Kaye, D. (2014). Critical issues in numeracy practice – contradictions and strategies. *Adults Learning Mathematics: An International Journal, 9*(2), 54-62.

Critical issues in adult numeracy practice – contradictions and strategies

David Kaye

Learning Unlimited, Institute of Education

<david.m.kaye@btopenworld.com>

Abstract

This paper discusses the critical situations I have been asked to 'improve' by providing professional development for teams of adult numeracy and functional mathematics teachers in the post-16 sector in London. These situations have not been identified through any research process, but arise from internal management reviews of course outcomes and staff development provision. The assessment by the institution's management of these situations is often very different from that of the teaching staff. And my view as a teacher trainer is probably different again. The main focus of my intervention is to suggest changes to planning and teaching strategies. However, organisational structures have also to be considered. The author argues that three significant theories, 'multiple intelligences', 'a profound understanding of fundamental mathematics' and 'how the mind creates mathematics' provided guidance for the reflection of practice. The approach taken is supported by the Open University's guide to action research.

Keywords: numeracy, mathematics skills, adult mathematics learning, critical issues, strategies.

Introduction

This paper provides a review of a series of interventions into adult numeracy teaching in London, United Kingdom (UK) over a two-year period from 2011 to 2013. The interventions were made at the request of Further Education Colleges to improve the standard of teaching. With reflection, the concerns of the local management have been identified as critical issues in the teaching of numeracy to adults. Similar issues were identified in a number of Colleges and contradictions between the teaching aims and methods were also identified. To help improve the outcomes some activities were suggested. These have since been reviewed and can now be examined as a set of strategies to improve teaching and learning. This paper recounts this journey from support for professional staff to a set of key theories that underpin innovative interventions in practice.

Though I aim to analyse a range of research sources that are relevant to this journey, I will follow a narrative that is founded on the experiences of giving support both in structured sessions and during teaching practice observations. This set of experiences was not designed at the time as a research project, but do now form the basis for a, retrospective, critical review of strategies for improving adults learning mathematics.

Critical Situations

The critical situations that form the teaching practice, core to this analysis, arose out of the formal provision of professional development to improve teaching and learning standards. Over a number of years the UK government funded support to educational and training institutions on a national basis. Such support reflected various formats, and included partner institutions supporting each other, banks of on-line resources or the provision of specialist trainers. There was, for a short period, a particular focus on adult numeracy, and it was this situation that provided the opportunity for staff development visits to be made. See, for example, the pages on "Whole Organisation Approach to literacy, language and numeracy (LLN) Framework" on the Excellence Gateway site for Supporting Skills and Improving Practice.

In retrospect, I identified the following as the main situations that concerned the institutional management about their numeracy teaching, and for which they requested some specialist help:

- Working with students on vocational courses
- Working with ESOL students
- Raising students' level from Level 1 to Level 2
- Preparing for functional mathematics assessments
- Making the numeracy class more interesting

Let us look at these in a little more detail.

Working with students on vocational courses comes out of a long history of adult numeracy and mathematics being seen as one of the basic skills that underpin success in almost all vocational education and training. Those familiar with the policy issues in this field in the UK since 2000 might be aware of the debates that have developed over the issues of integration, embedding and context. (See for example the NRDC report on embedding literacy, language and numeracy [Casey, H. et al 2006]). The iColleges were concerned about attendance and outcomes on numeracy and mathematics support classes.

Teaching ESOL students is a particularly large part of the work of adult numeracy practitioners working in London. The expression, ESOL, a contraction for "English for speakers of other languages" is used as shorthand for students who do not have English as their first language, whether or not they are attending language classes. Many numeracy teachers work with classes that are largely or entirely comprised of 'ESOL' students and so institutions are concerned with how best to serve this cohort.

Raising students' level from Level 1 to Level 2 is with reference to the levels of the Adult Numeracy Core Curriculum (ANCC) and to the more recently introduced Functional Mathematics. The content of these levels can be explored on the Excellence Gateway site for Skills for Life Core Curriculum, particularly in the "numeracy progression overview" document[26]. For some teachers and curriculum managers the change of content from Level 1 to Level 2 is seen as a much larger challenge than movement between other levels, when planning teaching and learning.

Preparing for functional mathematics assessments is particular to the English situation, as this was a new form of assessment for the sector introduced in pilot form in 2007. It has, only quite recently, become the main form of assessment for adult students. It is a very different form of assessment compared to the national tests that were used previously. The national tests were multiple-choice questions, whereas functional mathematics aims to measure process skills and requires more writing and explanation. The mathematical content however, is very similar.

Making the numeracy class more interesting is a very broad category that in practice covers issues in which the curriculum managers considered that the mathematics teaching was too traditional, and

[26] http://www.excellencegateway.org.uk/node/14938

the teaching staff were not open to new approaches. See for example, the approaches associated with collaborative learning, such as described by Malcolm Swan (Swan, 2007]).

The practice for this 'reflection-on-action' [Schön quoted in OU (2005) p24] comprised staff development sessions devised by the author. These took place in colleges of further education and local adult education services in the London (UK) area. The courses at these institutions were for students aged 16 or above. However for organisational and funding purposes the courses are usually organised separately for young adults, aged 16 to 19 and adult classes for those aged 20 and above. The courses can generally be classified under three headings: vocational, functional mathematics and English language (ESOL). The teachers attending the staff development sessions included mathematics and numeracy specialists, support teachers (for literacy and numeracy) and specialist vocational teachers.

Contradiction and strategy 1 – Order of numeracy topics

The impact of reports about poor numeracy, particularly the Moser report (DfEE 1999), led to the publication of the Adult Numeracy Core Curriculum (ANCC) in 2001 (Basic Skills Agency). There remains considerable dispute whether this document is properly described as a curriculum, despite its name. However, what is certain is that it set out a list of topics divided into sections, sub-sections and curriculum elements. These curriculum elements were presented across three levels: Entry Level, Level 1 and Level 2. The Entry Level was itself sub-divided into three, Entry 1, 2 and 3.

The three sections of the ANCC are number, measure, shape & space and handling data. These were based on a model established by the National Curriculum for primary school mathematics. An example of an element from the number section at Entry 3 is "add and subtract using three-digit whole numbers". An example of an element from the measure shape & space section at Level 1 is "work out the perimeter of simple shapes". The Core Curriculum is now available as an on-line document, however, for about 5 years the printed document was the only version available and the order of the elements tended to be followed as a syllabus by many numeracy teachers. This close adherence to the printed document was further compounded by the common practice in many institutions to encourage (at the very least) numeracy teachers to identify the numeracy elements covered in their lesson plan by their distinct element reference number. The ANCC itself encourages this.

> The curriculum elements must be clear and used with learners. The aim must be that learners develop the concepts and the language that will help them make sense of their learning and go on doing it. Evidence shows that the inclusion of explicit curriculum targets in learning programmes has resulted in a clearer identification of outcomes by learners, and in better attendance and progression by learners (BSA, 2001, p. 8).

As the core curriculum has been used as a syllabus, schemes of work begin with the four arithmetic operations, proceed through whole numbers and then decimals and fractions and percentages. Here is the contradiction. All of these teachers are aware that it is considered good practice to take the students experience into account and place calculating techniques into context. Yet the part of the curriculum most removed from any context is introduced first and can easily take up half of the course time.

The ANCC itself emphasises the need to take into account the students' past experiences.

> The skills and knowledge elements in the adult numeracy core curriculum are generic. They are the basic building blocks that everyone needs in order to use numeracy skills effectively in everyday life. What is different is how adults use these skills and the widely differing past experience that they bring to their learning. This is the context that the learner provides . . . (BSA, 2001, p.8)

The strategy I propose is simple and straightforward, yet experience has shown it is frequently condemned and rejected. The ANCC is divided into three sections, Number, Measure, shape & space and Handling data. That strategy is simply to start the course in a section other than Number. To begin the course with some aspect of measuring or collecting data. There are three main advantages to be gained from this strategy.

1. It avoids presenting adult students with the mathematical techniques, such as mental calculations, that they probably find the most difficult, if not impossible, right at the start of the course. This is often countered with the argument that they 'have to know how to multiply – to know their tables'. Perhaps they do. However, I question whether this traditional approach can work with most adult students. The students are in the adult numeracy class because they have not achieved previously. If they have completed secondary school they will have been shown the techniques for multiplication at least 10 times; if they have already had additional help in school and attended other post-16 classes this is probably closer to 15 times. Why should this occasion be any different?
2. Measure shape & space and handling data provide 'in-built' context for working with numbers. Something must always be measured or a shape must be a shape of something, and have dimensions. If data is being collected it must be about something. Starting a programme of study with topics drawn from these sections provides the opportunity for the examples used to be relevant to the students' lives or the other courses they are studying. All of the calculating techniques from the 'Number' section occur when manipulating problems within these topics. Over time, appropriate support can be developed where it is necessary.
3. By starting with measuring or data not only are we avoiding starting with topics that are likely to be the most challenging for students – there is the opportunity to start with topics that the students are more familiar with. Very often the students themselves do not identify what they can do as mathematics at all (Colwell, 1997). For example, a student may have poor multiplication skills, and therefore have considerable difficulty in converting measurements. However they may have excellent estimating skills, demonstrating a thorough understanding of measurement, but the students may well consider this 'just common sense'.

Contradiction and Strategy 2 – Numeracy for speakers of other languages

The problem as it is posed is 'what we have to do to teach mathematics to the students who do not have English as their first language?' In discussing this further with the teachers concerned, there appears to be a contradiction between what the teachers think they should be teaching and what the students need to learn. For teachers in stand-alone adult numeracy classes, this problem has been compounded by the recent introduction of Functional Mathematics. As was described above the new Functional Mathematics assessments require more writing to explain why a particular solution has been chosen. Part of the strategy here is to know about and understand the background of these students. The term 'ESOL' is used to refer to a very wide range of students. Many of the students will have lived in Britain for a comparatively short period of time, and therefore their schooling or education would have taken place elsewhere. In many institutions ESOL students are placed in classes according to the level they have been assessed at in English, and these are often at Entry Level. In the mathematics class the teaching is likely to begin with calculating methods, as discussed above. This may well be totally unnecessary and even cause confusion.

The students may well (currently) have a low level of English, but that does not mean that they cannot calculate; they may well have a good knowledge of mathematics. If a student has completed their secondary education in another country they are likely to be fully competent in their calculating skills. They may well be proficient using other methods, and this is where confusion can occur. If a different way to calculate is demonstrated, they may well think that they are doing something wrong using the one they have been taught previously in school. Given they may have a low level of English it will be difficult to discuss this, and so care needs to be taken to ensure previously acquired skills are recognised and supported. It is important to recognise that the skill some students need to learn is the language of mathematics. There is quite a complex relationship between the language in which mathematics was learnt and the current learning medium of English. Dhamma Colwell (1997) gives examples of the processes people experience as they move from one language to another in their mathematical practices. For example M changed from Cantonese speaking school to an English-speaking one at the age of eleven. She found that maths was the only subject that she could understand easily, because the symbols used were the same in both languages (Colwell, 1997 p67)

In this example skills in mathematics are compensating for the lack of skills in English, by depending on familiar symbols.

The other part of the strategy is to ensure that connections are repeatedly made between the mathematical items, saying and writing the words that describe it, and the symbols used to represent it. An example of this is ‘ratio’. This is the mathematical item. It is written as ‘3:2’ and said as “three to two”. The concept of manipulating quantities in ratio may well be understood, but to discuss it and ask questions it is necessary to have the written and spoken language of ‘3:2’ and “three to two”.

This can be represented by an image using the concept of a number.

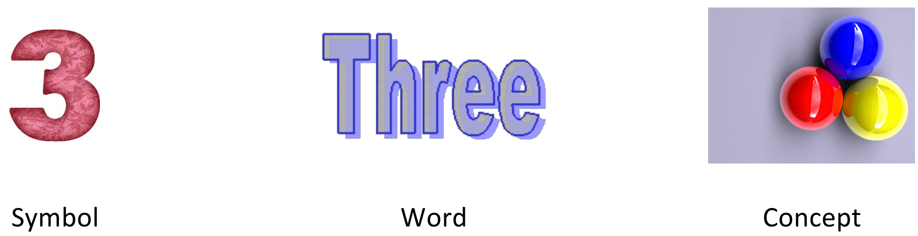

Figure 1. Representations for number three

Explanations given in a numeracy or mathematics lesson usually use all three - representing the concept in some form, saying or writing in words a definition or explanation and presenting the concept in symbolic form. These are very often not presented at the same time and moving from one to the other, with the intention to explain more clearly, can cause confusion.

Contradiction and strategy 3 – Numbers with and without context

The need to consider the context is particularly relevant to working with students on vocational courses. The pressure on institutions to ensure students have the mathematical skills to achieve their primary learning goal on a vocational course has long been an issue. For example Gail FitzSimmons discusses this in the Australian context in the late 1990s (FitzSimmons 1997). It is still a very live issue. At the time of writing, August 2013, the UK Government has just announced new measures for 17 year olds to continue to learn English and mathematics. Professor Alison Wolf, who headed a government review of vocational qualifications, described continuing in the two subjects as the most important recommendation of her inquiry. “Good English and maths grades are fundamental to young people’s employment and education prospects,” she added. “Individuals with very low literacy and numeracy are severely disadvantaged in the labour market.” (Wolf, 2013)

The contradiction is that mathematics can be presented differently in a vocational class to how it is introduced in the mathematics support class. An example of this was observed during an LSIS support session (see LSIS Support Programme – Barking and Dagenham College). In a painting and decorating class the students had to make a six-colour wheel on the doors they were decorating. Under the instruction of the painting and decorating teacher the students drew a circle. They then marked out the length of the radius of the circle six times around the circumference of the circle and drew lines from these marks to the centre. They completed the activity by painting in the three primary colours of red, yellow and blue, and by overlapping creating the three secondary colours of green, orange and purple (or violet). The mathematical solution to this problem would involve considering that a circle can be divided into 360 degrees and that to divide the circle into six equal parts then requires the calculation of 360 divided by six. To complete the practical task angles of 60° would then need to be measured or constructed.

This situation raises many more questions about the purpose of certain problems, and the reasons given for doing certain calculations. However, for the purposes here the strategy to be noted is that practical solutions are used in vocational classes that are different from those a mathematics teacher is likely to use. If this is not taken into account the numeracy / mathematics support classes are likely to be seen as irrelevant. The recognition of different sorts of mathematics in vocational and cultural contexts has been developed far more deeply, practically, pedagogically and theoretically under the heading of 'ethnomathematics', particularly in South America. (See for example Knijnik's (2007) study of the mathematical practices in the Brazilian Landless Movement).

Theoretical inspiration

The contradictions and strategies I have been discussing arose out of my own practice in teaching adult numeracy, in teacher education and in professional development. This practice was informed by reflection on the feedback received from teachers and discussions with colleagues and also on a whole body of theories and research on teaching adults mathematics. In reflecting on my own practice, , I realised that I was concerned that such reflection and evaluation should lead to change This was associated with certain approaches to action research, such as that described in the Open University guide for action research:

> The second approach has other attractions. As noted, it draws upon Schön's (1983; 1987) ideas of 'the reflective practitioner' and 'reflection-on-action': the active and critical consideration and reflection by us, as practitioners, on such aspects as the motives behind and the consequences of our professional practice. This is achieved through a process of action-reflection-action and is what permits us as teachers to analyse our practice, both for ourselves and for others, and thus to change and develop. (OU, 2005, p.24).

The next section provides a summary of my thoughts about the contradictions and strategies in teaching adults under three headings:

- Different ways of thinking about a problem . . . and solutions
- A deeper understanding of how people calculate
- Considering how the brain manipulates numbers

These ideas have been inspired by the work of three very different researchers, whose work has helped to explain the contradictions and inspire the new strategies. The first is the theory of 'Multiple intelligences'. Howard Gardner first published this in 1983 in Frames of Mind. Since then he has updated the theory by taking into account how others have used this theory and adding one more intelligence to the original seven (Gardner, 2006). Gardner's theory, in its current form, identifies eight different sorts of intelligences. Two of these are linguistic and logical-mathematical, and in his debate with the psychometricians (those who work with intelligence tests) he argued that the traditional tests primarily measured these two only.

The other intelligences that Gardner describes are musical, spatial, bodily kinaesthetic, interpersonal, intrapersonal and naturalist. What I found particularly helpful from this theory is that it provides a theoretical basis for recognising that people can be poor at some tasks but very good at others. Particularly they may have poor mathematical skills, or mathematics approached in a particular way, but have many other talents. If that is the case, then these talents can be used to build their numeracy experience, rather than continuing to focus most on the parts of mathematics they cannot do.

The second source is that of the researcher Liping Ma, in her study Knowing and Teaching Elementary Mathematics (Ma, 1999). The main focus of this study is to compare the mathematical knowledge and teaching practices of teachers trained in the USA and China. The examples she focuses on are very instructive, such as looking at how teachers understand the rules for dividing a fraction by a fraction. However, what I found particularly instructive was the section entitled: 'Profound Understanding Of Fundamental Mathematics' (Ma ,1999, pp118-124).

What this provides is an argument for having a deep understanding of the concepts that underpin the processes involved in basic calculating. This, once again, provides support for the development of alternative strategies. With this 'profound understanding of fundamental mathematics,' a teacher would be easily able to adapt a calculating process to suit a particular student, and would have the personal skills to evaluate a different method used by a student. Without such understanding, the teacher is left with only the method they have learnt, which they may be able to perform by rote, but cannot be explain or deviate from.

The third source is the work of Stanislas Dehaene (1999). His ideas are summarised in the book, The Number Sense which is sub-titled 'how the mind creates mathematics'. There are three things that give me inspiration from this book. The first is the introduction the author presents to the neuroscientific approach to understanding mathematics. He introduces the reader to studies of the brain, which show where, and possibly how, numbers and quantities are manipulated. Much of the work of the neuroscientists Dahaene showcased has been to work with patients who have lost specific number skills, after an illness or an accident, and identify which parts of the brain have been damaged. The second is the introduction to the concept of 'subitizing'. This is described as a particular ability that enables one, two or three (and possibly four) objects to be recognised and distinguished without one to one counting. It is used to show there is a number sense in very young babies and animals and to support arguments for some aspects of understanding numbers as being innate.

The third is introducing the term 'numerosity'. This is the attribute of a group of things that gives it countable quantity. It is recognising amounts. This I found useful in discussing at a fundamental level what we mean when we talk about 'a number' or 'numbers'. The word 'numbers' has so many meanings that having a specific word which refers to the concept of 'amounts' rather than how a number is written or said can help clarify thinking and from that, how number concepts are explained and demonstrated.

Finally there is one more source that needs to be noted. I have spoken briefly about the importance of collaborative work with colleagues. Over recent years my reflections and self-evaluation of staff development initiatives have been supported by discussions and joint work with my colleagues and by the initiatives in teacher training for adult numeracy specialists. This body of knowledge and experience can be found summarised in 'Teaching in Adult Numeracy' (Griffiths & Stone, 2013).

Conclusion

In this paper the experience of working with a wide range of adult numeracy professionals is reflected upon in order to identify the key changes to teaching strategies that were being promoted. The key changes to teaching strategies are recognised as being underpinned by three diverse theories: Howard Gardner's 'multiple intelligences', (2006); Liping Ma's 'a profound understanding of fundamental mathematics' (1999) and Stanislas Dehaene's 'how the mind creates mathematics' (1999). The process has been seen to have similarities with the reflective practices associated with action research.

References

Adult Numeracy Core Curriculum on the Excellence Gateway. Retrieved from: http://www.excellencegateway.org.uk/node/1514.

Basic Skills Agency ([BSA], 2001). *Adult numeracy core curriculum*. London: Cambridge Training and Development on behalf of the Basic Skills Agency.

BIS (2011). *Skills for life survey: Headline findings.* BIS Research paper number 57. London: Department for Business, Innovation and Skills.

Casey, H., Cara, O., Eldred, J., Grief, S., Hodge, R., Ivani,c R., Jupp, T., Lopez, D. & McNeil, B. (2006). *You wouldn't expect a maths teacher to teach plastering…. Embedding literacy, language and numeracy in post-16 vocational programmes – the impact on learning and achievemen*t. Summary Report London National Research and Development Centre for adult literacy and numeracy.

Coates, M. (2005). *Action research: a guide for associate lecturers*. Milton Keynes Open University Press.

Colwell, D. (1997). Adults' experiences of learning and using maths in a second language in Coben, D. (comp) *Adults Learning Mathematics – 3.* Proceedings of ALM3 the Third International Conference of Adults Learning Maths - A Research Forum. London: Goldsmiths College, University of London in association with ALM.

Dehaene, S. (1999). *The Number sense – how the mind creates mathematics.* London: Penguin Books.

DfEE (1999). *A fresh start: Improving literacy and numeracy*. The report of the Working Group chaired by Sir Claus Moser. London Department for Education and Employment.

FitzSimmons, G. E. (1997). Mathematics in the vocational education and training sector: the professional development implications for teachers. In Coben, D. (comp) *Adults Learning Mathematics – 3.* Proceedings of ALM3 the Third International Conference of Adults Learning Maths - A Research Forum. London: Goldsmiths College, University of London in association with ALM.

Gardner, H. (2006). *Multiple Intelligences – New Horizons*. New York: Basic Books.

Griffiths, G. & Stone, R. (Eds.) (2013). *Teaching Adult Numeracy – principles and practice.* Maidenhead: Open University Press.

Knjnik, G. (2007). Cultural differences, adult education and mathematics in Seabright, V. & Seabright, I. (Eds) *Crossing Borders – Research, Reflection, & Practice in Adults Learning Mathematics.* Proceedings of the 13th International Conference of Adults Learning Mathematics – A Research Forum. Dublin. ALM with CAMET (Centre for Advancement of Mathematics Education in Technology) & Institute of Technology Tallaght Dublin.

Ma, L. (1999). *Knowing and teaching elementary mathematics.* Mahwah, New Jersey: Lawrence Erlbaum Associates.

Swain, J. Newmarch, B. & Gormley, O. (2007). *Numeracy – Developing Adult Teaching and learning: practitioners guides.* NRDC / NIACE Leicester (Crown copyright)

Swan, M. (2006). *Collaborative learning in mathematics: a challenge to our beliefs and practices* London: NRDC / NIACE.

Wolf, A (2103). The Independent (online). Retrieved from http://www.independent.co.uk/news/education/education-news/pupils-who-fail-gcse-english-or-maths-will-be-forced-to-stay-on-at-school-and-resit-their-exams-8793614.html.

Resources from the Excellence Gateway

Functional mathematics: Standards: http://www.excellencegateway.org.uk/node/20517

Teaching and learning support material http://www.excellencegateway.org.uk/node/22188

LSIS Support Programme – Barking and Dagenham College Collaboration between functional skills specialists and vocational specialists

http://repository.excellencegateway.org.uk/fedora/objects/eg:5390/datastreams/DOC/content accessed September 2013

Whole Organisation Approach to literacy, language and numeracy (LLN) Frameworkhttp://www.excellencegateway.org.uk/node/1151 accessed 28th August 2013