The evolution of 14-19 mathematics pathways: a recent history

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Abstract

In the twenty years since the introduction of the National Curriculum, school mathematics has undergone a number of transformations in parallel with the broader currents of curriculum change and school reform agendas of successive governments. We now find ourselves on the brink of a new era for 14-19 education: an era in which functional mathematics will be of central importance to learners; where diplomas will have a significant impact on who does what mathematics beyond 14; and where the form and future of A level continues to be hotly debated. Much of this current curriculum discussion would have been unimaginable ten years ago. This paper offers an account of this curriculum trajectory in order to understand the motivations for the development of currently piloted 14-19 mathematics pathways. In so doing it also offers some thoughts on where such a trajectory might lead, what problems can be addressed and what issues might remain or arise in the future. There are many strands of educational policy and change that need to be understood to compile a detailed account over this time. The paper is an overview divided into four sections. After outlining three chapters in the development of the story: 1) National Curriculum to New Labour, 2) National Strategies to Making Mathematics Count 3) Pathways and functionality, I move to a more detailed overview of what is now happening in the development of 14-19 Mathematics Pathways, including the work of the Evaluating Mathematics Pathways project.

Introduction

I recently had the experience of getting some PGCE students to read a draft of some writing about the history of the mathematics curriculum. Surprisingly they found it quite interesting. The most memorable response was that they hadn’t realised that there had not always been a National Curriculum. These beginning teachers have competed all of their mathematics education under a National Curriculum; they have been tested at the end of each Key Stage of schooling and were in schools judged by their success in such tests by Ofsted and the publication of league tables. It is now a long time since the landmark Cockcroft report (1982) and a generation of mathematics teachers is being replaced by a new breed of professionals, who have been trained (through their own school learning and PGCE programmes) in arguably different forms of schools mathematics. It is important that the mathematics teaching profession have some collective understanding of this history and the process of change as I
believe that this will help us to respond positively to increasingly frequent curriculum change. For my beginning teacher colleagues, seeing back over these twenty years enables them to consider what is foundational – and worth keeping – and what is merely passing fad. They can begin to develop an understanding of how mathematics education is shaped by current political thinking. This paper is part of my ongoing concern (Noyes, 2007a, 2007b) to make sense of this policy trajectory.

In writing a history of the mathematics curriculum we need to look at both mathematics education and the wider education policy-scape, which is dependent on other social changes both within the UK and internationally. I offer here two examples which I will explore further in the following sections. Firstly, the neo-liberal policy agendas over this time have developed education markets and parental choice. School league tables offer a means of selecting the best education product for the child and teachers and schools sell their wares by maximising certain types of educational profit (we call this Contextual Value Added), in particular examination performance. How teaching to tests has affected mathematics education is not really the focus of the paper but this trend in recent years has certainly impacted on the day-to-day experiences of learning mathematics. The second example is the role of international comparisons, e.g. TIMSS and PISA, in influencing government perceptions about the level of skills (both basic and advanced) in the future workforce. Brown (1998) has called this “the tyranny of the international horse race”. Governments see such comparisons as barometers of current educational effectiveness and possible future economic productivity. Gordon Brown, the then chancellor, described science (and I include mathematics here) as “the bedrock of the economy”. There is no doubt that the level of intervention in mathematics (as part of the broader STEM agenda) reflects these concerns about guarding future economic prosperity.

Such examples lead us to question what, and who, mathematics education is for. Such matters are considered by beginning teachers when they are in the privileged position (shared with academics) of being able to stand back and critique the system before they are overwhelmed by the daily pressures of fulfilling their contractual requirements. The same issues, although not explicitly referred to, underpin the Tomlinson (DfES, 2004) and Smith (2004) reports and require careful examination. But these are not new ideas. Ernest’s (1992) critique of the mathematics National Curriculum and the influences which shaped it are still very relevant here.

**National Curriculum to New Labour (1988-1997)**

Twenty years ago, the Education Reform Act (1988) heralded a new era for education in England and Wales. Tomlinson (2005) characterises the first part of this 1988-1997 period as ‘creating competition’ in which “education was to become a product” (p. 52). During this period legislation...

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included consolidating a market ideology to be achieved by parental choice, establishing central government control over curriculum and assessment, further eroding the powers and responsibilities of local authorities, teachers and their trainers, demanding accountability from individuals and institutions, especially universities, and encouraging selection under a rhetoric of diversity. (Tomlinson, 2005, p. 48)

The conservative government was motivated in part by a perception that the performance of the education system was not keeping pace with those of our industrial competitors. This concern remains at the heart of educational reform and needs to be remembered when considering mathematics education policy. The first incarnation of the mathematics NC was unwieldy with a system of 14 attainment targets divided into 10 levels. It has undergone subsequent revisions but the underlying aims remain largely unchanged, and, as argued by Gill (2004) have not been met. Setting up the full National Curriculum (and its associated assessment) cost around £800 million and the “influence of right-wing bodies and individuals...ensured that the curriculum became a virtual battleground” (Tomlinson, 2005, p. 62)

Ernest (1992) characterised the influential groups which shaped the original mathematics NC and these categories continue to be useful (also see Ball, 1990). In summary, Ernest explained how the ‘old humanists’ (those in the academy) and ‘industrial trainers’ (the employers) dominated the development of the new curriculum, marginalising a third group: the child-centred ‘progressive educators’. One group - the ‘public educators’ - were really not given a say whatsoever. These groups had, and still have, different aims for mathematics teaching and learning and the curriculum. His more recent summary (Ernest, 2004, p. 316) of these aims is as follows:

1. Acquiring basic mathematical skills and numeracy and social training in obedience (authoritarian, basic skills centred)
2. Learning basic skills to solve practical problems with mathematics (industry and work centred)
3. Understanding, and capable in, advanced mathematics, with some appreciation of mathematics (pure mathematics centred)
4. Confidence, creativity and self-expression through mathematics (child-centred progressivist)
5. Empowerment of the learner as highly numerate critical citizen in society (empowerment of social justice concerns)

Ernest’s earlier analysis saw these groups largely in competition with one another but has more recently argued that their concerns could be brought together to produce a more balanced curriculum. This seems rather optimistic (Noyes, 2007b) and it appears that such
contestation of the mathematics curriculum is still very much alive in the current work on 14-19 Pathways.

The National Curriculum (for Mathematics) was followed closely in the early 1990s by other significant policy shifts in education. The introduction of Ofsted, national testing and league tables became the technologies of what Ball (2003) calls “performativity” in schools. Some of the innovations of the National Curriculum, for example the emphasis on Using and Applying mathematics, began to be undermined by the drive for examination success. Teacher assessment, which had been valued in the original curriculum, became less valuable in this climate of external accountability. Having established centralised control over curriculum, albeit with a slimmed down version appearing in 1993 it was not long before developments of more detailed frameworks for mathematics and English (or rather numeracy and literacy as they became) appeared. By the time New Labour came to office in May 1997 the National Numeracy Project (1996-99) had begun which would be followed by the National Numeracy Strategy within a couple of years.

As part of this focus on transforming mathematics in primary classrooms, the adoption of ‘numeracy’ signified a clear intention; mathematics as ‘acquiring basic skills’ (see Ernest’s (1) above). At the other end of the schooling range another concern was emerging. In parallel with the embedding of the NC and GCSEs in this new performative culture there was an increasingly worrying decline in participation in A level mathematics. But concerns about mathematics were not unique. Fuelled in part by concerns (whether real or manufactured, (Brown, 1998)) arising from international comparison data (e.g. TIMSS) the waning conservative government tasked Ron Dearing with reviewing the qualifications for 16-19 year olds. Dearing’s 1996 report which proposed a new national framework for qualifications (included modular AS and A2 awards), prepared the ground for what Smith (2004, p.8) later termed a "disastrous" change for post-compulsory mathematics.


When the New Labour government were swept into power on Tony Blair’s “education, education, education” manifesto political intervention in schooling went into overdrive (Tomlinson’s, 2005, chronology of events is helpful here). With the establishment of the Standards and Effectiveness Unit, the long hoped for new government continued with many of the policies of its Conservative predecessors. One important strand of continuity was in the increased pedagogic ‘recommendation’ in the form of the National Numeracy Strategy and the Framework for Teaching Mathematics which arrived in secondary schools in 2001. Designed to raise standards, i.e. the meeting of government targets in national tests, new pedagogies were encouraged (and in some cases imposed) on classrooms. Through the various strategies for mathematics teaching cherry picked teaching methods from apparently more successful countries began to creep into English classrooms. Not that this was all bad news but the
gradual deprofessionalisation of the teacher workforce over the previous decades left teachers in no position to adopt a more critical stance on these new ideas.

The New Labour government continued to expound the necessity of mathematics and science for a prosperous economy and global competitiveness and quantitative literacy debates fed a growing concern with employees’ mathematical skills. Accordingly Key Skills were adopted at the turn of the century as part of the new qualifications framework but were quickly discredited when it became clear that they had little currency with many employers or HE. The more drastic impact of these 16-19 changes were felt by the first cohort of AS mathematicians. To compound the problems of declining participation in A level mathematics since the late 1980s the new qualifications left vast numbers of students having failed their AS. Only now, following revisions to A level mathematics programmes in 2004, is this dip showing clear signs of recovery. This apparent crisis in mathematics (one of a regular pattern of crises!) precipitated renewed concern over mathematics (and science) qualifications and considerable discussion and advisory activity has resulted. A focused review of 14-19 mathematics took place alongside a broader review of 14-19 qualifications by Tomlinson (2004). His proposed diploma framework, which seemed to mark an end to GCSE and A level qualifications, was not fully adopted amidst confusion about what government wanted from 14-19 education (Tomlinson, 2005, p. 152). The key point for our discussion here is the place of numeracy – reinvented as functional mathematics - in all proposed ‘lines of learning’.

The landmark Smith (2004) report made many recommendations concerning the 14-19 curriculum including (in brief):

4.1 Two tier GCSE
4.2 Double award GCSE
4.3 Reduced time on coursework
4.5 Incentives to draw people back to post-16 mathematics
4.7 Review and rationalisation of FSMQ, UoM, AoN and Adult Numeracy and greater integration of ICT in teaching and learning
4.9 Review of pattern and style of GCE assessment
4.10 Support for most able at GCE
4.11 (finally) Develop pathway models, pilot and select ‘preferred pathway’

As with the original development of the NC, we should be mindful that individuals and groups have particular perspectives about what is important in mathematics education and what should happen in the future. It would appear that not all of Ernest’s categories are represented equally (Noyes, 2007a) in Smith’s report.

**Pathways and functionality**

Many of Smith’s recommendation have been acted upon quickly. The rise of functional skills, with precedence in earlier attempts to develop key/basic skills, comes as little surprise.

considering the influence of the ‘industrial trainers’ and the repeated effort of governments to bridge the academic/vocational divide, this time through the introduction of diplomas. However, despite attempts to define functional mathematics (e.g. Roper, Threlfall, & Monaghan, 2006), and a growing literature on quantitative literacy there still seems to be considerable difference of view on what functional mathematics is. This seems to be very important as qualifications are now being developed to assess functional mathematics skills. Although the standards clearly set out what functional mathematics is there remains considerable uncertainty about the assessment and therefore teaching of this mathematics, with its strong emphasis on process skills. This is perhaps unsurprising given the ‘situatedness’ of mathematics practices in the workplace and elsewhere in life. Even Smith’s concession that mathematics could be learnt “for its own sake” (a nod to Ernest’s third aim, see above) is overwhelmed by the sense in the report that mathematics is largely functional in nature. But the skills deficit is not the only crisis - the supply of mathematicians to the academy is critical as Smith reports: “perhaps the greatest concern to many respondents to the inquiry...has been the dramatic decline in A level mathematics entries since curriculum 2000 was introduced”. These two areas of concern (mathematics for work/economy, mathematics for itself/HE) reflect a historically embedded division which stretches back to the introduction of mass education in the industrial revolution (Noyes, 2007b; Rogers, 1998).

Recommendation 4.11 paved the way for developing new 14-19 mathematics pathways that might help to redress the long-term concerns about declining mathematics participation. Here was presented the opportunity to rethink mathematics education, creating something appropriate for the needs of learners in the 21st century. Various stakeholders take quite different views and this can be seen in the development of the 14-19 mathematics pathways. In fact, we might need to consider at this point what is meant by a pathway. In parallel with my earlier question about the meaning of functional, we might want to question what is meant by a pathway and how that differs from what is currently in place. To what extent should pathways offer coherence and continuity in content, pedagogy, difficulty and so on? Are pathways mutually exclusive; do they intersect; can students move along pathways at different speeds and transfer between them? It appears that consensus on these questions, which are critical to the establishment of pathways, has not been reached by a wide range of stakeholders prior to the development of assessments. The Pathways project faces another challenge as quite a lot of the mathematics that students do when they go into colleges is embedded in qualification routes that are largely non-mathematical and therefore not part of the Pathway models and development. Mapping the multiplicity of pathways is not a straightforward task. The pathway metaphor used here is important as it aims to open up certain possibilities. With a focus on assessments a more appropriate metaphor for current developments might be stepping stones (see Noyes, 2006, for a discussion of the framing power of metaphor).

Evaluating Mathematics Pathways – the current state of play

I want to focus here on one aspect of the pathways programme: functional mathematics and the proposed GCSEs in Mathematics and Additional Mathematics. But first I will present a brief review of the Pathways project. This is not an easy task as the project has changed in a number of key ways during this period but the following should give an idea of process.

Phase I

In 2005 QCA contracted two teams to develop pathway models: the University of Leeds and Kings College London/Edexcel developed independent models for mathematics pathways.

The KCL/Edexcel model deliberately retained a simple pattern of two GCSEs, A levels and functional mathematics for all pre-18 but had a distinctive emphasis on mathematical modelling and the use of ICT, both within the course and in the assessment of the mathematics. Functional mathematics would be stand alone and assessed by a computer-mediated test with portfolio assessment being proposed for trial at all levels. They suggested two models for the GCSE awards; “Model A proposes that both papers cover a mixture of Applications, Skills and Techniques. Model B proposes that GCSE 1 looks at the applications of mathematics across the grade range and GCSE 2 focuses on pure mathematics and an appreciation of the nature of mathematics and mathematical thinking” (July 2006, p.4). They recommended that both GCSEs be required to start the A level. A level is recommended to reduce from 6 to 4 units (similarly AS from 3 to 2): “all units will incorporate a modelling philosophy which, as at GCSE level, would involve a high degree of computer use” (p.5). This model was designed to engage students and build learner confidence through an emphasis on modelling and a belief that some big mathematical ideas are simply worthy of inclusion in the curriculum.

The Leeds model aimed to develop “a curriculum and assessment structure which would encourage more students to study mathematics beyond compulsory schooling, engage and motivate students and provide students with a mathematically challenging experience within their capabilities” (p. 2.7). Whilst looking similar to the KCL/Edexcel model at GCSE level (with some notable exceptions, e.g. the removal of some statistical content), Leeds proposed a far wider range of components after KS4. This included Free Standing Mathematics Qualifications, an A level in Use of Mathematics as well as a GCSE Use of Mathematics. These would be renamed supplementary mathematics modules and some would be designed to meet the mathematical requirements of other A level courses and diploma routes. For Leeds, functional mathematics should also be assessed separately and would consist of a competence and functionality element. They recommended a reduction in A level units to 4 and that greater emphasis should be placed upon proof.

It seems that these two models reflect different visions of mathematics education (thinking back to Ernest's categories) which is not necessarily a problem but needs consideration. The emphasis on mathematical proof and challenge sounds a little different from modelling and the use of relevant ICTs. Whether these distinctions are significant is unclear but suffice to say that the two groups do seem to represent different priorities albeit with a fair degree of common ground.

**Phase II**

Following the development of the two models QCA contracted three awarding bodies (OCR, AQA and WJEC) to develop various aspects of the Phase I models. AQA are developing assessments based upon the Leeds model and continue to work with the Leeds team. OCR are associated with the KCL/Edexcel model but have not been able to fully implement the recommendations of the Phase I team. This is due in part to the quite significant shift in pedagogy that would be required to implement this model. In addition, the challenges of using ICT have proved problematic. Both piloting contractors designed and ran trial qualifications in 2006-7. These included functional mathematics being a component of GCSE Mathematics which was not the recommendation of either of the Phase I teams. The government policy is that functional mathematics (at Level 2) will act as a hurdle to achieving a higher grade in GCSE mathematics for awards from 2012. The aims for the GCSE in *additional* mathematics were not finalised in the two Phase I models and this lack of clarity has continued into the development of the pilot GCSEs. Currently the two GCSEs are assessing the same programme of study. The second GCSE has a greater emphasis on mathematical thinking and problem solving which reflects changes in the new programme of study for KS4 in which mathematical process skills (including mathematical thinking and problem solving) have a prominent position.

*From trials to pilots*

In the summer of 2007 QCA announced that functional mathematics would no longer be accredited from the GCSE qualification but would be a stand-alone award. This presented the awarding bodies with two challenges. The first issue was the willingness of centres to continue to participate in the piloting process. This policy change does not seem to have had a major impact upon participation in the pilot. The more critical consequence is the delay to the development of qualifications which can be implemented in 2010. The decision to change the substance of GCSE Mathematics can only be worked through in 2008-9, shortly after which awarding bodies will need to have specifications ready for distribution to examination centres. However, this is probably not going to be the last change which will have a big impact on the pilot process.

**GCSE consultation**

At the time of writing QCA are in the final stages of a national consultation on the GCSE criteria. Despite the intention to have two GCSEs the consultation is concerned with the subject criteria for GCSE mathematics only, together with some questions about the nature and purpose of a second GCSE. This situation has arisen for a number of reasons but one explanation for the delay in consulting on a second GCSE goes back to Ernest’s categories: different influential stakeholder groups have different visions for a second GCSE. This was illustrated clearly in the last 12 months in the wide ranging estimates for participation in additional mathematics (from the ‘most or all’ of the Sainsbury Review and down to 50% as reported by DCSF sources at the ACME conference in February 2008)

**Future Scenarios**

The future of GCSE mathematics is central to the pathways project, in particular whether there should be a second GCSE in mathematics and what it should consist of. The Evaluating Mathematics Pathways project is spending considerable amounts of time in schools exploring why teachers would, or would not, enter students for two GCSEs. There seem to be a number of possible scenarios for the future including:

1. **Retaining a single GCSE** albeit with changes in accordance with a new programme of study (e.g. process skills). This would be the entitlement mathematics course and schools would continue to design other provision around this in order to provide further challenge, enrichment, etc. Many schools already do this in a variety of ways to construct pathways for mathematics learners.

2. **Moving to two GCSEs, both of which assess the same programme of study.** This was, in essence, Smith’s proposal but since 2004 changes in the qualifications landscape have occurred (e.g. science is no longer a ‘double GCSE’, functional mathematics is no longer accredited as part of GCSE mathematics) and so it is unlikely that two distinctive sets of criteria can be developed to the satisfaction of Ofqual.

3. **Moving to two GCSEs with the second assessing some additional content.** What this additional content might be is not clear. Moreover, should there be any increase in difficulty, as is being piloted in Wales? There are many issues surrounding this option, for example access, timetabling and teacher development.

These options could achieve quite different ends and the EMP team are exploring these scenarios to speculate on what might be the result of each model, based on the extensive dataset collected from work in a large number of case study schools. This process will help to sift out potential unintended consequences of different decisions being made following the consultation. Whatever happens in 2010 we know that GCSE will change and will be based on the new program of study, which includes the functional skill standards and has a greater emphasis on mathematical thinking and problem solving. The final decision will depend, no doubt, on the political and educational priorities of a small number of key stakeholders.

References


This document was added to the Education-line database on 5 February 2009