use mathematics to promote equity and democratic citizenship (Ernest, 1991). Whilst Ernest's typology provides a useful theoretical framework, it should be remembered that "individual educators are not located wholly, exclusively, or unproblematically within one of these ideologies" (Povey, 2003, p. 57).

Ernest's ideas about the relationship between ideologies and approaches to teaching mathematics have been developed by other authors. Lerman (2000), for example, describes a *social turn* in mathematics education, associated with increasing concerns about inequalities within society, which took place in the mid 1980s. This social turn resulted in a greater reliance on social theories, rather than cognitive theories, to explain differences in achievement amongst mathematics learners and drew attention to the influence of ideology on classroom practice. Gates (2006), for example, describes a broad consensus in the international mathematics education community in favour of a pedagogy of investigation and a progressive teaching approach. In contrast, however, much classroom practice remains teacher-centred and based on conservative teaching approaches. This apparent conflict of ideologies can be explained through the Bourdieuian notion of *habitus*, whereby teachers, without being fully aware, are influenced by their own experiences of schooling: "We are all prisoners of our past and act according to various social norms and consequently develop enduring dispositions" (Gates, 2006, p. 352). Thus, deeply embedded ideological frameworks can lead to teachers' acquiescence in policies that promote the same conservative teaching approaches that they themselves experienced as successful learners of mathematics.

The development of mathematics curricula in the US and England

There are many parallels between how the school mathematics curriculum has evolved in England and in the US, typified by a shift in one direction, with the dominance of one educational ideology, followed by a shift in a different or opposite direction, with the ascendancy of a conflicting ideology. In both countries, schools have historically served the needs of an elite group of children from society's most privileged and wealthiest families, reflecting the old humanist ideology. A huge rise in school enrolment from the 1930s to the 1960s was accompanied by a shift in ideological aims, from providing education for an elite group to establishing education for all, referred to as the "democratization of schooling" (Schoenfeld, 2004, p. 256).

In the US, the 1950s witnessed a modernisation of the mathematics curriculum to include set theory, logic and modular arithmetic. A reaction of teachers and parents to this "new math", the rationale for which was not clearly understood, led to a back-to-basics movement in the early 1970s and a reversion to a mathematics curriculum based on skills and procedures. However, this curriculum in turn came to be perceived as outdated in the context of students' poor problem-solving skills and ever-increasing drop-out rates.

In the 1970s and 1980s a "cognitive revolution" (Schoenfeld, 2004, p. 262) took place in mathematics education with the dominance of an alliance of progressive educator and technological pragmatist ideologies, and endorsement of utilitarian and progressive teaching approaches. This dominance was reflected in the publication of the *Cockcroft Report* (Cockcroft, 1982) in England and the *Standards* (NCTM, 1989) in the US. Both influential reports rejected a reliance on rote learning whilst promoting problem-solving, reasoning, discussion, group work and the use of computers and calculators as mathematical tools (Ernest, 1991; Schoenfeld, 2004). However, the New Right political ideologies of the Thatcherite government, from 1979 to 1991 in England, and the Reagan presidency, from 1981 to 1989 in the US, both examples of industrial trainer ideologies, led to a reversal of many reforms made to school mathematics curricula. With no federally initiated national curriculum in the US, it was left to each state to decide the direction of its school mathematics curriculum. In many states, there was a backlash from conservatives, who led vigorous and aggressive political campaigns against the reforms, resulting in the Math Wars (Schoenfeld, 2004).

In England, the imposition of the National Curriculum (DES, 1989) reversed the move towards progressive teaching approaches. The government overruled many of the findings of its own Mathematics Working Group (DES, 1987), set up to review the mathematics curriculum, and rushed through legislation establishing an assessment driven curriculum based on traditional subject boundaries and discrete items of mathematical knowledge and skills:

> For the reintroduction of anachronistic algorithms—long made obsolete by the advent of the calculator and, in any case, largely irrelevant in terms of application in work and elsewhere—runs directly counter to the utilitarian perspective espoused by the [Mathematics Working Group] and its government sponsors. (Noss, 1990, p. 20)

The National Curriculum represented "the triumph of the old humanist and technological pragmatist alliance, with marginal influences of the progressive educators, but within a framework dominated by the industrial trainers" (Ernest, 1991, p. 229). It was soon followed by the introduction of national tests for all children aged 7, 11 and 14 and the publishing of school performance league tables. The National Numeracy Strategy, an unprecedented national programme of training in schools initiated by the Labour government in 1999, promoted a focus on whole class teaching and basic numeracy skills, and was accompanied by a significant increase in ability grouping in primary schools (McSherry & Ollerton, 2002). The publication of curriculum frameworks (DfEE, 1999, 2001) reinforced assumptions made in the National Curriculum about the hierarchical nature of mathematics, introduced specified routes of progression and detailed age-related expectations of attainment.

Mirroring the US in the 1970s and 1980s, this reversion to a conservative approach to teaching resulted in a curriculum considered by many to be outdated, lacking relevance and not fit for purpose. One influential report, demonstrating the resurgence of progressive educator and technological pragmatist ideologies, highlighted "the failure of the current curriculum, assessment and qualifications framework [...] to meet the needs of many learners and to satisfy the requirements of employers and higher education institutions" (Smith, 2004, p. 3). A subsequent retreat from conservative teaching approaches was apparent in the revised National Curriculum (QCA, 2007) which, in contrast to previous versions, regarded key concepts and processes in problem solving as permeating the traditional content of the mathematics curriculum, rather than as additional content.

This revised National Curriculum seemed to advocate a critical approach alongside the more dominant utilitarian and progressive approaches to teaching mathematics:

> Learning and undertaking activities in mathematics contribute to achievement of the curriculum aims for all young people to become [...] responsible citizens who make a positive contribution to society [...] Mathematics equips pupils with uniquely powerful ways to describe, analyse and change the world [...] Pupils who are functional in mathematics and financially capable are able to think independently in applied and abstract ways, and can reason, solve problems and assess risk. (QCA, 2007, p. 139)

The introduction of citizenship as a subject in the revised National Curriculum provided opportunities for mathematics teachers to bring issues of global inequality and social justice into the classroom. However, caution should be exercised, since citizenship has tended to be interpreted narrowly as carrying out socially useful activities, rather than gaining a "critical view of social statistics and social structures, as well as positive action to redress inequalities" (Ernest, 1991, p. 294).

The Math Wars

Following the publication of the *Standards* in the US (NCTM, 1989), "the teaching of mathematics became the subject of heated controversies known as the math wars" (Schoenfeld, 2004, p. 253). The reformers believed in equity, education for the masses and advocated primarily progressive and critical teaching approaches. They saw mathematics as a value-laden subject, which served as a barrier to social and economic advancement for particular groups in society, although it had the potential to be a democratising force. The traditionalists saw mathematics very much as a value-free subject and believed in the maintenance of excellence, advocating a primarily conservative teaching approach:

> The Standards [...] clearly sat in the education-for-democratic-equality and education-for-social-mobility camps. In contrast, [...] the traditional curriculum was a vehicle for social efficiency and the perpetuation of privilege. (Schoenfeld, 2004, p. 268)

The reformers gave less value to some topics which involved memorizing rules and algorithms, for example, long division, leading to accusations of "dumbing down" from the traditionalists (Jackson, 1997a, 1997b; Becker & Jacob, 2000a, 2000b; Schoenfeld, 2004).

California was initially at the "forefront of the reform movement" (Schoenfeld, 2004, p. 271) and in 1992 adopted a reform oriented mathematics framework for public schools. This action was significant because, with one eighth of all public school students in the US, it had enough purchasing power to persuade publishers to produce new teaching resources consistent with the aims of the *Standards*. Consequently, changes in California had a "profound effect on how mathematics is taught in the rest of the country" (Jackson, 1997a, p. 699). However, in 1998, the state reverted to a more traditional curriculum following resistance from parents and a reaction from conservatives. This reversal of policy was partly attributed to insufficient training and support for teachers, with relatively weak mathematical backgrounds, combined with the additional pedagogical demands of a problem-solving approach (Jackson, 1997a, 1997b; Becker & Jacob, 2000a). However, it was also attributed by reformers to the "extreme steps" taken by the California State Board of Education resulting from "manipulation" of the press and a "persuasive (albeit deceptive) campaign" by a "powerful group of parents and mathematicians" (Becker & Jacob, 2000a, p. 530). An initial draft of the state's new standards was revised by a group of four mathematics professors, including Milgram, "who had negligible experience with K-12 classrooms or curricula" (Schoenfeld, 2004, p. 275).

Entrenched views were also expressed by traditionalists:

> In December 1997, the State Board of Education surprised the world by not accepting extremely bad, "fuzzy" math standards, written by one of its advisory committees [...] Instead, in a few short weeks and with the help of four Stanford University math professors, the state board developed and adopted a set of world-class mathematics standards of unprecedented quality for California's public schools. (Klein, 1998, p. 15, cited in Schoenfeld, 2004, p. 274)

California now became a base for traditionalists across the US, who used ever more extreme language to ridicule the reform curricula: "The gloves were off and those who held power did not hesitate to use it" (Schoenfeld, 2004, p. 276).

There have been several attempts to reach common ground in mathematics education in the US (Jackson, 1997b; Schoenfeld, 2004; Ball *et al.,* 2005) including a revised version of the *Standards* (NCTM, 2000) which outlined "a balanced view of teaching for understanding that pays adequate attention to both skills and problem solving" (Becker & Jacob, 2000a, p. 536). By the end of 2011, forty-six US states had formally adopted the Common Core State Standards for Mathematics, introduced in 2010, which included a significant focus on problem solving: "The high school standards call on students to practice applying ways of thinking to real world issues and challenges; they prepare students to think and reason mathematically" (CCSSI, 2011). However, these standards are voluntary and likely to be embraced to varying degrees (Heck *et al.,* 2011).

Despite continued attempts at a truce, the Math Wars still persist. In May 2009, for example, the Seattle School Board voted to adopt the reform-based *Discovering* mathematics curriculum. In February 2010, however, a state judge overturned this decision, causing controversy and concern that "such pedagogical disputes are beyond the courts' proper constitutional role and institutional capacity" (Dunn, 2010, p. 11).

Boaler's research at Railside High School

Through her research at Railside High School, Boaler reports on Complex Instruction, an approach in which students are encouraged to explore different ways of representing and solving a problem and to work collaboratively. The teacher encourages students to discuss their ideas and to pose their own questions, and uses praise to raise the status of less confident students within each group. Relational equity, implicitly fostered by the Complex Instruction approach, involves students demonstrating respect for the contributions of others and taking responsibility for the learning of the whole group by helping those with less understanding. The success of this approach is exemplified by Ana (a student at Railside):

> Like, when I'm in a group I try to make sure that everyone understands it. Like some people just wanna get their work done so they can say Oh, I'm done. But me, I don't like to leave people behind [...] So like I know if someone's sitting there quiet it's probably because they don't know how to ask a question or they just don't get it so then I'll help. (Boaler, 2008, p. 187)

The in-depth analysis of a large number of lesson observations, videos, interviews, questionnaires and assessment outcomes, carried out by a team of researchers over a four year period, provides convincing and compelling evidence of the relatively high and equitable levels of mathematical attainment and relational equity exhibited by students at Railside School (Boaler, 2006, 2008).

In the context of the Math Wars, Boaler is positioned firmly in the reformist camp, with a commitment towards a critical teaching approach:

> I contend [...] that one of the goals of schools should be to produce citizens who treat each other with respect, who value the contributions of others with whom they interact, irrespective of their race, class or gender, and who act with a sense of justice in considering the needs of others in society. (Boaler, 2008, p. 167)

The authors of the counter article, all mathematicians rather than mathematics educationists, are positioned firmly within the traditionalist camp. They devote a detailed and lengthy paper entirely to criticising Boaler's findings on the basis that: "a close examination of the actual outcomes in these schools shows that Prof. Boaler's claims are grossly exaggerated and do not translate into success for her treatment students" (Bishop *et al.*, 2008, p. 1). They claim that Boaler's study "had verified the most controversial of the deeply held beliefs of this country's education schools about mathematics education" (p. 2) referring to claims that students taught using a reformist approach could outperform those taught using a traditionalist approach. Milgram's belief in mathematics as a value-free subject is illustrated by his assertion, in another co-authored article, that one of the aims of the new mathematics framework he helped to write was "to make sure that teachers are aware that problem solving and proof are essentially the same thing" (Haimo & Milgram, 2000, p. 146).

In questioning the statistical validity of Boaler's research and criticising the assessment methods used to compare performance, Bishop *et al.* (2008) seem to adhere to a normative paradigm:

> If we are to reverse the woeful performance of our students it seems crucial that K-12 education research be subject to the same high standards as are the norm in medicine and the sciences. (p. 1)

They argue that the treatment groups from the three schools were not directly comparable and that the standard algebra test scores used to compare attainment were not from the cohorts being followed. They argue that the post-tests used in the study do not cover a high proportion of the curriculum content, illustrating conflicting views between traditionalists and reformers over the role of assessment.

The traditionalists' view of the curriculum as content-based means that assessment is seen as essential for testing recall of the facts and procedures which have been taught. They maintain that the relative success of traditionalist and reformist approaches can only be legitimately evaluated using the same standard tests. In contrast, a reformist view of assessment focuses on how students are able to demonstrate the mathematical processes they have learnt in relating them to their own experiences. This might be measured through producing portfolios of work, or group assignments, as well as by using tests.

Reformers also advocate other ways of measuring positive outcomes such as students' enjoyment of mathematics and their readiness to continue to study the subject at a higher level (Jackson, 1997b; Boaler, 2003). They argue that a reliance on standard tests "drove the traditional curriculum to sacrifice understanding in favor of the narrow skills of arithmetic computation and symbol manipulation" (Jackson, 1997b, p. 817). These standard tests, which use unfamiliar and confusing language and contexts, also create inequities and "stack the deck against language learners, and students from minority ethnic and cultural groups and low-income homes" (Boaler, 2003, p. 502). Boaler accepts that, whilst Railside students appear to under-perform based on results from the standard tests, they outperform students from the other two schools using tests which have more accessible language and are designed to more directly assess students' mathematical understanding (Boaler, 2003).

Bishop *et al.* (2008) draw attention to other factors, omitted from Boaler's published reports, that they believe to be important, such as the upheaval experienced by both comparison schools during the research period, due to a recent imposition of traditional methods of teaching mathematics. However, the majority of their criticism is focused on an attempt to discredit the statistical rigour of Boaler's research with claims that are difficult to verify without full access to the original data collected. They focus on the quantitative aspect of the research and ignore the most important and, in my view, most convincing aspect of Boaler's findings—the qualitative data presented through a case study of *Complex Instruction.*

With such a narrowly focused analysis carried out by the authors, influenced by an ideological reaction to the findings of Boaler's research, it is perhaps not surprising that the counter article can only be found on the Stanford University website, seemingly placed there by the authors. Presumably, it has not been subject to the same level of peer scrutiny as Boaler's findings, which have been published in several peer-reviewed journals including *Theory into Practice* in the US (Boaler, 2006) and the *British Educational Research Journal* (Boaler, 2008). With the doubts I have expressed about the credibility of the counter article, it raises the question of whether space should be given to discussing its criticisms. However, I believe setting the counter article in context, and subjecting it to scrutiny, is important for understanding how it relates to the Math Wars.

It is unfortunate that Boaler, by including an element of quasi-experimental design in the Railside Project, with direct statistical comparisons between Railside and the two comparison schools, appears to provide ammunition for the traditionalists to take pot shots at her findings. The teaching approach at Railside has clearly proved to be inspirational and transformational for its students. The reports describe the hard work and care exhibited by mathematics teachers at Railside and hints at their highly developed pedagogical expertise, for example, in the sophisticated use of praise and questioning. Boaler describes a department where:

> teachers meet every week to discuss and improve their lessons [...] all the teachers in the department are mathematics specialists [...] this would be unusual for any school, but this is a school in a low-income area with few resources [...] yet qualified mathematics teachers are queuing up to join. (Boaler, 2003, p. 502)

In contrast, there is no evidence of similar levels of commitment and expertise of teachers at the comparison schools, questioning the extent to which the achievements at Railside might be attributed to this factor, rather than the Complex Instruction approach. There are other ways in which Railside is described as differing from the other schools in the study, with greater ethnic and cultural diversity and students generally coming from lower-income homes in more urban areas, further questioning the extent to which direct statistical comparisons can justifiably be made.

Boaler presents a powerful case study of the Complex Instruction approach at Railside, providing a thorough and detailed contextualised account of students' experiences in mathematics classes. However, a more detailed account of Complex Instruction at Railside, giving added voice to the teachers and additional information about other relevant aspects of policy and practice at the school, would result in an even more powerful and compelling case study, thus providing stronger supporting evidence for those wishing to adopt or advocate a similar teaching approach.

The question then arises as to why Boaler decided to include an element of quasi-experimental design in the study. It may be that she felt compelled to provide quantitative data in order to pre-empt the criticism she anticipated from the traditionalists, in other words, to play them at their own game. Alternatively, it may be that, in an attempt to convince other schools to adopt a reformist curriculum, she was over-eager to provide evidence that the Complex Instruction approach was directly transferable to other situations. Or perhaps, in common with many researchers, she felt the pressure to provide quantitative as well as qualitative data in order to attract funding, to encourage journals to publish articles, or to convince policy makers to take notice of her findings and recommendations (Drake & Heath, 2011). In any case, by including direct statistical comparisons of three very different schools, she provided ammunition to traditionalists, including Bishop *et al.,* who have an interest in discrediting the findings of her research.

Conclusion

Boaler's study of mathematics teaching at Railside High School has made a significant contribution to the mathematics education debate in the US and provides added weight to the reformist agenda. It provides a powerful model for an approach to mathematics teaching that incorporates group work and problem-solving, areas which are widely recognised as relatively poorly developed in England, particularly in secondary schools (NCETM, 2008; ACME, 2009; Ofsted, 2008). It also demonstrates what a critical approach to mathematics teaching, with its success in developing positive attitudes amongst learners, might look like. Such an approach, with Boaler's own acknowledgement, contrasts greatly with current educational policy in England. For example, mixed-ability teaching groups are seen as a key element in the Complex Instruction approach, contrasting with the current situation in England where setting, or grouping by ability, is increasingly accepted as the norm in secondary schools (DfEE, 2001) without any apparent justifying evidence.

The reaction to Boaler's study from the traditionalist camp in the Math Wars, exemplifies how contrasting ideologies of education have led to disagreement and conflict amongst policy makers and practitioners within Stanford University, California and the US. In England, similar conflicts have led to a shift in emphasis from progressive and utilitarian approaches to teaching mathematics, associated with the *Cockcroft Report,* towards conservative teaching approaches, with the introduction of the National Curriculum. More recently, the pendulum has swung back once more towards progressive and utilitarian approaches, with an increased focus on functional mathematics skills as exemplified in the new General Certificate of Secondary Education (GCSE) examinations for 16 year olds, introduced in 2010.

The current use of GCSE mathematics results as a key measure of school performance has led to the mathematics curriculum becoming particularly vulnerable to the increasing politicisation of education policy and the promotion of a conservative approach to teaching:

> the current high stakes assessment system, where institutions are more accountable for results than for the mathematical understanding of their students, has a detrimental effect on the ability of young people to apply mathematics […] some areas of mathematics which are more difficult to assess, such as problem-solving, reasoning and communication, are not given

sufficient teaching time and are often replaced in the classroom by teaching routines and procedures necessary to pass the test. (ACME, 2011, p. 3)

The high-stakes nature of mathematics assessment makes it difficult to generate quantitative data that provide evidence in support of progressive and critical teaching approaches. Whilst the case of Complex Instruction, exemplified through the Railside study, provides powerful evidence in support of these teaching approaches, such qualitative research findings tend to be undervalued, in comparison to quantitative evidence, particularly amongst policy makers.

The weight of evidence from recent reviews of mathematics teaching in England is that the curriculum does not prepare students adequately for everyday life or employment, and that school mathematics remains disengaging and not relevant for many students (NCETM, 2008; Ofsted, 2008; ACME, 2011; Vorderman *et al.*, 2011). Change is certainly needed, but change that builds upon a renewed emphasis on functional skills and problem-solving approaches, whilst developing a critical approach to teaching mathematics. However, my own experiences as a teacher for fifteen years, a curriculum developer and consultant for seven years, and more recently as a teacher educator, suggest that conservative teaching approaches still hold sway in many schools, accompanied by a more authoritarian approach to discipline, more formal school uniforms, more regular use of testing and increased levels of setting students by ability in mathematics.

In January 2011, the new Conservative and Liberal Democrat coalition government in the UK announced a review of the curriculum with a greater emphasis on "facts and figures" and "academic rigour" (Garner, 2011). Whilst an initial report for this review acknowledged concerns raised by recent reviews of mathematics teaching, it also suggested the need in mathematics teaching to make stronger connections between "conceptual understanding" and "factual and procedural knowledge", with a renewed emphasis on the latter (DfE, 2011, p. 67). It remains to be seen whether the government follows the rhetoric of its public commitment to a back-to-basics agenda, thus further promoting a conservative approach to teaching mathematics, or whether it listens to the call from the mathematics education community for a more engaging and relevant curriculum.

Notes

[1] I refer to England, rather than the United Kingdom, as a degree of autonomy over education legislation has led to significant differences in mathematics curricula in Wales, Scotland and Northern Ireland.

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Mathematics teaching at all levels should include opportunities for

- Exposition by the teacher;
- Discussion between teacher and pupils and between pupils themselves;
- Appropriate practical work;
- Consolidation and practice of fundamental skills and routines;
- Problem solving, including the application of mathematics to everyday situations;
- Investigational work.

In setting out this list we are aware that we are not saying anything which has not already been said many times and over many years. (pp. 71-72)

A more important reason for including the practice of mental calculation is the now well established fact that those who are mathematically effective in daily life seldom make use 'in their heads' of the standard written methods which are taught in the classroom, but either adapt them in a personal way or make use of methods which are highly idiosyncratic […] no attempt should be made to force a single 'proper method' of performing mental calculations; pupils should be encouraged to make use of whatever method suits them best. Teachers should also encourage pupils to reflect upon the methods which they develop for themselves so that facility in mental computation can be consolidated and extended. (pp. 75-76)

Cockcroft, W. H. (1982) *Mathematics Counts (The Cockcroft Report*). London, UK: HMSO.