

Maths for life and work: defining functional mathematics

Eddy Knasel **has been involved with the developments in functional mathematics. Here he shares the thinking behind the government's proposals and explains their relevance for key skills, Skills for Life and vocational learning.**

Introduction

In February and March 2005 the government produced two education White Papers. These were *14–19 Education and Skills* (DfES 2005a), which proposes significant reforms in provision for young people, and *Getting on in business, getting on at work* (DfES 2005b), which focuses on education and training for adults. There are close connections between these two policy statements: the intention is that, taken together, they should lay the basis for a coherent approach to lifelong learning.

One of the main priorities in these documents is the proposal that all young people and adults should have every opportunity to develop their functional skills in three core areas: English, maths and ICT. The Department for Education and Skills (DfES) has now commissioned a comprehensive programme of work to define standards of achievement in these functional skills, using existing key skills qualifications and the closely related adult literacy and numeracy qualifications as a major starting point.

The aim of this article is to look at the role that functional skills will play in the emerging pattern of education and training and, more specifically, to share some of the issues that must be resolved in arriving at standards for functional mathematics. Of these three key areas, it has always been mathematics or numeracy that has attracted the most debate. There is, however, a considerable body of research which demonstrates the importance of core mathematical skills in work and in life more generally. This article highlights how this research is likely to influence the work that is starting on defining functional mathematics. The article also looks at close connections between ideas on how we learn and use mathematical skills and the skills highlighted in the improving own learning and performance key skill qualification.

Functional mathematics and the 14–19 White Paper

3.14. Without these basics for modern life, no young person can consider themselves truly educated. Without these basics, no-one can make the most of everyday life or better themselves at work. Without these basics, no-one will be able to progress to learn as much as they otherwise could, whatever their abilities. ... No-one who is capable should leave education without achieving functional mastery of English and maths.

From: 14–19 Education and Skills (DfES 2005a)

At the heart of the reforms proposed by the government is the goal of helping as many people as possible to reach a practical level of competence in the skills in English, maths and ICT. The focus is on the skills that are used most frequently in employment and in other important aspects of life.

These proposals have implications for GCSEs and for the future of government-funded vocational training. Perhaps understandably, it was the proposals on the relationship between functional skills and GCSEs that grabbed the attention of the media when the White Papers were published.

Functional skills and GCSEs

The central proposition is that in future no one should be able to achieve GCSE grades A*–C in English, maths or ICT unless they have demonstrated ‘mastery’ of the functional skills in these areas. Furthermore, the government plans to change the criteria for school league tables based on GCSE results. As things stand, statistics are provided on how many students have achieved grades A*–C in five subjects. In the future these five subjects must include English and mathematics, and a diploma will be introduced which recognises this standard of achievement at the individual level.

The crucial point is that these diplomas will be issued only to those young people who have reached the required standards in the functional skills. Work remains to be done on exactly how the functional skills will be incorporated into the relevant GCSE qualifications, and it is worth noting that the White Paper envisages that there should be some recognition available for students who have achieved the functional component but not the full GCSE.

Functional skills and vocational learning

In effect, the two White Papers lay out a very similar position for the functional skills in government-funded vocational education and training, including Apprenticeships. The plan is to develop specialised diplomas covering the main occupational sectors. These diplomas will be available at levels 1–3 and there is a requirement that ‘anyone achieving a Diploma at level 2 must have functional English and maths at level 2’. The intention is that these new diplomas should be available through schools and colleges and should also form the core of future Apprenticeship frameworks.

Functional skills, key skills and Skills for Life

Of course, the proposal that Apprenticeships should include functional English and functional mathematics mirrors the present position of the key skills qualifications in communication and application of number within Apprenticeship frameworks. As the following quotation makes clear, the White Papers assume a very close relationship between the functional skills and both the relevant key skills and the equivalent adult literacy and numeracy qualifications.

5.10. We will work with employers and universities, as well as teachers and lecturers and subject specialists to describe clearly what is to be understood as functional skill and make sure that this definition is applied in all qualifications, covering all ages. The KS4 curriculum, the Key Skills qualifications and the Skills for Life standards and qualifications provide a good starting point.

From: 14–19 Education and Skills (DfES 2005a)

There is much work to be done in defining the functional skills, but it is clear that the policy is to use the key skills and Skills for Life standards, which are already mapped against and aligned with the requirements of Key Stage 4 in the National Curriculum, as the starting point for this work.

A longer timescale for work on functional maths

The White Papers specify a timeframe for the development of the functional skills. They stipulate that functional English and functional ICT should be available for use by the spring of 2008. An extra year is allowed for the completion of work on functional mathematics – these standards will come into play in April 2009. The implication is that reaching agreement on the skills that make up functional maths could be a more involved process than will be the case with the other two subjects. Two factors may have influenced this thinking:

- Work on functional maths will also need to take account of *Making Mathematics Count* (Smith 2004), the report of Professor Adrian Smith's inquiry into post-14 mathematics education in the UK that was commissioned by the Treasury. Published in February 2004, this wide-ranging report took account of topics such as the recruitment and training of maths teachers. It included the proposal that the 14–19 curriculum should include a number of differentiated mathematics pathways.
- A recognition that reaching agreement on the mathematical skills needed for success in most areas of work and in important aspects of everyday life has always been a significant challenge. There has long been a view that mathematics is absolutely crucial in many occupations but really much less important in many others. Indeed, this view influenced the original work on the application of number key skill.

The rest of this article looks at some of the specific issues that will be faced in defining functional mathematics and offers some pointers on how these issues may be resolved.

Questions in defining functional mathematics

The development of functional mathematics specifications will be a specialist and highly technical job: there will be a wide variety of issues and questions to address. In this article, however, there is space to highlight three questions that seem especially relevant to those presently supporting application of number and adult numeracy in the workplace:

- Is 'functional mathematics' the right term for this skills area?
- Will functional maths mean a new approach to teaching and learning?
- Do most people actually need mathematical skills?

Is 'functional maths' the right term?

It should be called 'relevant maths'.

Apprentice quoted in: *Simple guide to key skills* (Learning for Work 2004)

The key skill and Skills for Life titles – application of number and adult numeracy – avoid the words 'maths' and 'mathematics'. In part this reflects an awareness that the skills included in these qualifications do not cover the full gamut of mathematical concepts and operations. Instead, they focus on the ones that adults are most likely to use in practical situations. Leaving 'mathematics' out of the titles probably also shows an attempt to assure potential learners that working towards these qualifications will build on skills that they already have. Introducing the phrase functional

maths, or something like it, will represent a significant change – one that may be questioned by practitioners who feel comfortable with the present titles.

In practice, however, there are a number of key players who are dissatisfied with the existing terms. Several teachers and trainers point out that the scope of the key skill and adult qualifications is broader than the simple fluency with numbers implied by the phrases ‘application of number’ and ‘numeracy’. The titles we have at the moment undersell the achievements of the young people and adults who gain these qualifications. This may limit their recognition in the eyes of employers and higher education. And some learners also have reservations. Learning for Work (2004) developed the introductory publication *Simple guide to key skills* with a group of apprentices. They would have preferred a qualification title that included the word mathematics.

It's like maths but more about what people do every day ... invoicing, pricing, discounts, VAT.

Apprentice quoted in: *Simple guide to key skills* (Learning for Work 2004)

Will functional maths mean a new approach to teaching and learning?

One of the characteristic features of what might be called ‘traditional’ approaches to mathematics education is the way in which techniques and ideas are introduced sequentially so that one concept builds on another. So, for instance, in introducing measures of distribution a teacher may start with the concept of ‘range’ and then use ‘interquartile range’ as a stepping-stone towards the mathematically more sophisticated statistic ‘standard deviation’.

Interquartile range earns its place in this sequence as a building block. There are, however, far more practical situations where staff are required to work with standard deviation – a common scenario with organisations using statistics to monitor quality – than there are real-life uses of interquartile range. Knowledge of interquartile range – which was included at level 3 in the original (1995) version of the application of number specifications – is rarely of any use on its own. This makes it difficult to include in work-based programmes or in realistic simulations, and this is why it was dropped from the subsequent 2000 and 2004 versions of the qualification.

The discussion of interquartile range shows how the application of number and adult literacy qualifications break with a strictly sequential approach to the syllabus: they focus on skills which find a practical use and do not specify stepping-stones or building blocks. This break with tradition is highlighted in the following quotation from an LSDA publication produced for the Key Skills Support Programme:

There is therefore a tension – even a contradiction – between best practice in teaching mathematics (i.e. following a sequence of number skills) and best practice in teaching Application of Number in context (i.e. on an ‘as-needed’ basis).

From: *Teaching and Learning: Application of Number* (LSDA 2004)

It seems inevitable that the specifications for functional mathematics will also be written using an ‘as-needed’ basis. Those experienced with supporting key skills and Skills for Life will probably welcome this. Some ‘mainstream’ maths teachers may find it more of a challenge.

Do most people actually need mathematical skills?

The recent White Papers and, indeed, the government's whole strategy for lifelong learning entertain no doubts over the importance of competence in a range of mathematical skills both to individual people and to the UK economy. But this assumption has not always been taken for granted. It was, in fact, a matter for considerable discussion during the initial development of the application of number standards.

The original work on key skills – at that point called 'core skills' – was carried out by two of the agencies that later merged to form the Qualifications and Curriculum Authority (QCA). These were the National Curriculum Council (NCC) and the National Council for Vocational Qualifications (NCVQ). Back in March 1990 NCC proposed a list of six core skills. They argued that three of them should be included in all post-16 qualifications but they were more equivocal about numeracy and ICT:

- *Communication, problem-solving and personal skills are capable of being developed and assessed in all post-16 programmes and embedded in all A & AS syllabuses. It is proposed that the assessment of these skills should influence the final grading of any certification.*
- *Numeracy and information technology should be embedded in syllabuses wherever appropriate, and would not be a necessary part of all qualifications.*

**Quoted in: *Developing and Piloting the NCVQ Core Skills Units*
(Oates and Jessup 1991)**

At this point of development the sixth core skill was competence in a modern language. NCVQ endorsed NCC's proposed list of units and stated that:

- *numeracy, Information Technology and competence in a modern language, these would be relevant to particular NVQs where necessary for occupational competence.*

**Quoted in: *Developing and Piloting the NCVQ Core Skills Units*
(Oates and Jessup 1991)**

This debate is still 'live'. Surveys consistently show that employers value communication and the areas of performance covered by the wider key skills ahead of number and ICT. And, to date, noticeably fewer adults have enrolled in the numeracy qualification than has been the case with literacy.

So, is the government right to give such a central position to functional maths? There is an increasing body of research evidence that suggests that they are.

Maths for work

Almost anyone who has worked with adults and young people in helping them to improve their mathematical skills knows that this can be an emotionally charged area. Adults, including workplace supervisors, can feel rusty and lack confidence. And the skills that we do use at work can be so routine that we take them for granted. Many of us make more use of a wider range of mathematical skills in our work than we realise.

Some of the most convincing and potentially most influential research demonstrating the place of mathematical skills in working life has been carried out by a team from the Institute of Education at the University of London headed by Professor Celia Hoyles. In a study commissioned by the Science, Technology and Mathematics Council (now part of the SEMTA Sector Skill Council) they compiled a series of 22 case studies of the use of mathematics in the workplace, drawing their sample from a range of occupations and a spread of locations across the country. Their conclusion is that an increasing number of us are using mathematical skills and that the level of the skills we are using is also increasing. But these skills are frequently 'invisible':

It is not always easy for companies, or individuals within them, to identify the precise role of mathematical skills in their work practices. The way in which the mathematics is bound up with factors specific to workplaces and tasks can make it hard to identify the components of skills and knowledge that are regarded as 'all part of the job'.

From: *Mathematical Skills in the Workplace* (Hoyles et al. 2002)

Hoyles and her team concluded that a major task in supporting mathematical learning in the workplace is 'making the invisible visible'.

Which skills matter?

Celia Hoyles' voice will carry some weight in any debate about the definition of functional maths. She is the government's Chief Advisor on Mathematics Education – a position that led the *Daily Telegraph* to dub her 'the Government's mathematics Czar'. At an exploratory workshop on functional mathematics organised by QCA and ACME (the Advisory Council on Mathematical Education) in March 2005 she gave a presentation titled 'Functional Mathematics: What could it be?' (Hoyles 2005). Among her starting points she included the following quotation from a former President of the Mathematical Association of America:

At school we teach complicated maths with simple use but in the workplace people often use simple maths with complicated use.

Lynn Steen

The implication is that the focus in functional mathematics should be on how skills are applied rather than on the 'level' of the skill as would be defined in a strictly sequential syllabus.

Hoyles went on to suggest four areas of application which could help to define the content of functional maths:

- Shape and space
- Change and relationships
- Quantity
- Uncertainty – knowing what *must* be, what *might* be and what *cannot* be.

The first three areas are clearly addressed by the existing application of number and adult numeracy qualifications. Hoyles' fourth area, however, is based on an understanding of basic concepts in probability. This topic was included in the 1995 version of application of number but was dropped as part of the 2000 revision. There is some reference made to probability in the adult numeracy standards – this, in fact, represents the most significant difference in content between the key skill and the otherwise very similar adult qualification. The Institute of Education research

suggests that some understanding of probability is important in many jobs. There are also strong arguments that it is important in everyday life.

... and life

The government's case for the importance of functional skills is not based purely on the need to support our economic competitiveness. Functional maths is also intended to help us with 'making the most of everyday life'.

There is a link here with the government's concern with citizenship. To function properly, a democracy relies on informed voters who can make sense of the data that the media make available to them. To understand a newspaper – any newspaper – involves some ability to look critically at figures and graphs on topics ranging from the incidence of violent crime, to immigration through to global warming.

Maths for an increasingly complex world

Unusually for a Professor of Mathematics, the American John Allen Paulos has become a best-selling author. He has written a series of highly readable books with titles like *A Mathematician Reads the Newspaper* and *A Mathematician Plays the Stockmarket* which present a series of anecdotes on how an understanding of relatively simple mathematical concepts can help us to make sense of the world we live in.

Many of Paulos' examples are based on two interconnected ideas: the importance of understanding large numbers and the value of grasping the basic concepts of probability. He points out that most of us glaze over when we see the words 'million', 'billion' and 'trillion'. We think of each of these as unimaginably large numbers. Paulos quotes court cases that have hinged on the assumption that a coincidence that has a probability of one in a million cannot in practice have happened by chance. And yet in a country like the US, with a population of more than 200 million, a one-in-a-million chance is by no means unlikely. Probability, argues Paulos, is not just for mathematicians:

In an increasingly complex world full of senseless coincidence, what's required in many situations is not more facts – we're inundated already – but a better command of known facts, and for this a course in probability is invaluable. ... Probability, like logic, is not just for mathematicians any more. It permeates our lives.

From: *Innumeracy* (Paulos 2001)

A reading of one of Paulos' books makes a convincing case for the relevance of functional mathematics to everyday life, and for the inclusion of some aspects of probability in functional mathematics.

The way ahead: mathematics and reflective learning

Overall, the evidence suggests that, with the addition of probability, the skills included in application of number and adult numeracy at level 2 should provide a sound basis for the equivalent specification for functional mathematics. But the specific skills highlighted in Part A of the key skill and in adult numeracy are only part of the picture. At level 2 application of number also requires learners to take a set of data through the three stages of interpreting information, carrying out

calculations, and interpreting results and presenting findings. This three-stage approach is also likely to be incorporated in functional mathematics. To understand why, it makes sense to explore the approach to mathematical learning that shaped the original key skills specification and also to recognise the strong links between these three stages and the three-stage model of learning that provides the basis for the improving own learning and performance key skill.

Mathematisation, de-mathematisation and the plan–learn–review cycle

NCVQ took the lead role in developing the initial specifications for what became the key skills qualifications. Working with the Shell Centre for Maths Education at Nottingham University, they decided to base the unit on the model of mathematical learning known as the ‘mathematisation cycle’. In this model the learner begins by considering the problem in hand and interpreting it in mathematical terms. This is known as mathematisation. The next step, having expressed the problem in a mathematical way, is to carry out one or more mathematical operations on the data. To complete the cycle, the learner then ‘de-mathematises’ the problem, translating it back into practical terms and then exploring its findings. This is the basis for the three stages highlighted in application of number.

Celia Hoyles’ QCA/ACME presentation argued that functional maths specifications should also be based on the mathematisation cycle. There are two reasons why this model seems particularly relevant to qualifications that, at level 2, are intended to accredit a practical mastery of the most frequently used mathematical skills.

- The ability to pursue a specific problem through all three stages of the cycle – which is a requirement of Part B of application of number – is widely held to demonstrate a significant level of competence in mathematical reasoning. The actual computations carried out as part of a level 2 application of number portfolio may not be particularly complex but, echoing Steen’s comments on the workplace importance of putting simple maths to complicated use, the ability to frame the right calculation and to interpret the practical implications of the results can be more important than the perceived ‘difficulty’ of the calculation itself.
- The model also fits well with approaches to mathematics teaching that stress the value of learning through a problem-solving approach linked to opportunities to reflect on what has been learned. This method is well expressed in the following quotation:

Experience in working with students of all ages has convinced us that mathematical thinking can be improved by:

- *tackling questions conscientiously;*
- *reflecting on this experience;*
- *linking feelings with action;*
- *studying the process of resolving problems;*

and

- *noticing how what you learn fits in with your experience.*

From: *Thinking Mathematically* (Mason, Burton and Stacey 1982)

The improving own learning and performance key skill is also based on a three-stage model of learning. At level 2 learners are expected to:

- help set targets and plan how they will be met
- take responsibility for some decisions about their learning
- review progress and provide evidence of achievements.

There are clear parallels between this 'plan–learn–review' model of learning and the mathematisation cycle. Both put an emphasis on the importance of initial planning and analysis and both stress the role of reflection in increasing the depth and value of learning. Those who develop the functional mathematics specifications could do well to use the improving own learning and performance standards as one of their main reference points.

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