FUNCTIONAL MATHEMATICS: WHAT IS IT?

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Functional mathematics, introduced in the Tomlinson Report (DfES 2004b), and taken up by two succeeding white papers (DfES 2005a, DfES 2005b), might be described as a 'charmed phrase', a phrase that every body can sign up to because of its "penumbra of vagueness" (Apple, 1992). But what is functional mathematics? What problem has it been called into being to solve? Have there been previous solutions to the problem and if so what can we learn from them?

THE PROBLEM – THE SKILLS SHORTAGE

The Skills white paper (DfES, 2005b) makes clear that there is a severe skills shortage in the UK. The thrust of the paper is the establishment of vocational training and with it functional mathematics and literacy as essential skills. Evidence is presented concerning the desperate personal and economic outcomes of skills shortages. Perhaps there is a feeling within government circles that education, for a section of the 14-16 cohort, has failed and skills training is the solution to the skills shortage.

PREVIOUS SOLUTIONS

NUMERACY

The word 'numeracy' was coined by the Crowther Report, "15 to 18", of 1959 (Ministry of Education 1959):

> By "numeracy" we mean not only the ability to reason quantitatively but also some understanding of scientific method and some acquaintance with the achievement of science. (Page 282, paragraph 419)

It was to be the mirror image of literacy and high level skill.

In 1963 the Newsom report offered advice on the education of 13-16 year-olds of "average or less than average ability" (Ministry of Education 1963, page v). On page 120, paragraph 335, in setting out the demands of literacy and numeracy states, "But a lower standard of numeracy than of literacy will do as a bare minimum." This "bare minimum" appears to comprise "the arithmetical four rules" and application "to running a home or earning a living in a simple routine job". Throughout the report there are references to a core of numeracy/arithmetic where the arithmetic is characterised as "common-sense in figure handling" (paragraph 314), arithmetic in wage packet deductions, hire purchase and value for money (paragraph 211) and "social arithmetic" concerning budgeting etc. (Chapter 18B paragraphs 441-460). Thus numeracy has become equated with basic arithmetic and its application to the needs of everyday living.

The mid 70's saw criticism of the mathematical capabilities of schools leavers. Criticisms were gathered in evidence by the Parliamentary Expenditure Committee for its tenth report, "The attainments of the school leaver" (HMSO 1977). It recommended the setting up of an inquiry into the teaching of mathematics, the Cockcroft Committee.

Cockcroft (DES 1982) acknowledged the Crowther Report as the origin of the word numeracy and acknowledged that the meaning now reflected more the Newsom version. He wanted more for numeracy and re-defined it:

> We would wish the word 'numerate' to imply the possession of two attributes. The first of these is an 'at-homeness' with numbers and an ability to make use of mathematical skills which enables an individual to cope with the practical mathematical demands of his everyday life. The second is an ability to have some appreciation and understanding of information which is presented in mathematical terms, for instance in graphs, charts or tables or by reference to percentage increase or decrease. (Paragraph 39, page 11, DES 1982)

To provide the basis for a syllabus which would ensure that the ideals of numeracy were met, Cockcroft advanced the idea of a 'foundation list of mathematical topics' which all pupils would cover and would be the basis of other syllabi. The durability of this list can be seen in the Standards for Adult Numeracy (QCA, 2000) where the mathematics content is very similar to the Cockcroft Foundation List.

The next official attempt to define numeracy within the area of compulsory education was in 1998 by the National Numeracy Task Force, created because of unfavourable international comparisons via SIMSS and TIMSS and, again, concern for the mathematical abilities of school leavers. They felt the need to give a "clear definition" of numeracy and adopted the one used by the National Numeracy Project, the immediate forerunner of the National Numeracy Strategy (NNS):

> Numeracy means knowing about numbers and number operations. More than this, it requires an ability and inclination to solve numerical problems, including those involving money or measures. It also demands familiarity with the ways in which numerical information is gathered by counting and measuring, and is presented in graphs, charts and tables. (DfEE, 1998)

The definitions of numeracy from Cockcroft and NNS, whilst they are associated with basic content, seek to rescue the word from the basic arithmetic of Newsom, to include two things. First there an is appreciation of data in whatever form it may appear. Second there is some idea of functioning with this basic content, of engaging willingly with the mathematics. It might be inferred that the introduction of functional mathematics represents a partial failure of previous attempts to solve the problem and an attempt to move the debate on with a new term.

Mathematical literacy is a common synonym for numeracy. It appears to be used by many authors, when writing about school mathematics, as a term that is widely understood and not in need of definition. However Kent (2002) provides a thorough description of mathematical literacy in the context of mathematics in the workplace. The definition is lengthy and not given here. It is related to modelling and the use of mathematics in the work place in conjunction with IT. The definition comes from a summary of a report upon research by Hoyles et al (2002). Hoyles et al have referred to this elsewhere as ***techno-mathematical literacy***.

Tomlinson and the White Papers

Tomlinson (DfES 2004b) gives no definition of functional mathematics, stating that the content is "to be determined by QCA, actively seeking advice and views from experts and end-users". However it must, according to Tomlinson:

- meet the needs of end-users – particularly through the development of mathematical skills and the use of ICT;
- prepare young people for adult life – this should include financial literacy alongside the application of mathematics in a variety of other real world contexts;
- encourage the wider study of mathematics as a subject in main learning – by providing foundations in a range of mathematical concepts and techniques; and
- encourage progression to level 3. (Annex C)

There is little here about functioning. The mathematics, by implication, is viewed as a skill to be used and applied in a way that is unproblematic.

The two white papers (DfES 2005a, DfES 2005b) do not define functional mathematics but there are indications:

> "We are renewing our focus on English and maths and particularly the ability to apply them in everyday contexts." (DfES 2005a, paragraph 5.2)
>
> "Functional English and maths are the English and maths that people need to participate effectively in everyday life, including the workplace." (DfES 2005a,, paragraph 5.5)
>
> "At the same time, the separate identification of the core of functional maths and English and the introduction of level 1 functional qualifications will ensure that more young people are working at an appropriate level in the basics." (DfES 2005a, paragraph 9.2)

The language, "basics", "everyday contexts", "everyday life", is very reminiscent of the Newsom version of numeracy; it is the language of the skills agenda. There is again a conflict to be resolved as to the interpretation of a word or phrase that will be used to convey what it means to be able to function mathematically in a data rich society.

FUNCTIONAL MATHEMATICS – SOME APPROACHES

The notion of useful mathematics, of functional mathematics, can be approached in at least three ways:

1. by deciding what mathematics content is more useful– leading to a syllabus that is a detailed sub-set of the main mathematics syllabus, and teaching and assessment of each of the identified skills;
2. by analysing the notion of application of mathematics, and identifying the processes involved in it – leading to a syllabus outlined in terms of competencies, and teaching and assessment that ensures each is covered;
3. by focusing primarily on possible contexts, and considering just what people do in such contexts to be functional with mathematics – leading to holistic teaching and assessment through simulation and problems taken from a range of possible contexts, developing mathematics in situ, rather than teaching a specified syllabus.

The first approach is content led, and advocated in the skills agenda. It is a notion that education needs to secure the basics, so the focus is on the parts of the curriculum that are useful. It is assumed that, because of the reduced coverage, and greater motivation to learn useful mathematics, more students will learn more of the basic skills at each level.

The approach implies that the application of mathematics is unproblematic, what is needed is to learn the right mathematics content. The second approach to functional mathematics says that mathematics content is not enough to be functional, as there are mathematical processes as well that students need to learn, or their knowledge of content will only be evident in isolated exercises in mathematics classes and examinations. Thus to learn to use and apply mathematics every student needs to develop a number of identifiable mathematical processes. These are in the National Curriculum as aspects of problem solving and reasoning within the Using and Applying strand. An example of process aspects being thought about specifically in relation to the ability to function in the world can be found in the idea of mathematical literacy developed in assessment terms for PISA (OECD 2003)).

The third approach starts with observations about mathematics when it is actually used in the workplace or other real settings. The TechnoMathematical Skills in the Workplace project (TLRP), done by Celia Hoyles, Richard Noss, Phillip Kent and Arthur Bakker (www.ioe.ac.uk/tlrp/technomaths), notes that there is far less problem with people following a mathematical procedure when they are told what is required, compared to working out exactly what should be done when the problem is expressed in terms that are appropriate to the context. One of their examples of a context problem is “Is spending using charge cards declining in Manchester stores?” To deal with this a mathematical approach has to be developed to the available information. The TLRP team think of this as a kind of mathematical modelling; the theoretical foundation of the PISA assessments (OECD 2003) also refers to modelling – calling it “mathematising”.

Neither group is concerned with teaching, so how modelling might be realised in a curriculum and taught is a point of exploration. One aspect of this is the different levels. Modelling has to apply at all levels, including level 1, to be parallel to, complementary to, basic useful mathematics content. Modelling at lower levels, whatever it may mean, is very unlikely to be taught as a topic, as it may be at higher levels.

A second aspect of the focus on real context is the observation that the mathematics used is often much simpler than expected, but the context is complex. Lyn Arthur Steen is quoted as saying that:

> "At school we teach complicated maths with simple use but in the workplace people often use simple maths with complicated use." (Quoted by Celia Hoyles at QCA Workshop on Functional Mathematics, 3 March 2005)

– and it is the complexity of context that unsettles.

Thus the emphasis of the third, context focused, approach to functional mathematics is on building experience of complex contexts in which students might, at their level, need to do some mathematics, which it is expected will require no more than that with which they are already familiar. Through exposure to such contexts, with the teacher working with students to guide them in how to use what they know, it is hoped that they will become able to be function, transforming their school mathematics into useful mathematics.

We do not have any extant examples of curriculum or assessment based on simple mathematics modelling a complex situation, as this is new thinking. It may turn out that although the idea resonates with many people and appears to make sense, it cannot be translated into a form that is appropriate for the age group.

CONCLUSIONS

If functional mathematics is not to suffer the fate of numeracy and be seen as another expression for competence at basic arithmetic then it must, at all levels, seek to offer a guarantee of two things:

- a degree of competence or mastery in some areas of mathematics and
- a willingness to engage with situations that are amenable to some form of mathematical analysis, where the mathematics involved is within the competence of the students.

Not to offer these is to be politically naive and surrender the term to others engaged in the process of seeking a meaningful interpretation.

The alignment of the mathematics content of functional mathematics with GCSE is something that needs to be researched. There are at least two other problems. The first is what modelling at the levels discussed might mean. Its meaning is well understood at higher levels of mathematics. At the levels discussed here the meaning is less well understood and the difficulties associated with modelling at higher levels might take on added dimensions. We have chosen to use the term because is has common currency within the literature referred to above. The second problem is twofold, how it might be taught in the classroom and how teachers might be trained to teach it. Using and Applying Mathematics, in its original form, perhaps a forerunner of functional mathematics, suffered from both these problems and has changed considerably in conception.

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