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JMC REPORT: DIGITAL TECHNOLOGIES AND MATHEMATICS EDUCATION

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ABSTRACT

This 'report'† was recently published (September 2011) by the Joint Mathematical Council [JMC] of the United Kingdom—of which the LMS is a 'Constituent Society'. It is an important 'report' though perhaps not for the intended reasons. The report reveals in stark terms the current level of professional debate about 'digital technologies and mathematics education'. It also raises a number of significant issues relating to how the JMC operates, which we address at the end of our response.

The JMC report was conceived just as a new administration was about to take over in 2009/2010, and was published as the National Curriculum Review was struggling to decide how ICT should be incorporated within the new draft curriculum. It is evident that a key aim of this report is to influence policy. (This makes it all the more remarkable that the JMC, which describes itself as a "joint coordinating" body for its Constituent Societies, felt no need to seek to reflect a consensus.)

The confident tone of the report's many *ex cathedra* pronouncements is such that one can imagine that the target audience (civil servants and policy makers) might easily be swept along. On the other hand one would like to think that any such temptation might be tempered by the report's omission of any evidence for its many bold claims.

The report begins by inviting us to feel embarrassed by the contrast between a typical pupil's everyday world of 'portable digital technologies' and the wretchedly plodding world s/he is likely to find in the typical classroom—as though the former were some kind of 'Brave New World', and the latter a painful hangover from a former age.‡

Even those who may be inclined to applaud the report's opening parable may yet be surprised by the apparent conclusion (p. 3) in blue ink, which

2000 *Mathematics Subject Classification* 00A05 (primary), 01A55 (secondary).

† http://cme.open.ac.uk/cme/JMC/Digital Technologies files/JMC_Digital_Technologies_Report_2011.pdf

‡ The report shows no hint of recognition that the modern world is full of such apparent 'contradictions'—between trendy, superficial 'glitz', and solid, mundane reality. Or that our current economic woes may have their roots partly in precisely such a clash (between (a) living on credit whilst seeking to 'magic away' the risk by 'slicing and dicing' credit portfolios, and (b) careful long-term investment based on savings and hard work). The world of advertising agencies may exist to persuade us that satisfaction is available to everyone at the touch of a button; in the truly 'real' world (of friends, of family, of teachers, etc.) things are always less flashy and more down-to-earth, but ultimately more worthwhile and reliable.

appears to have nothing whatever to do with the preceding text:

> "What is needed in schools and colleges is student-led mathematical modelling, problem solving and computer programming which makes use of the powerful mathematical digital technologies that are widely used in society and the workplace."

The logic here is hard to follow. 'Mathematical modelling', 'problem solving', and 'computer programming' are all of interest; and all have had their proponents over the years. But the report seems oblivious to the fact that our attempts so far to interpret these themes in a form that is suitable for the basic curriculum underscore the dangers of being too ambitious, and of taking time away from key mathematical prerequisites. For example: we have neglected the possibility that a regular diet of word problems (and appropriate instructional support) may be a crucial prerequisite to full-blown modelling; and if pupils are ever to use basic techniques for 'higher' ends (as in solving simple multi-step problems), they may first need to achieve a significant level of mastery which may take more time and effort than we have acknowledged. And while it is natural to want to exploit the possible links between the world of elementary mathematics and that of computer programming and computer science, there are few signs that we know how one might do this successfully in a coherent way.

One cannot escape the flashier world of gizmos. But the question of how this digital world can be usefully embedded in the down-to-earth 'real world' of education is one that confronts parents and teachers every day—and a question that has no easy answer. The recent Royal Society report Shut down or restart? presents impressive evidence of our failure to engage effectively with digital technologies in schools, and offers a convincing 'restart' strategy; but it does so only after declaring that its subject matter cannot be addressed in mathematics classes. The authors of the JMC report may have had in mind certain admirable goals; but they have failed to explain why (or how) these are best addressed within the mathematics curriculum.

Mathematics teachers are currently in the awkward position of being expected to demonstrate their 'use of ICT'.[†] The pressure arising from this requirement that mathematics teachers demonstrate their 'use of ICT' makes it difficult to begin a professional debate as to how to distinguish the good from the bad, or mere 'use' from 'abuse'. Some software is excellent; but much (maybe most) would seem to be seriously flawed—even though it may be found useful by some teachers. And, however impressed we may be with what can sometimes be achieved using software, we should not lose sight of the longitudinal EPPSE study funded by the Department for

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[†] We need an open discussion about who controls, and who benefits from, this politically imposed imperative!

Education, which reveals the extent to which subsequent progress depends more strongly on very traditional interactions (such as talking, or actively engaging with and reciting repetitive nursery rhymes or games), rather than on passively engaging with 'digital technology'—even in High Definition![‡]

The JMC report sees digital technologies as holding the key to the future and hence to education. From time to time it claims to recognise that this future will require a higher level of mathematical competence; but it shows no serious interest in to how this is to be achieved. And it is curiously selective when it comes to translating this 'need for mathematics' into 'curriculum recommendations'.

> "Learning in science, technology and engineering is underpinned by an understanding of mathematics. In particular the study of science relies on the collection, analysis and interpretation of data" [my italics]

One is left wondering why this one "particular" is singled out (rather than, for example, the much more basic need to understand linear dependence, ratio, and proportion). Those who find 'modelling' and 'problem-solving' more congenial than place value, learning one's tables, and calculating with fractions and percentages, often slip in more ambitious themes such as 'the analysis and interpretation of data'—as though this could somehow be achieved without prior fluency in working with fractions. Yet our failure in achieving the more basic requirement (fluency in working with fractions) is ignored.

In place of serious analysis, the report allows the desired end (economic well-being based on digital technologies) to distort the perceived means (the requisite mathematical competence), and concludes that the mathematics classroom must therefore embrace digital technologies. My version of the first page of the report may sound like a parody, but it is a fair summary of the argument: digital technologies hold the key to pupils' learning because they are all around us, and should therefore dominate the maths classroom. No evidence is provided to indicate that (or how) digital technologies can be used to help pupils learn mathematics, or that the resulting diversion of funds (e.g. from text books or from CPD) can be justified. We are simply told, without any explanation at all, that the evident need to align the classroom with children's everyday experience implies the need to shape the mathematics curriculum around three additional strands student-led mathematical modelling, problem solving, and computer programming—strands which rightly handled may have something to contribute, but which

[‡]The same study indicates how too much engagement with 'digital technologies' appears to have negative consequences.

our experience suggests need to be very carefully interpreted if they are not to displace their own prerequisites, and so have negative consequences for student progress. Moreover, there is no attempt to consider what material could be safely omitted to make room for extensive engagement with digital technologies.

There are occasional glimpses which might have indicated that the report was prepared to grasp the nettle:

> "4.1 A key issue facing the UK is how to inspire and develop the next generation of innovators, creators, scientists, technologists, engineers and mathematicians on which our future well-being and economy depends."

Who among us would not wish to "inspire the next generation" (even if some might see the goal of education as more profound than simply to prop up an economy which has betrayed fundamental weaknesses)? But this concern for "our future well-being" never moves beyond rhetoric.

The rhetoric exploits the all-too-familiar shortcomings of mathematics teaching; but never recognises that what is being loosely proposed would prove to be a much more expensive alternative, with less mathematical content, and in a form that is far harder for the ordinary teacher to implement effectively! In place of evidence, we are treated to negative sideswipes aimed at some parody of the status quo:

> "6.2 Unless we can develop mathematics education in a more stimulating way, which takes into account the modern world and students' interests we are in danger of turning mathematics into an increasingly 'dead language' and alienating groups of students whose mathematical potential will remain undeveloped.
>
> 6.3 Rote learning of the current mathematics curriculum will not be sufficient to produce the problem solvers, independent thinkers and designers the country needs."

The proposed solution never rises above the level of assertion:

> "6.5 Learning in science, technology and engineering in schools and colleges could be greatly enhanced if students were able to use digital technologies to perform mathematical processes, mirroring the types of applications used in STEM-based applications in the workplace."

One suspects that in reality such digital technologies are being increasingly used—for "science, technology and engineering", and for mathematics. But experience suggests that we still need to think much more carefully how and when digital technologies are used if learning is to be "greatly enhanced".

The resulting 'recommendations' read like an assemblage of self-evident dogmas. These may seem wholly convincing to those who subscribe to the implicit creed; but they are likely to leave the open-minded reader gasping

"But why?":

> "Recommendation 1: For policy makers and teachers
> School and college mathematics should acknowledge the significant use of digital technologies for expressive and analytic purposes both in mathematical practice outside the school and college and in the everyday lives of young people.
>
> Recommendation 2: For policy makers
> Curriculum and assessment in school mathematics should explicitly require that all young people become proficient in using digital technologies for mathematical purposes.
>
> Recommendation 3: For policy makers
> High stakes assessment needs to change in order to encourage the creative use of digital technologies in mathematics classes in schools and colleges.
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> Recommendation 4: For policy makers and school leaders
> As the development of a technologically enriched student learning experience occurs at the level of the classroom, such change has to be supported by school leaders and accompanied by sustained professional development opportunities for teachers.
>
> Recommendation 5: For policy makers
> The UK Departments for Education and for Business, Innovation and Skills should establish a Task Force to take the lead in bringing together various parties with appropriate expertise to take forward the recommendations of this report and advise the Departments on required policy initiatives."

The assertions are clear enough. What is less clear is how their asserted efficacy could be justified.

According to its website the Joint Mathematical Council:

> "was formed in 1963 to: 'provide co-ordination between the Constituent Societies, and generally to promote the advancement of mathematics and the improvement of the teaching of mathematics'. In pursuance of this, the JMC serves as a forum for discussion between societies and for making representations to government and other bodies."

Thus, the JMC depends on these Constituent Societies for its raison d'etre, for its influence, and for its financial survival. Yet there is a danger that the report, far from "providing co-ordination", may be perceived as using the JMC to lend kite-flying an authority which it does not deserve. For example, there is no indication that the draft report was available to any of the Constituent Societies before publication, or that it results from any prior "forum for discussion" to which these Societies may have had a chance to contribute.

No evidence is offered to explain why or how the recommendations contained in the report would "promote the improvement of the teaching of mathematics". Indeed, one of the more remarkable features of the report is that it contains not one single example of how 'digital technologies' have already been, or might in future be, used to improve the teaching of a single mathematical theme. Instead, the focus is on technology and engineering:

> "[Mathematics, Science and Technology play] a key role in growing adequate research and development (R& D) capacity, ensuring economic and productivity growth, and in other areas that are key to Europe's future competitive position. Europe needs more technology-driven highly skilled people to push back the frontiers of technology and drive innovation forward."

As this extract illustrates, the quotations often come from reports† that use a curious version of English, which is a disturbingly upbeat, confident-sounding blend of vacuousness and presumed self-evidence.

So we are left to make what we can of this wholehearted, but apparently superficial burst of enthusiasm for 'digital technologies', and the repeated assertion that these impact on our daily lives, and must therefore be embraced within mathematics education.

Over the last 30 years similarly enthusiastic claims have been made for successive generations of digital technologies. And during that period there have been isolated instances where impressive flesh has been put on these rhetorical bones. But in the typical UK classroom, the attempt to force a marriage of digital technologies and mathematics education is not a success story. Many of us have looked on with eager anticipation as successive generations have been promised a 'digital bonanza', only to see the educational 'rewards' go increasingly to those who have been taught relatively traditionally. Official attempts to oblige schools to demonstrate their incorporation of ICT into mathematics lessons has largely benefitted those who sell electronic white boards, or software packages of dubious worth, rather than supporting improved mathematics teaching.

The impact of digital technologies on modern life is undeniable (even if it is hard to know whether this impact will ultimately prove to have been entirely healthy or sustainable). However, the implications of this fact for the way beginners learn mathematics remain far from clear: it may be that the processes whereby each child has to internalise that mental world of number remain more-or-less as they always were (as would seem to be true for other mental internalisations—such as learning to read and to interpret text, or learning to read music and to play the piano, and as appears to be supported by the aforementioned EPPSE study). After 30 years of rhetoric and exhortation, inspectors and advisers continue to hide behind words like "appropriate use", whilst still being unable to specify what is, and what is not, "appropriate". The original national curriculum working group tried to oblige teachers to use calculators and computers. They sent a delegation to

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†It is hard to be sure, but having tried to follow up the numerous reports referenced in the text, it often seemed that they were either irrelevant, or that their conclusions did not match those attributed to them.

Japan in 1989, who reported that they saw no use of calculators, and patronisingly concluded that the Japanese appeared not to understand how such tools 'had changed the way mathematics should be learned' in the modern world. The Numeracy Task Force in 1999 reverted to something closer to the Japanese position. But the National Curriculum and QCA/QCDA still knew better. It would be good to think that we might now be better placed to explore where and how digital technologies can best be used so as to support traditional mathematics instruction (at a proportionate cost).

The report's authors are clearly enthusiastic about 'digital technologies'; but they do not begin to analyse their relevance to the beginner's learning of mathematics. Where the goal is merely to use some digital technology, there may be no need for the user to first master the underlying mathematics or engineering. But where the key goal is to construct some 'universe in the mind'—as with arithmetic, or with applications of arithmetic such as handling money—the tried-and-tested route may be the only one available: adults may access money 'digitally', but for these transactions to make sense, we may still need to begin by playing shop with (toy) coins and notes in order to slowly establish some inner grasp of quantity and value, and to link these with place value and arithmetic. Sometimes there is no short cut.