

From Standards-Led to Market-Driven: A Critical Moment for Adult Numeracy Teacher Trainers

Martyn Edwards

Sheffield Hallam University

<m.edwards@shu.ac.uk>

Abstract

There has been a shift in the training of numeracy teachers in England away from a highly regulated 'standards-based' approach to teacher training towards one that seeks to engage employer groups and stakeholders in determining the training needs of teachers in further education. This shift has taken place within the context of rapid reform to numeracy and mathematics curricula for post-16 learners. The planned curriculum changes have again highlighted the shortage of qualified numeracy teachers needed to implement national policy initiatives, and has brought numeracy teacher training onto the policy agenda once again. This paper uses Bernstein's notions of vertical teacher knowledge and horizontal teacher knowledge to consider how trainee teachers may be supported to bridge the gap between their own mathematical knowledge and their classroom practice as numeracy teachers. It also draws on Shulman's seven types of teacher knowledge to make these connections. Recommendations made relate to the entry criteria for adult numeracy teachers, allowing 'time and space' to reflect with other trainees rather than 'immersion in practice', the benefits of practitioner-led enquiry to develop innovative pedagogies, and enhanced links between further education and school-based mathematics and between further education and higher education.

Key words: numeracy, teachers training, standards-based approach

Introduction and policy context for adult numeracy teacher training in England

The Moser report (DfEE, 1999) signalled the introduction of the 'skills for life' policy in England with a commitment to raise the literacy and numeracy skills of adults. This policy initiative was introduced in the context of a largely casualised teaching workforce where literacy and numeracy teachers often existed on the margins of further education and were sometimes perceived as lacking the subject or occupational expertise often associated with teachers of academic or vocational subjects (Lucas, 2007). The introduction of 'subject specifications for teachers of adult literacy and numeracy' (DfES/FENTO, 2002) sought to address this by ensuring "that all new teachers [of literacy and numeracy] are equipped with the appropriate knowledge, understanding and personal skills in their subject, in order to put them on a par with teachers in any other subject" (Lucas, 2007, p.127).

The drive to raise the subject knowledge of literacy and numeracy teachers in England through the introduction of the DfES/FENTO (2002) subject specifications was to some extent subsumed within the wider 'equipping our teachers for the future' initiative (DfES, 2004) that sought to raise the subject knowledge of all teachers in further education. This was partly driven by a critical Ofsted report (2003) into the initial training of further education teachers that found little systematic development of the specific skills and understanding needed for effective subject specialist teaching and that the lack of this specialist dimension to be "a major shortcoming in the present system of FE teacher training" (Ofsted, 2003, p.23).

The DfES/FENTO (2002) 'subject specifications for teachers of literacy and numeracy' were replaced in 2007 by 'new overarching professional standards for teachers, tutors and trainers in the lifelong learning sector' (LLUK, 2007a) and an application of those standards for specialist teachers of adult numeracy (LLUK, 2007b). These new professional standards were followed by a qualification framework, workforce regulations and the imposition of highly prescriptive learning outcomes that sought to regulate the competencies trainee teachers were expected to demonstrate during initial teacher training. Nasta (in Lawy and Tedder, 2009, p.56) described this policy model as driven by a "linear notion that the standards must be specified first, then regulations and qualifications must be developed that incorporate the standards, and only at the final stage are a curriculum and assessment model to be developed that will form the basis of what trainees actually experience".

Two research projects were carried out by the National Research and Development Centre (NRDC) into the DfES/FENTO (2002) 'subject specifications for teachers of numeracy and literacy'. The earlier of these studies (Lucas *et al.*, 2004) was based on nine universities that piloted the subject specifications alongside their initial teacher training courses whilst the later study (Lucas *et al.*, 2006) drew upon a larger sample of mostly in-service courses delivered by both universities and colleges. The key foci of these research projects included an exploration of how the subject specifications were being translated and re-contextualised into teaching practice; different approaches taken to delivering the subject specifications; and the balance to be struck between subject specific knowledge, pedagogic knowledge and practical teaching skills (Lucas, 2007). The two NRDC projects led to a number of peer-reviewed publications by the researchers involved in the projects (Lucas, Loo and McDonald, 2006; Lucas, 2007; Loo, 2007a; Loo, 2007b). These discussed issues relating to the increased subject knowledge of numeracy (and other 'skills for life') teachers and the relationship of that increased subject knowledge to classroom teaching practice using Bernstein's (2000) notions of vertical teacher knowledge and horizontal teacher knowledge.

Whilst a body of literature began to emerge specific to adult numeracy teacher training as a result of the two NRDC studies (Lucas *et al.*, 2004; Lucas *et al.*, 2006), this literature did not explicitly take account of the more developed debates on the nature of subject knowledge needed for teaching mathematics in schools (e.g. Ball and Bass, 2003; Davis and Simmt, 2006; Ball, Thames and Phelps, 2008; Hodgen, 2011). It is appropriate in considering subject knowledge for teaching adult numeracy to engage with the wider debate of subject knowledge for teaching mathematics in schools, particularly given the research that has taken place into the longer-established subject knowledge enhancement courses (formerly called mathematics enhancement courses) that are by universities to prospective trainee mathematics teachers for secondary schools (e.g. Adler and Davis, 2006; Askew, 2008; Stevenson, 2008; Adler *et al.*, 2009).

The change of government in the UK in 2010 resulted in a shift of educational policy on teacher professionalism away from centralised government-control through a standards-based

and regulatory system towards one that afforded greater autonomy to employers to determine the professional qualifications their teaching workforce needed to respond to the needs of the learners and employers they seek to serve. The Lingfield review of teacher professionalism in further education (BIS, 2012, p.5) did confirm the need for specialist pre-service or early in-service teacher training for “lecturers in the foundation skills of literacy and numeracy”, albeit within the context of the revocation of the statutory regulations for teacher qualifications in further education. What Lingfield did not attempt to do was define what constitutes foundation skills in numeracy (whether it includes functional mathematics for 14 to 19 year-olds or GCSE mathematics, for example) or the specific outcomes trainee teachers should be expected to demonstrate during initial teacher training.

This article seeks to develop Bernstein's notions of vertical teacher knowledge and horizontal teacher knowledge found in the literature relating to adult numeracy teacher training in England by comparing it with Shulman's seven categories of teacher knowledge found in the literature from the more established subject knowledge enhancement courses offered by universities for intending mathematics teachers in secondary schools. Bernstein and Shulman's theoretical models will be used to analyse post-hoc three teacher training activities drawn from courses designed to meet the subject knowledge requirements of the DfES/Fento (2002) subject specifications for adult numeracy teachers.

Throughout this article the term ‘numeracy’ is used to distinguish the curriculum taught to post-16 learners in vocational contexts from ‘mathematics’ as the curriculum taught as a compulsory subject in schools. Similarly ‘numeracy teachers’ refers to those teachers qualified or training as specialist teachers of adult numeracy and ‘mathematics teachers’ to those qualified or training as specialist teachers of mathematics in secondary schools. The use of these terms to distinguish between curricula and job roles does not imply that such a simplistic division between numeracy and mathematics exists. Indeed, as will be seen in the later section *critical moment in a changing policy context*, the labels numeracy and mathematics can be used to signal the ideological perspectives of policy-makers and as such be subject to different interpretations. For a flavour of the debate on the use of the terms numeracy and mathematics see the papers presented by Kaye in earlier conference proceedings of this journal (Kaye, 2002; Kaye 2010).

Subject specifications for adult numeracy teachers - Bernstein's vertical teacher knowledge and horizontal teacher knowledge

The two NRDC studies (Lucas et al., 2004; Lucas et al., 2006) into pilot courses designed to meet the requirements of the FENTO ‘subject specifications for teachers of numeracy and literacy’ identified three different types of participant on the courses studied. These included very experienced practitioners who also held management posts and staff training roles in colleges; practicing teachers with some classroom teaching experience; and new entrants to teaching with little teaching experience. Each group had different expectations from the course with the most experienced wanting “a high level of theoretical content that would ... provide them with a synoptic perspective on their specialism” (Lucas, Loo and McDonald, 2006, p.341) whilst the newer entrants to teaching wanted an emphasis on practical teaching to prepare them for teaching practice. Lucas, Loo and McDonald (2006) applied Bernstein's notions of horizontal teacher knowledge and vertical teacher knowledge to understand the distinction between theoretical and practical knowledge for teachers and ways in which the courses attempted to bridge these two types of knowledge through what Bernstein called ‘re-contextualisation’.

An examination of the FENTO subject specification for adult numeracy (DfES/FENTO, 2002) shows that it consisted primarily of Bernstein's 'vertical knowledge' separated into the sections of number and numeric operations, geometry and spatial awareness, statistics, and working with algebra. It was primarily 'vertical knowledge' in the sense that the specification required an academic or theoretical understanding of the content that was independent of context or experience. A closer inspection of the elements listed in the specification revealed that most of them approximated to topics that might be found on the first year of a course in GCE Advanced Level mathematics (level 3 on the English National Qualifications Framework) whilst other topics were identifiable from the content required for higher level tier of GCSE mathematics syllabi (level 2 on the English National Qualifications Framework). The specifications immediately raised the questions of (i) how the courses can be justified as being at level 4 on the national qualifications framework (equivalent to the first year of undergraduate study) when the content was clearly a repetition of level 3 study, and (ii) how all the elements listed in the specifications can be covered in a course of one-year part-time duration.

The first of these two questions relating to academic level was the simplest to answer. In the case of the experienced practitioners seeking a theoretical and synoptic perspective of mathematics this 'level 4-ness' could be justified as being demonstrated through the adoption of a connectionist approach to mathematics that emphasised relational understanding over procedural understanding (Skemp, 1976; Askew, 1997). For new entrants to teaching it was the requirement for 60 hours of practical experience in teaching adult numeracy that were seen to bring the 'level 4-ness'. In both cases there were significant challenges for numeracy teacher trainers supporting trainees in the process of re-contextualising vertical teacher knowledge of mathematical content into horizontal teacher knowledge of classroom practice in teaching adult numeracy.

The second of the two questions posed more difficulties for course designers with different approaches taken by awarding bodies and universities to the problem of achieving coverage of the specifications within the learning hours available. Lucas (2007) identified that whilst national awarding bodies adopted a 'standards-based approach' that emphasised 'coverage' and 'mapping' in the competency tradition, universities were more innovative in a 'knowledge-based approach' where they chose which elements of the specifications to emphasise and in what depth to explore them.

Three examples, one from a course that I delivered at Thames Valley University, another from a course delivered by LLU+ at London South Bank University reported in the proceedings of the 13th annual international conference of Adults Learning Mathematics (Stone and Griffiths, 2006), and a third from one of the NRDC pilot studies (Lucas et al., 2004; Lucas et al., 2006) illustrate ways in which universities developed innovative 'knowledge-based approaches' towards the DfES/FENTO (2002) subject specifications:

Example 1: Thames Valley University

One element of the DfES/FENTO (2002) subject specification within the statistics section required knowledge of discrete probability distributions. The direct contact-time available to the trainer to teach this topic was a single session of four hours duration, albeit with the expectation that trainees would engage in self-directed study to further their knowledge outside of the taught session. There were several problems with this. Discrete probability distributions include rectangular, binomial and Poisson distributions. Each of these constitutes a topic in its own right worthy of more than four hours of direct contact-time. Furthermore, knowledge of discrete

probability distributions does not easily translate to strategies for teaching adult numeracy learners. Interestingly, coverage of the normal distribution was not required by the DfES/FENTO (2002) subject specifications since this is a continuous rather than discrete probability distribution, even though an understanding of the normal distribution is arguably more relevant to teachers than the discrete probability distributions due to its usefulness in interpreting assessment results for large populations, understanding IQ scores, and so on.

The trainer made the decision in planning the session to teach both the continuous probability distribution (normal) and the discrete probability distributions (rectangular, binomial and Poisson) within the four hour session. Being aware of the impossibility of teaching such a range of mathematical knowledge within four hours the trainer elected to see the content as a vehicle towards meeting an overarching course aim rather than specific content to be covered. The overarching aims of the trainer were (i) to provide trainees with the opportunity to carry out self-study in pairs on an area of mathematics unfamiliar to them and then teach that concept to the rest of the group, (ii) appreciate the uses of mathematical modelling (e.g. the normal distribution to interpret IQ scores and the Poisson distribution to predict volcanic activity), and (iii) to make links with own practice as teachers of adult numeracy.

Example 2: LLU+ at London South Bank University

Stone and Griffiths (2006, p.148-149), in reflecting upon their experiences as numeracy teacher trainers at LLU+, argued that:

making teachers ‘do some hard sums’ and giving them some background information on personal and social factors affecting learning was not really equipping them to teach their subject. ... Clearly, something was missing. At LLU+ the feedback from our own teacher training programmes was that while the course sessions were fun and participants were exposed to [an] imaginative variety of teaching methods, they did not feel they were learning as much as they would have liked that would be useful to them in the numeracy classroom. To this end, we began enriching our programmes on offer with opportunities to explore mathematics and numeracy at a basic level and to discuss and evaluate ways to teach it.

This extract appears to indicate a similar orientation to the trainer in example 1 where a commitment to overarching course aims allowed the subject specifications to be interpreted creatively. In the case of the two trainers at LLU+ the overarching course aims appeared to include learning as fun, modelling variety in teaching methods, valuing the ‘student voice’, and ensuring relevance of activities to participants’ professional practice.

Example 3: Broken keys activity

Loo (2007) describes an activity used by one of the institutions in the NRDC studies called ‘broken keys’. This involved trainees creating problems for others in the group to solve using mathematical functions. These were then linked to word cards and picture cards to illustrate the links between algebraic symbolism and real life. Finally the trainees were encouraged to reflect on how the approaches could be applied to the teaching of topics from the Adult Numeracy Core Curriculum (DfES, 2001).

Whilst the starting point to the ‘broken keys’ activity was drawn from the ‘working with algebra’ section of the subject specifications a commitment on behalf of the trainers to overarching course aims such as modelling the Standards Unit approaches of learners creating problems, multiple representations and encouraging discussion (Swan, 2005) can arguably be inferred from the teaching approach described.

Subject knowledge enhancement courses for schoolteachers in secondary mathematics - Shulman's seven major categories of teacher knowledge

Subject knowledge enhancement courses (previously known as mathematics enhancement courses) are well-established in many English universities offering Post-Graduate Certificate in Education (PGCE) courses for intending mathematics teachers in secondary schools (Sheffield Hallam University, 2013). These courses are usually offered as short part-time courses to graduates who have already been offered a place on secondary mathematics PGCE courses. They are designed to meet the needs of new entrants to teaching whose undergraduate degree is not in mathematics but in a related subject such as engineering or finance. Since such courses are more established and theorised than those developed to the DfES/FENTO (2002) subject specifications that are the subject of this article it is worth considering what lessons can be learnt from them, and whether those lessons are transferable to adult numeracy teacher training.

Shulman (1986), in developing a theoretical model for teacher knowledge that can be applied to mathematics (and adult numeracy) teacher training, defined the seven major categories of teacher knowledge shown in figure 1. The first four of these categories related to generic teaching skills and these were the mainstay of teacher education programmes at the time. These four categories were seen as relevant to all teachers irrespective of the subject-specific context of their teaching. Shulman acknowledged the crucial importance of these four categories for teaching but went on to propose three further categories that he termed content knowledge, curriculum knowledge and pedagogical content knowledge.

‘Content knowledge’ includes knowledge of the subject to be taught and how it is organised, including an understanding of which concepts are central to the discipline and which are peripheral (Ball, Thames and Phelps, 2008). This type of knowledge can be related to the expectations of the most experienced practitioners in Lucas, Loo and McDonald’s (2006) study of pilot DfES/FENTO courses who wanted a high level of theoretical content to provide them with a synoptic view of their specialism.

‘Curriculum knowledge’ relates to knowledge of the full range of courses available to teach particular subjects and topics at a particular level, including the range of instructional materials available (Ball, Thames and Phelps, 2008). It also includes ‘lateral curriculum knowledge’ (what is being taught to learners in other subject areas) and ‘vertical curriculum knowledge’ (what has been taught in the subject in previous years, and what will be taught in subsequent years).

Shulman’s final category of ‘pedagogical content knowledge’ sought to define that specific knowledge about a subject that is unique to teachers of the subject. It includes an awareness of what makes particular topics conceptually easy or difficult for learners to understand; the most useful analogies, illustrations, examples, explanations and demonstrations that can be used to support learning whilst remaining consistent to the integrity of the subject matter; and common conceptions and misconceptions of particular topics typically held by learners at different ages or ability levels (Ball, Thames and Phelps, 2008). Interestingly, Shulman’s approach was quite different to that of subject specifications and prescribed learning outcomes adopted by FENTO and its successor bodies in that he “did not seek to build a list or catalogue of what teachers need to know in any particular subject area” but instead “sought to provide a conceptual orientation and a set of analytic distinctions that would focus the attention of the research and policy communities on the nature and types of knowledge needed for teaching a subject” (Ball, Thames and Phelps, 2008, p.392).

By analysing Shulman's categorisation of different types of teacher knowledge it becomes apparent that his content knowledge related most closely to Bernstein's vertical teacher knowledge whilst Shulman's curriculum knowledge and pedagogical content knowledge are more akin to Bernstein's horizontal teacher knowledge.

- General pedagogical knowledge, with special reference to those broad principles and strategies of classroom management and organization that appear to transcend subject matter
 - Knowledge of learners and their characteristics
 - Knowledge of educational contexts, ranging from workings of the group or classroom, the governance and financing of school districts, to the character of communities and cultures
 - Knowledge of educational ends, purposes, and values, and their philosophical and historical grounds
 - Content knowledge
 - Curriculum knowledge, with particular grasp of the materials and programs that serve as "tools of the trade" for teachers
 - Pedagogical content knowledge, that special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding
- (Shulman, 1987, p. 8)

Figure 1. Shulman's major categories of teacher knowledge

There are currently two dominant views on the subject knowledge that mathematics teachers in secondary schools need to know to effectively teach their subject (Bell, Thames and Phelps, 2008). The first view is that they need to know whatever mathematics is in the curriculum at the level they are intending to teach plus some additional years of further study at a higher level of mathematics. The second view is that they need to know the mathematics in the curriculum at the level they are intending to teach, but that this should be a 'deep understanding' incorporating aspects of Shulman's 'pedagogical content knowledge' (Shulman, 1986). The notion of deep understanding in mathematics is evident in the literature in a number of guises. Ma (1999), for example, refers to 'profound understanding of fundamental mathematics' whilst Adler and Davis (2006) use 'understanding mathematics in depth' to describe their conceptualisations of subject pedagogical knowledge.

Bringing together the theories of Bernstein and Shulman

Bernstein's notion of the re-contextualisation of vertical teacher knowledge into horizontal teacher knowledge applied by Loo (2007a; 2007b) to adult numeracy teacher training and Shulman's seven categories of teacher knowledge applied to secondary mathematics teacher training (Ball and Bass, 2003; Davis and Simmt, 2006; Ball, Thames and Phelps, 2008; Hodgen, 2011) can be brought together by considering the three examples of teacher training activities discussed earlier.

In example 1 the teaching of discrete probability distributions was discussed. Knowledge of discrete probability distributions (rectangular, binomial and Poisson) fits comfortably within Bernstein's vertical teacher knowledge in that it provides teachers with a synoptic view of their specialism. The re-contextualising of that vertical teacher knowledge into horizontal teacher

knowledge is more problematic since the pedagogical techniques adopted of peer-led teaching and mathematical modelling could have been achieved more effectively through studying a numeracy concept drawn from the curriculum that trainees were being trained to teach, rather than through an unfamiliar mathematical topic that trainees themselves experienced as conceptually difficult. It could be argued, for example, that it would be more beneficial for teacher trainers to model the use of a 'washing line' strung across the classroom to order the probability of events occurring on a scale of 0 to 1 rather than being required to teach discrete probability distributions in the tradition of Bernstein's vertical teacher knowledge as a proxy for Shulman's pedagogical content knowledge.

In example 2, discussed earlier, the difficulties teacher trainers experienced in supporting trainees to re-contextualise Bernstein's vertical teacher knowledge into horizontal teacher knowledge was even starker. In this case the phrase 'do some hard sums' was contrasted negatively with what teacher trainers saw as necessary to equip trainees to teach adult numeracy effectively. Their response was to enrich the programmes (presumably by adding what they considered to be more relevant pedagogical content knowledge) to the content prescribed by the subject specification. In this case, it could be argued that the trainers' pedagogical content knowledge replaced, or at least marginalised, the vertical teacher knowledge found in the subject specification in such a way as to obviate the need for the re-contextualisation by trainees of different types of teacher knowledge.

The broken keys activity described earlier in activity 3 resonates with the first example in that mathematical functions do not feature in the adult numeracy core curriculum (DfES, 2001). Nevertheless they appear to have been used with some success to introduce Shulman's pedagogical content knowledge by proxy through the use of Standards Unit (Swan, 2005) approaches to teaching mathematical functions. In spite of the apparent success of this approach it could again be argued that using the algebraic notation of functions unfamiliar to trainees adds an unhelpful layer of conceptual difficulty that clouds the more pressing concern of how to effectively teach the basic algebraic concepts found in the adult numeracy core curriculum (DfES, 2001).

Critical moment in a changing policy context

In recent times teaching has been practiced within a rapidly changing policy context (Ecclestone, 2008; Earley et al., 2012). This has led to changes in the way that the teaching role and teacher professionalism has been conceptualised, along with related changes within teacher training itself. It is within this context that a 'critical moment' for adult numeracy teacher training may emerge.

Current government policy in England raises the expectation that all school-leavers without the GCSE mathematics pass expected of sixteen year-olds should be required to retake the full GCSE in mathematics if they progress to full-time further education (DfE, 2013). Additionally, those school leavers progressing to full-time further education who have already achieved the GCSE mathematics pass expected of school-leavers should be required to continue to study mathematics to a higher level rather than being allowed to discontinue mathematics at age 16 as previously (ACME, 2012). Such an approach is seen by policy-makers as promoting the more rigorous and academic study of mathematics rather than the development of numeracy skills for vocational learners through qualifications such as adult numeracy and functional mathematics. Such curriculum reforms are seen by policy-makers as ensuring the UK can compete with leading industrialised nations (Vorderman, 2011).

Recent policy initiatives in teacher training for schools have included encouraging high-achieving graduates to enter teaching through targeted bursaries and to encourage school-centred initial teacher training (SCITT) consortia to provide teacher training as an alternative to more traditional university-led provision (DfE, 2010; DfE, 2011). Such an approach to teacher training assumes that the acquisition of subject content knowledge at a high level should be attained prior to entering teacher training, and that the practical skills of teaching itself are acquired as a 'craft' by working alongside practicing teachers. The speech by the Secretary of State for Education to the National College (Gove, 2010) expressed the view that "Teachers grow as professionals by allowing their work to be observed by other professionals, and by observing the very best in their field ..." and that "teachers ... improve their **craft** by learning from others while also deepening their academic knowledge" (my emphasis). The dichotomy between teaching as a craft and teaching as a profession was challenged by Kirk (2011) who argued that whilst teaching generates substantial personal craft knowledge, often in the form of tacit knowledge, it also required engagement with a broader type of knowledge that "... implies a professional duty to keep in touch with the literature of teaching and learning, and indeed to contribute to it as a way of raising the level of public and professional debate on teaching and learning" (Kirk, 2011).

Similar tensions have been experienced in the training of further education teachers to those found for schoolteachers. The Lingfield Report (2012) recommended the revoking of the regulatory framework for teachers in further education and called for new qualifications for teacher training to be developed by an employer-led 'guild'. However, Lingfield (2012, p.33) also called for a strong professional identity for further education teachers underpinned by increased autonomy to develop innovative pedagogies specific to the vocational focus that is unique to further education. Such practitioner-led enquiry hinted at by Lingfield (2012) is not new to further education. Previous initiatives have included the practitioner-led research initiative (NRDC) and the teacher enquiry funded projects (NCETM). Such initiatives were consistent with Hoyles' (1975) notion of extended professionalism and sit comfortably with emerging measures of professional esteem such as chartered mathematics teacher status and chartered status for further education teachers. In reflecting upon such initiatives, however, it is necessary to sound a cautionary note concerning the culture within the further education sector that can mitigate against such initiatives. *The using research to enhance professionalism in further education project* (Economic and Social Research Project) identified that whilst practitioner research had a significant role to play in shaping the professional identities of those teachers that engaged in it, the benefits were often undermined by managerialist cultures within colleges where short-term gains, such as compliance with national policy agendas, hindered practitioners from asking more fundamental and critical questions about their practice (Goodrham, 2008).

The reforms to the post-16 mathematics curriculum described earlier in this section are a case in point where the shortage of qualified mathematics teachers to deliver the policy initiative has led to the launch of a government-subsidised six-day training programme intended to "further develop the skills of those currently teaching functional skills, preparing them to teach GCSE maths" (Education and Training Foundation, 2013). Such a quick-fix approach to numeracy training appears unlikely to provide teachers with the space or time to gain Bernstein's vertical teacher knowledge and re-contextualise it into horizontal teacher knowledge, nor to acquire those aspects of Shulman's subject pedagogical knowledge critical for effective teaching of numeracy to 'second-chance' learners in further education. Regional training programmes promoted as up-skilling teachers of numeracy by "enhance[ing] their knowledge so that they can teach GCSE effectively" (EMCETT, 2013) is likely to lower the status of numeracy teachers and undermine the gains made through the introduction of specialist

teacher training for adult numeracy teaching rather than raise the quality of numeracy teaching. The ambitious targets set to engage post-16 learners in the study of mathematics up to the age of eighteen is laudable, as is the intention to enhance the subject knowledge of teachers so that they can effectively meet the challenges of the new curriculum. These targets and intentions need to be matched by a strategy for recruiting high quality graduates into teaching mathematics and then providing specialist teacher training courses to support them to re-contextualise their own knowledge of mathematics into effective numeracy pedagogies for further education. Similarly, experienced teachers of vocational subjects cannot be expected to retrain to teach GCSE mathematics without first being provided with the opportunities to increase their own mathematical knowledge to the standards that would be required for teaching in any other curriculum area.

Conclusions and recommendations

Mathematics subject knowledge should be a prerequisite for new entrants to numeracy teaching, whether for new entrants to teaching or for experienced teachers retraining to teach numeracy from other curriculum areas, in the same way that the best graduates and those with substantial vocational experience are sought as teachers for other academic and vocational subjects. Whilst it is unlikely that a consensus can be reached amongst the mathematics community on the detail of the content and level necessary, it is nevertheless important for the status of numeracy that minimum entry criteria be developed. These criteria should be credible when compared with entry requirements for teaching in other academic and vocational areas of further education.

Numeracy teachers should be given opportunities to build upon and extend their own mathematical knowledge and subject pedagogical knowledge throughout their careers, including at Masters level. They should be given support, time and space to develop innovative numeracy pedagogies related to the particular vocational contexts and specialist settings they encounter within further education. Supporting practitioner-led enquiry holds much promise as an effective form of continuous professional development for numeracy teachers.

Whilst acknowledging the benefits of observing the best teachers to learn the 'craft of teaching', it is also necessary to allow teachers the time and space to reflect on their professional learning with other trainee teachers. Such an approach is more likely to develop the critical skills to adapt to the fast-changing and policy-driven culture of further education than immersion in practice. The benefits gained from the subject specialist teacher training in adult numeracy from 2002 need to be maintained and strengthened if the challenges of post-16 curriculum reform are to be met.

Opportunities for developing links between further education and school-based mathematics and between further education and higher education should be grasped. These links can be beneficial both to share effective practice in teaching mathematics and to identify the nature of numeracy pedagogies specific to the contexts and learners in further education.

References

- Adler, J. & Davis, Z. (2006). Opening another black box: researching mathematics for teaching in mathematics teacher education. *Journal for Research in Mathematics Education*, 37(4), 270-296.
- Adler, J., Hossain, S., Stevenson, M., Grantham, B., Clarke, J. & Archer, R. (2009). Interpretations of, and orientations to, "understanding mathematics in depth": students in MEC programmes across

- institutions. In M. Joubert (Ed.), *Proceedings of the British Society for Research into Learning Mathematics*, 29(3).
- Askew, M., Brown, M., Rhodes, V. William, D., & Johnson, D. (1997). *Effective teachers of numeracy*. London: King's College London.
- ACME (2012) *Post-16 mathematics: a strategy for improving provision and participation - ACME post-16 mathematics project*. Last accessed 20 January 2014 at: http://www.acme-uk.org/media/10520/20121217acme_post_16_strategy.pdf.
- Askew, M. (2008). Mathematical discipline knowledge requirements for prospective primary teachers, and the structure and teaching approaches of programs designed to develop that knowledge. In P. Sullivan & T. Wood, (Eds.), *The International Handbook of Mathematics Teacher Education Volume 1: Knowledge and beliefs in mathematics teaching and teaching development*. Rotterdam: Sense Publishers.
- Ball, D. L. & Bass, H. (2003). Making mathematics reasonable in school. In J. Kilpatrick, W. G. Martin, & D. Schifter (Eds.) *A research companion to principles and standards for school mathematics*. Reston, VA: National Council of Teachers of Mathematics.
- Ball, D. L., Thames, M. H. & Phelps, G. (2008). Content knowledge for teaching: what makes it special? *Journal of Teacher Education*, 59, 389-407.
- Bernstein, B. (2000) *Pedagogy, symbolic control and identity: theory, research and critique*. London: Taylor and Francis.
- BIS (2012). *The 'Lingfield report' professionalism in further education: final report of the independent review panel*. London: Department for Business, Innovation and Skills.
- Davis, B. & Simmt, E. (2006) Mathematics for teaching: an ongoing investigation of the mathematics that teachers (need to) know. *Education Studies in Mathematics*, 6 (3), 293-319.
- DfE (2010) *The importance of teaching: the schools white paper*. Norwich: The Stationery Office.
- DfE (2011) *Training our next generation of outstanding teachers: implementation plan*. Department for Education.
- DfE (2013) *Post-16 English and mathematics*. [Online]. Last accessed 20 January 2014 at: <http://www.education.gov.uk/childrenandyoungpeople/youngpeople/qandlearning/programmes/a00225749/post-16-eng-and-maths>.
- DfEE (1999). *The 'Moser report' improving literacy and numeracy: a fresh start*. Sudbury: Department for Education and Employment.
- DfES (2001). *Adult numeracy core curriculum*. Nottingham: DfES Publication.
- DfES (2004). *Equipping our teachers for the future: reforming initial teacher training for the further education sector*. Nottingham: DfES Publications.
- DfES/FENTO (2002). *Subject specifications for teachers of literacy and numeracy*. London: FENTO.
- Education and Training Foundation (2013) *The NCETM GCSE Mathematics Enhancement Programme*. [Online]. Last accessed 20 January 2014 at: <http://www.et-foundation.co.uk/services-and-support/maths-enhancement-programme.html>.
- EMCETT (2013) *Professional development*. [Online]. Last accessed 20 January 2014 at: http://www.emcett.com/professional_development.
- Gove, M. (2010). Presentation at the National College Annual Conference, Birmingham, 16 June 2010.
- Hodgen, J. (2011) Knowing and identity: a situated theory of mathematics knowledge in teaching. In Rowland, T. & Ruthven, K. (eds.) *Mathematical knowledge in teaching*. Dordrecht: Springer/Kluwer.
- Hoyle, E. (1975), Professionalism, professionalism and control in teaching. In V. Houghton et al. (eds.) *Management in education: the management of organisations and individuals*. London: Ward Lock Educational in association with Open University Press.
- Lawy, R. & Tedder, M. (2009). Meeting standards: teacher education in the further education sector. What of the agency of teacher educators? *Studies in the Education of Adults*, 41 (1), 53-67.
- Earley, P., Higham, R., Allen, R., Allen, T., Howson, J., Nelson, R., Rawar, S., Lynch, S., Morton, L., Mehta, P. & Sims, D. (2012) *Review of the school leadership landscape*. Nottingham: National College for School Leadership.
- Ecclestone, K. (2008) The impact of assessment on pedagogy can have damaging consequences. In I. Nash, S. Jones, K. Ecclestone & A. Brown (Eds.), *Challenge and change in further education: a commentary by the teaching and learning research programme*. London: Teaching and Learning Research Council.

- Economic and Social Research Council. *Using research to enhance professionalism in further education*. [Online]. Last accessed 16 January 2014 at: <http://www.esrc.ac.uk/my-esrc/grants/L139271007/read>.
- Goodrham (2006) The place of research in FE professionalism must be protected. In I. Nash, S. Jones, K. Ecclestone & A. Brown (Eds.), *Challenge and change in further education: a commentary by the teaching and learning research programme*. London: Teaching and Learning Research Council.
- Hodgen, J. (2011) *Knowing and identity: a situated theory of mathematics knowledge in teaching*. In T. Rowland & K. Ruthven (Eds.), *Mathematical knowledge in teaching*. Dordrecht: Springer/Kluwer.
- Kaye, D. (2002) Defining numeracy. In J. Evans, P. Healy, D. Kaye, V. Seabright & A. Tomlin (Eds.), *Proceedings of the 9th International Conference of Adults Learning Mathematics (ALM9): policies and practices for adults learning mathematics - opportunities and risks*.
- Kaye, D. (2010) Defining numeracy - the story continues. In H. Christensen, J. Diez-Palomar, J. Kantner, & C. Klinger (Eds.), *Proceedings of the 17th International Conference of Adults Learning Mathematics (ALM): maths at work - mathematics in a changing world*.
- Kirk, G. (2011) It's not craft or profession. Teachers without both skills will be a walking disaster. [Online]. *Times Educational Supplement*, 11 February 2011. Last accessed 09 January 2014 at: <http://www.tes.co.uk/article.aspx?storycode=6069934>.
- LLUK (2007a). *New overarching professional standards for teachers, tutors and trainers in the lifelong +learning sector*. London: LLUK.
- LLUK (2007b). *New overarching professional standards for teachers, tutors and trainers in the lifelong learning sector: application of the standards for teachers of mathematics (numeracy)*. London: LLUK.
- Loo, S. (2007a). Theories of Bernstein and Shulman: their relevance to teacher training courses in England using adult numeracy courses as an example. *Journal of Further and Higher Education*, 31 (3), 203-214.
- Loo, S. (2007b). Learning to be teachers of adult numeracy. *Journal of Education for Teaching: International Research and Pedagogy*. 33 (4), 425-440.
- Lucas, N. (2007). The in-service training of adult literacy, numeracy and English for Speakers of Other Languages teachers in England; the challenges of a 'standards-led model'. *Journal of In-Service Education*, 33 (1), 125-142.
- Lucas, N., Casey, H., Loo, S., McDonald, J., Young, M. & Giannakaki, M. (2004) *New initial teacher education programmes for teachers of literacy, numeracy and ESOL 2002/3. An exploratory study*. London: NRDC.
- Lucas, N., Casey, H., Loo, S. McDonald, J., Sagon, O. & Koutsoubou, M. (2006). *Towards a professional workforce: adult literacy, ESOL and numeracy teacher education 2003-5*. London: NRDC.
- Lucas, N., Loo, S. & McDonald, J. (2006). Combining 'subject knowledge' with 'how to teach': an exploratory study of new initial teacher education for teachers of adult literacy, numeracy and ESOL for Speakers of other languages. *International Journal of Lifelong Education*, 24 (4), 337-350.
- Ma, L. (1999). *Knowing and teaching elementary mathematics*. Mahwah, NJ: Lawrence Erlbaum.
- National Centre for Excellence in the Teaching of Mathematics. *Teacher enquiry funded projects*. [Online]. Last accessed 10 January 2014 at: https://www.ncetm.org.uk/enquiry/funded-projects/funded_projects_tefp.
- National Research and Development Centre for Adult Literacy and Numeracy. *Practitioner-led research initiative*. [Online]. Last accessed 10 January 2014 at: <http://www.nrdc.org.uk/content.asp?CategoryID=512>.
- Ofsted (2003). *The initial training of further education teachers: a survey*. London: Ofsted.
- Sheffield Hallam University (2013). *Subject knowledge enhancement (SK1) secondary mathematics education*. [Online]. Last accessed 25 July 2013 at: <http://www.shu.ac.uk/prospectus/course/1061/>.
- Shulman, L. S. (1986). Those who understand: knowledge growth in teaching. *Educational Researcher*, 15 (2), 4-14.
- Skemp, R. (1976). Relational understanding and instrumental understanding. *Mathematics Teaching*, 77, 20-26.
- Stevenson, M. (2008) Profound understanding of fundamental mathematics: a study into aspects of the development of a curriculum for content and pedagogical subject knowledge. In M. Joubert (Ed.), *Proceedings of the British Society for Research into Learning Mathematics*, 28 (2).

- Stone, R. and Griffiths, G. (2006). What should pedagogy for adult numeracy consist of? Or it ain't what you do but the way that you do it. In V. Seabright & I. Seabright (Eds.), *Proceedings of the Adults Learning Mathematics (ALM) 13th Annual International Conference: crossing borders – research, reflection and practice in adults learning mathematics*.
- Swan, M. (2005). *Standards Unit – improving learning in mathematics: strategies and practices*. Nottingham: DfES Publications.
- Vorderman, C. (2011) *A world class mathematics education for all our young people*. Last accessed 20 January 2014 at: <http://www.nationalnumeracy.org.uk/resources/15/index.html>.