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Feedback, talk and engaging with learners

Formative assessment in adult numeracy

Research report

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In memory of Cathy Magee, dedicated teacher-researcher on this project, who died in January 2009.

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Executive summary

This project focused on the development and evaluation of teaching strategies for formative assessment in numeracy. It was a collaborative project involving King's College London researchers working with a team of teacher-researchers.

A design research methodology was adopted to address the following research questions:

- How can formative assessment best be devised for and successfully incorporated into adult numeracy teaching?
- What are the best methods and materials to use whereby formative assessment can be incorporated into normal adult numeracy classroom activities?

In comparison to other educational interventions, the research evidence on the efficacy of formative assessment is impressive, yet there is little research on how formative assessment can be implemented in adult numeracy settings.

The research raised a series of issues and challenges for implementing formative assessment in adult numeracy settings:

- organising classroom talk given the particular fragmentary mathematical knowledge and experiences of adult learners;
- fostering peer- and self-assessment;
- working with English for Speakers of Other Languages (ESOL) learners;
- the particular problems of embedded numeracy;
- using individual learning plans (ILPs);
- the use of representations and tools;
- using summative assessment formatively.

It is clear from our evidence that formative assessment practices can yield significant improvements in the quality of classroom learning in the teaching and learning of numeracy with adult learners. Many of the formative assessment techniques developed in other educational settings and highlighted in the literature on formative assessment transfer very well to adult numeracy classes.

Teachers felt that formative assessment did make a difference to teaching and learning in their classrooms. There were some indications that learners viewed aspects of the approach positively, but the project timescale was too short to fully evaluate the effect on learners and learning.

Formative assessment practices can be developed by teachers if they are given support, feedback and opportunities to learn, extended over several structured training and feedback occasions involving collaboration.

Any policy initiatives aimed at dissemination need to pay careful attention to how this collaboration can be replicated on a wider scale. There is a need for further research investigating how formative assessment can be implemented and disseminated more widely with adult numeracy teachers.

There are particular constraints to implementing formative assessment within adult numeracy, although many of these present opportunities as well as challenges for teachers.

The research identifies a number of strategies specific to adult numeracy that can be disseminated through pamphlets and training.

1. Introduction

This project focused on the development and evaluation of teaching strategies for formative assessment in numeracy. It was a collaborative project involving King's College London researchers working with a team of teacher-researchers. This report describes and evaluates the changes in classroom practice that occurred in the project, particularly those involving the clarification and communication of assessment criteria to learners, and the processes by which this comes about.

The project aimed to devise a research evidence-based teaching approach for adult numeracy learners using formative assessment strategies, and to carry out a trial implementation and evaluation of it.

It addressed the following research questions:

- How can formative assessment best be devised for and successfully incorporated into adult numeracy teaching?
- What are the best methods and materials to use whereby formative assessment can be incorporated into normal adult numeracy classroom activities?

Our definition of formative assessment follows Black and Wiliam (1998b):

> those activities undertaken by the teachers, *and by their students in assessing themselves*, which provide information to be used as feedback to modify the teaching and learning activities in which they are engaged. *Such assessment becomes 'formative assessment' when the evidence is actually used to adapt the teaching work to meet the needs.* (p. 2, original emphasis)

The notion of feedback is central to our definition. It is important to distinguish formative assessment, the assessment *for* learning, from summative assessment, the assessment *of* learning, and from continuous assessment, where work from all stages of the learning process contributes towards the assessment *of* learning. The purpose of formative assessment is to inform teaching and learning rather than solely to record progress. Moreover, our focus here is on formative assessment in the classroom rather than broader (and important) objectives aimed at increasing learner autonomy or involvement. We note also that we believe that summative assessment does have a place in education, but we share Black and Wiliam's concern that, in recent years, there has been too much focus on summative and too little on formative. Of course, assessments designed for summative purposes *can* be used formatively (Black et al. 2003) and we will touch on this issue later in this report. We note also that there are interesting examples of summative assessment tools that are designed both to record progress and to inform learning (e.g. The National Adult Literacy Agency 2004), but a detailed consideration of such tools is beyond the scope of this report.

Materials and methods for teaching using formative assessment strategies with adult learners were devised and evaluated while being implemented. These materials are not included in this report for space considerations, although many are discussed in Section 4. However, our intention is to use these as the basis for

a publication aimed at adult numeracy teachers in the style of the 'Black Box' series on formative assessment in schools (e.g. Hodgen and Wiliam 2006).

The project was funded by the Department for Innovation, Universities and Skills (DIUS) from June 2007 to March 2008 through the National Research and Development Centre for Adult Literacy and Numeracy (NRDC)[1]. It was conducted by a research team of three researchers from King's College London together with a group of five teacher-researchers (see Appendix A for the research team).

From previous research undertaken at King's College London for the NRDC 'Effective Practice in Inclusive Adult Numeracy Teaching' study, we know that formative assessment strategies are rarely seen in Skills for Life provision for adult numeracy learners (Coben et al. 2007), yet there is firm research evidence from the school sector that formative assessment is an essential component of classroom work and that its development can raise standards of achievement. Indeed, Black and Wiliam, in the first of what became known as the 'Black Box' series, point out that they know of no other way of raising standards for which such a strong *prima facie* case can be made (Black and Wiliam 1998c). Further studies have extended their research (Black et al. 2002, Torrance and Pryor 2001), including in mathematics/numeracy teaching, where Hodgen and Wiliam (2006) offer advice and guidance to teachers on how to develop formative assessment through developing questioning, feedback and self- and peer-assessment in classrooms and implementing formative assessment strategies in a whole-organisation context; other studies concur (see also OECD 2005).

This project built on this work, together with research and development in the NRDC's Maths4Life 'Thinking Through Mathematics' and 'Questioning' projects and in the 'Making numeracy teaching meaningful for adult learners' project, which called for more meaningful forms of assessment to be developed for adult numeracy learners (Swain et al. 2005). In the Maths4Life 'Thinking Through Mathematics' project it was recognised that building on the knowledge learners already have entails developing formative assessment techniques and adapting teaching to accommodate individual learning needs and this is included in the collaborative approach piloted in that study (Swan 2005). This project extended this work.

We focused on supporting teachers to implement formative assessment because, while we know that it is central to learners' progress, it is also very demanding of teachers. Changes in classroom practice are central to its effectiveness so, as Black and Wiliam point out, the accomplishment of formative assessment means changing pedagogy (Black and Wiliam 1998b). Also, as a recent review of research commissioned by the Qualifications and Curriculum Authority (QCA) noted, there is a need to raise teacher awareness of what formative assessment is, why formative assessment is important and how it can be incorporated into teaching and the important role learners can play (McCallum 2000). The national context exerts a powerful influence on whether formative assessment is practised. In particular, National Tests and teachers' preparation for these divert teachers towards mainly convergent systems of teaching (something which we also found in the NRDC Numeracy Effective Practice study). The QCA review states that consequently there is a need to raise the status of formative assessment in the eyes of teachers and enlighten them about

[1] NRDC is dedicated to conducting research and development projects to improve literacy, numeracy, language and related skills and knowledge. NRDC was established in 2002 by the predecessor of DIUS, the Department for Education and Skills (DfES), as part of Skills for Life, the national strategy for improving adult literacy and numeracy skills in England. See www.nrdc.org.uk for further information.

divergent approaches to assessment to enable them to distinguish ‘teacher assessment’ (done summatively in advance of National Tests) from ‘formative assessment’, a continual process which implies power being ceded to the learners to take control over their own learning (McCallum 2000, p.14). This project equipped teachers to undertake formative assessment with learners, to monitor their progress in implementing formative assessment strategies and to assess the effect on learners’ progress. Our hypothesis was that teaching using formative assessment strategies would support adult learners in making progress.

2. The background to formative assessment: evidence and guidance from research

In this brief review of the literature, we first consider the research evidence on formative assessment in general, then the literature relating to adult learning, and in the process we examine the guidance on implementing formative assessment in mathematics and numeracy. We note first however, that, as is often the case, much of the literature on formative assessment is set within the context of schools and, hence, applying this to adult education requires a degree of recontextualisation.

2.1 The literature on formative assessment

The value of formative assessment in raising attainment was highlighted in the UK through the work of Black and Wiliam (1998a), although formative assessment has a long history in education dating back at least to the 1970s (Bloom et al. 1971). From an extensive review of the literature focusing on the evidence from teachers in school or college classrooms, Black and Wiliam (1998a) concluded that 'Several studies show[ed] firm evidence that innovations designed to strengthen the frequent feedback that students receive about their learning yield substantial learning gains'. A number of other reviews internationally support these findings (e.g. Natirello 1987, Nyquist 2003). Black and Wiliam highlight a number of strategies, including: the value of increasing the proportion of higher-level questions i.e. questions that require the learner to think rather than recall facts or procedures (Burton et al. 1986); increasing the wait time i.e. the time a teacher pauses after asking a question (Askew and Wiliam 1995); and the use of feedback, including comment-only marking i.e. without marks or grades (Butler 1988). As part of the dissemination process, Black and Wiliam (1998c) subsequently summarised this review in a pamphlet, *Inside the Black Box*, aimed at teachers, in which they outline a number of broad characteristics of formative assessment, including:

- the use of rich and challenging tasks;
- the quality of classroom discourse and questioning;
- the quality and use of feedback;
- the sharing of learning criteria with pupils;
- use of self-assessment and peer-assessment.

Of particular note for adult numeracy is their finding concerning the benefits of formative assessment for student motivation and self-esteem.

In comparison to other educational interventions, the research evidence on the efficacy of formative assessment is impressive. In an extensive meta-analysis study Hattie (1999) found that interventions involving feedback are more effective than any other educational intervention with an effect size of 1.13[2]. (See also,

[2] Meta-analysis combines the effects of a number of studies. Effect sizes are commonly used to evaluate the practical impact of educational initiatives and interventions. As a rule of thumb, Cohen (1988) classed effect

Hattie and Timperley 2007.) Wiliam (2007) calculates that, for the achieved effect size, the cost of formative assessment is lower than that for any other educational intervention in comparison.

However, Black and Wiliam (1998a) found that, whilst the benefits of formative assessment can be established in principle, the approach is poorly described in practice. In order to examine *how* teachers could implement formative assessment in practice, a two-year research and development project was conducted in six secondary schools, involving 48 teachers in all, across English, mathematics and science. Known as the King's-Medway-Oxfordshire Formative Assessment Project (KMOFA Project), the researchers worked closely with teachers giving them time to reflect, to develop their practice and offering them practical ideas to enable them to begin implementing these new practices into their own teaching (Black et al. 2003, Black and Wiliam 2003).

In recognition that generic strategies on their own are not enough, a number of booklets have been published subsequently, giving subject-specific advice. These include *Mathematics Inside the Black Box* (Hodgen and Wiliam 2006), in which, for example, the authors argue that:

> providing opportunities for students to express, discuss and argue about ideas is particularly important in mathematics … Through exploring and 'unpacking' mathematics, students can begin to see for themselves what they know and how well they know it. By listening to and interacting with pupils, a teacher can provide feedback that suggests ways in which pupils can improve their learning. (p.5)

It is important to emphasise that the formative purpose of classroom talk is not for the teacher to *know* what the learners themselves know, but rather to inform and promote learning. We note that literature exploring the nature of rich classroom talk and how to facilitate it is abundant e.g. Alexander (2006), Blatchford et al. (2006), Mercer et al. (2004) and Van Lier (1996).

In an examination of how to integrate formative assessment in mathematics teaching and learning, Wiliam and Thompson (2007) identify five key strategies:

- clarifying, understanding and sharing learning intentions;
- engineering effective classroom discussions, tasks and activities that elicit evidence of learning;
- providing feedback that moves learners forward;
- activating students as learning resources for one another;
- activating students as owners of their own learning.

Despite the widespread take-up of formative assessment, a number of studies highlight the difficulties of implementing formative assessment and suggest that often the ideas have been understood in limited and procedural ways (e.g. Hodgen 2007, Marshall and Drummond 2006, Smith and Gorard 2005, Watson 2006). Drawing on the teacher development work of the KMOFA project (Lee and

sizes as follows: 0.2 = small; 0.5 = medium; 0.8 = large. Often, in education, an effect size of above 0.3 is regarded as having potential practical significance. Hattie's (1999) was a meta-analysis of meta-analyses involving in all around 180,000 studies. Interventions involving feedback produced the largest effect size of any educational intervention that Hattie considered.

Wiliam 2005), Hodgen and Wiliam (2006) argue for the importance of teachers' collaboration in overcoming this:

> … responding in the moment to pupils' ideas – is very complex … teachers in the KMOFA Project found collaboration – sharing, talking about and reflecting upon questioning with other teachers – to be a valuable way of increasing their repertoire of questions and their ability to use these questions in the classroom. (pp.15–16)

2.2 The literature on formative assessment in adult learning

Little research has been published into the use of formative assessment with adult learners in the UK. Two major research projects into the use of formative assessment with adult learners are notable of mention. In the UK a national three-year project 'Improving Formative Assessment' was undertaken between January 2005 and January 2008 by the NRDC, the Universities of Brighton and Exeter, the Learning and Skills Development Agency (LSDA) and the National Institute of Adult Continuing Education (NIACE). The project evaluated how the principles of formative assessment developed in the compulsory schooling sector could be adapted for use in post-14 education (Derrick 2007, Ecclestone 2007). On the basis of an extensive review of the literature conducted for this project, Derrick and Ecclestone (forthcoming) concluded that formative assessment is likely to be more beneficial in adult learning than in other educational settings. In particular:

- any damaging effects of summative assessment processes that can be shown to exist are likely to be more potent for these learners;
- any benefits of formative assessment approaches are likely to be more pronounced in relation to these learners. (p.54)

They highlight two aspects of formative assessment:

> first … practices and activities in which the purpose is to produce evidence for the planning of future learning and/or for constructive feedback and review … Secondly, formative assessment can take the form of learning activities which aim to develop the autonomy of the learner. (p.54)

They conclude by highlighting a number of messages for teachers from the research, which include:

- structure learning … [as] dialogue between themselves and their students, and between students;
- feedback, whether verbal or written, should focus on the task rather than the person;
- summative assessment processes can be utilised to produce benefits for formative purposes. In general, this involves finding ways to get students to 'get beneath' and 'go beyond' the bald results of the summative assessment processes and try to understand how they work and reflect on what they mean;
- create an atmosphere in which students are willing to take these risks;
- self-assessment and peer-assessment should be central elements of all learning situations, and in particular, students should be encouraged critically to evaluate the decisions and assessments of the teacher;
- encouraging learners to develop, discuss and evaluate their own assessment criteria and assessment materials, as well as collectively

designing 'perfect' answers, will at the same time help them understand and critique the language of official assessment criteria;

- collaborative discussions, tasks and activities, organised around conceptual obstacles, including disagreement and debate, rather than predominantly individual and more or less silent working, can have benefits for many learners;
- improving confidence in learning is a key aim of most adult students, who are generally highly-motivated to learn … assessment of learning can help develop motivation, confidence and autonomy, which may produce further benefits in terms of citizenship;
- balance the short-term demands of summative assessment with a view to addressing the needs of learners in the longer term. (pp.56–60)

The OECD's Centre for Educational Research and Innovation (CERI) recently carried out a two-year international study 'What Works in Innovation and Education: Improving Teaching and Learning for Adults with Basic Skills Needs through Formative Assessment' (Spring 2005 to Autumn 2006). The study aimed to:

> address significant gaps in understanding of 'what works', for whom and under what circumstances, and will identify policy levers to improve the quality of provision for this population[3].

As part of this work, participating countries were invited to prepare background reports on the current state of teaching and assessment techniques for adults with basic skills needs within their own country. Information is available from seven countries: Australia, Denmark, England, New Zealand, Norway, Scotland and Spain. The reports indicate that in most countries the use of formative assessment with adult learners is not well developed and there are often no formal policies for its implementation.

The report for England (OECD 2006) observed that there was no formal government policy on formative assessment in adult basic skills and noted that whilst it was recognised that the profession needed valid, reliable and manageable instruments for assessing adult literacy and numeracy, these did not exist. The authors also noted that there was no history in adult basic education of using the term 'formative assessment' and that any formal kind of assessment was a new area. Not surprisingly therefore, until recently, formative assessment practices have had a low profile. The report does, however, note that there has been some development and that formative assessment is a regular item on the agenda of policy and research communities. It evaluates two recent initiatives related to formative assessment, 'Planning Learning and Recording Progress and Achievement' (PLRA) (Grief 2004) and the 'Recognition and Recording of Progress and Achievement' (RARPA) project (LSC 2005). One criticism of these initiatives is that they are judged by teachers and learners to take a significant amount of time away from instruction. The report recognises that there are many priorities, not least of which is summative assessment, which too often is the overwhelmingly dominant preoccupation, leading to 'teaching to the test'. As the authors point out, England still has some way to go. A key imperative arising from the OECD study is to identify ways in which formative assessment strategies can be integrated within teaching and learning.

[3] See: www.oecd.org/dataoecd/35/23/35687039.pdf

In one of the few published papers specifically examining adult numeracy, Swain et al. (2006), worked with six adult numeracy teachers to develop formative questioning techniques. They suggested that teachers should use a variety of question types, including challenging, uncovering thinking and playing devil's advocate. Teachers began to realise that they needed to think carefully about the questions they asked, they needed to give learners the time to answer and be able to act upon their responses in order to move learning on. They also recognised that it was they, not the learners, who were doing most of the asking, and that as a result some learners felt overloaded. Teachers also came to understand that the learners needed to be encouraged to ask more questions both to the teacher and to each other. However, learners do not just suddenly begin to ask questions but need to be given a structure within which to work (Swain et al. 2006).

To date most published work on the use of formative assessment in adult education, has focused on how formative assessment can be best carried out based on development work carried out in the formal educational contexts of schools. This project was aimed at taking this work forward by exploring ways that formative assessment techniques can be used within the context of adult numeracy teaching, given the great diversity in terms of provision and learner population within this sector of education.

3 Research design and methods

This was a practice-focused project, building on basic research on formative assessment by developing and evaluating teachers' formative assessment strategies in their adult numeracy teaching[4]. The project adopted a design-research methodology (Kelly 2003)[5]. A central feature of the design was to collaborate with a group of teacher-researchers following a model established in previous research on formative assessment (Black et al. 2003, Black and Wiliam 2003) and in other NRDC studies.

In order to address the research questions, the project had two principal elements, which ran concurrently following initial input from the research team:

- developing and describing teaching strategies for formative assessment in adult numeracy teaching, including identifying formative assessment strategies that the teacher-researchers were already using;
- investigating how formative assessment could be implemented in adult numeracy settings.

A further (and subsidiary) objective was to evaluate the effect of formative assessment strategies on adult numeracy learners and the response of teachers to a more explicit use of formative assessment strategies.

The research was carried out by a team consisting of three academic researchers together with five trained teacher-researchers[6] [see Appendix A]. The fieldwork was conducted over three months from September to December 2007. The teacher-researchers were identified through King's College London's extensive network of adult numeracy contacts; two (Cathy MaGee and Mark Baxter) had been teacher-researchers on other NRDC/King's College London adult numeracy studies. Given the project's development aims and tight timescale, the teachers were deliberately chosen as 'telling cases' (Mitchell 1984) to be effective teachers who were already using some aspects of formative assessment, particularly rich questioning and talk, in their classrooms. In addition, they were chosen to encompass a range of adult learner groups (including parents, students on vocational courses and ESOL learners) and rural, suburban and urban settings (Oxfordshire, an outer London borough and an inner London borough). (See Appendix B for profiles of the teacher-researchers and Appendix E for details of their classes.)

The teacher-researchers were required to attend three collaborative training and feedback days between September and the end of November 2007. These

[4] This project complements a Sheffield project, also funded by the NRDC, on improving the quality of teaching and learning of reading (Burton et al. 2008). The literacy project arises from the Effective Practice studies, and particularly from the University of Sheffield/NRDC reading study (Brooks et al. 2007), which highlighted, *inter alia*, that certain strategies, which research suggests might be effective, were rarely seen in adult literacy classrooms. Three of these approaches were selected: phonics, oral reading fluency and sentence combining.

[5] Design research is aimed at 'support[ing] arguments constructed around the results of active innovation and intervention in classrooms. The operative grammar, which draws upon models from design and engineering, is generative and transformative. It is directed primarily at understanding learning and teaching processes when the researcher is active as an educator' (Kelly 2003, p. 3).

[6] In the original design it was intended to work with six teacher-researchers. However, as the project began in July 2007 when FE college courses were finishing for the year and many teachers were uncertain of their teaching commitments for the following academic year, only five were recruited.

meetings were designed to introduce them to formative assessment techniques, give them the opportunity to share ideas, and design and refine formative assessment materials and teaching methods that would be suitable for use with adult learners (see Appendix C for a detailed breakdown of the foci and content of these meetings). The materials and methods were then trialed and implemented in their classrooms and evaluated by them. The three training days also provided the opportunity for the teacher-researchers to exchange their experiences of using formative assessment techniques within their own classroom, in order to inform their future teaching. They kept research diaries in which they recorded the activities and learners' responses, and which helped them reflect on what was happening in their classroom in terms of their own teaching and the learners' experience. They were also involved in revising the final training materials for dissemination. Our original intention was to focus on one mathematical topic, the teaching and learning of place value. In the event, the teachers developed formative assessment in other curriculum areas as well in response to the learning needs of their students.

The research was based on approximately 50 lessons, of which 13 (23 hours) were observed by the academic researchers. Interviews were carried out with all five teacher-researchers and with seven learners from four classes (see Appendix D for further details of the interview questions and Appendix E for descriptions of the research settings/classes observed).

3.1 Ethical considerations

We followed the ethical principles of the British Educational Research Association (BERA 2004) and the project was conducted in line with King's College London's ethical procedures and requirements. Informed consent was obtained from all teachers and learners involved.

4. Formative assessment in adult numeracy: themes and issues

Our work was closely informed by the research evidence outlined in Section 2. As we expected, the teacher-researchers implemented many of the key strategies identified in the research literature, including wait time, using higher-order questions and giving feedback. This work raised some issues and challenges for implementing formative assessment in adult numeracy settings:

- organising classroom talk given the particular fragmentary mathematical knowledge and experiences of adult learners;
- fostering peer- and self-assessment;
- working with ESOL learners;
- the particular problems of embedded numeracy.

We consider three further issues more briefly:

- individual learning plans (ILPs);
- the use of representations and tools;
- using summative assessment formatively.

At the end of each section, we identify a series of strategies to promote formative assessment.

4.1. Classroom talk and formative assessment in adult numeracy

Davies (2005) uses the term 'spiky profiles' to describe how many adult learners are often 'strong in some skills, but not others' and suggests that while such 'learners [are] in a better position than those who needed to improve their skills across the board, they [are] still at a disadvantage because their lack of skills in some areas could prevent them from reaching their full potential' (p.10). This mix of strengths and weaknesses creates particular problems for formative assessment in adult numeracy. The following cases illustrate this:

> Learner A was having difficulty with multiplying: 7×4.5. His initial response was 28.5 [$7 \times 4 + 0.5$]. When talking the problem through, he appeared to use some strategies very well indeed. So, for example, he could multiply 7 by 4 by doubling and doubling again, and he could halve 7, although he initially appeared to have difficulty 'recalling' these strategies. Other ideas he found very difficult, for example, he did not appear to understand the equivalence of 7×4 and $7 \times 3 + 7$ or 7×4.5 and $7 \times 4 + 7 \times 0.5$.

[MB[7], Lambeth College, Electro-technical Technology C&G 2330, Level 2 Embedded Numeracy, Topic: Long multiplication]

Learner B was calculating 389 × 100. After reading the calculation aloud correctly, he looked at it for a considerable period of time (approximately 2 minutes), then he broke 389 into hundreds, tens and units aligning them vertically, then he wrote 30,000, 8000 and 900 quickly, aligning the numbers correctly:

389 ×100

300×100 =	30000
80×100 =	8000
9×100 =	900
	38900

Learner B, then, said, 'Is that [30,000] three thousand … three hundred thousand … thirty thousand?' He could read 38,900 as 'three, eight, nine, zero, zero', but not as thirty-eight thousand nine hundred. The procedure used here is similar to the kinds of expanded methods promoted by the National Numeracy Strategy. Given Learner B's age [approximately 25], it seems likely to us that this procedure had been taught to him relatively recently in a previous adult numeracy class rather than at school. Clearly, he had learnt this procedure very well, but he had great difficulty understanding (or even reading) the large numbers involved or describing how he had carried out the procedure. The topic of the session, however, was concerned with a technique for dealing with very large (and very small) numbers, for example, writing 38,900 as 3.89×10^4.

[MB, Lambeth College, BTeC Electronics First Diploma, Level 2 Embedded Numeracy, Topic: Standard form]

Both these learners demonstrate strengths and weaknesses in their mathematical knowledge. However, whilst we concur with Davies' aim to move away from a 'deficit model' of adult learning by emphasising learners' strengths as well as weaknesses, we suggest that a spiky profile does not quite capture the difficulties that these learners (and their teachers) face. Rather than being strong in some skills, these learners' knowledge about one particular concept, or 'knowledge package' (Ma 1999), seems to us to have both strengths and weaknesses. For Learner A, this related to multiplication, whilst Learner B appears to know how to carry out a procedure very well, but has only a very limited understanding of large numbers. In our view, both learners' knowledge is better described as *fragmentary* or *partial*. For us (and the teacher-researchers that we worked with), these notions not only convey the particular problems many adult learners face mathematically but also suggest strategies that might help them overcome these difficulties. In order to fill in the 'gaps', these learners need to build on their strengths, develop alternative approaches and make mathematical connections. This approach is not new to adult numeracy and such an approach to teaching and learning is described in some detail in several NRDC publications (e.g. Swain and Swan 2007). However, both learners were learning mathematics that in some sense built upon 'gaps' in their fragmentary knowledge: for Learner A, long multiplication, and, for Learner B, standard form. Assessing this fragmentary knowledge is essential to making formative judgements about the next steps in teaching and learning: how to work on

[7] These (and others like them after quotes hereafter) are the initials of one of the teacher-researchers. See Appendices A and B for full details

aspects of Learner B's partial understanding of large numbers alongside teaching standard form to the whole group. A crucial formative approach is to devote time during sessions to observing and listening to students doing mathematics in order to make judgements about what students know and how to help them take the next steps in learning. In order to do this, teachers need to create a classroom culture where learners feel confident and safe in expressing their ideas.

4.1.1. Encouraging learners to talk about mathematics

One way of encouraging talk is to set up activities that *require* learners to talk. *Thinking Through Mathematics* (Swain and Swan 2007) covers such strategies in some depth. But the problem faced by Learner A and Learner B's teacher goes deeper: both these learners had difficulty even beginning to express themselves mathematically. In the words of another teacher, '*beginning* to be able to explain own work to others' is a crucial first step (ML, Reflective writing, our emphasis). The teachers in our study used several approaches to encourage learners to begin this process of talking during classroom activities. Learner A and B's teacher encouraged learners to raise questions during group discussions, e.g. 'How did you get that?', 'I've seen that before', 'Does that mean …?'. He also encouraged learners to talk amongst themselves, a strategy that led to learners raising further questions. Another teacher encouraged her students as a group to discuss whether they remembered any of these ideas from previously, e.g. 'Yes, ish, I sort of remember that'. Another technique that she used was to encourage learners to talk to each other:

> The teacher had asked learners to generate a problem involving fractions.
> Learner: I don't know how to get a fraction
> Teacher: That's good that you've worked out you don't know something. Talk to the person next to you. They might know how to do it.
> [SR, Abingdon and Witney College, Level 2 Numeracy Course, Topic: Ratio, proportion and percentages]

As this teacher comments, talk has several purposes: not only does it enable teachers to assess learners, it enables learners themselves to assess themselves. One way of facilitating talk amongst peers is to identify something they need to talk to each other about.

In another class, the teacher encouraged learners to respond to each other's ideas:

> Learner 1: I can't divide 360 by 9.
> Learner 2: I take off the zero …
> Learner 1: … and 36 divided by 9 is easy, 4.
> [CM, Croydon LA/Tunstall Nursery, Family Numeracy/Healthy Eating, Level 1/2, Topic: Ratio and proportion]

Learner 2's partial strategy works only in certain circumstances (multiples of 10), although there are connections to the standard division algorithm and the partitioning of numbers. What we feel is important here is that the teacher provided a space for another learner to suggest an idea. The teacher, then, had more opportunity to listen to both students and consider her next intervention

which was directed at asking students to think where else they could use this strategy.

4.1.2. Keeping talk going: questioning, pausing and listening

One way to foster talk and discussion is through *questioning*. Actually doing this in practice is tricky, because it requires the teacher to listen to the learners in order to decide what questions (and other interventions) to use. One teacher reflected on this:

> [I was asking] quick firing questions such as '8 lots of 7' and then '56 divided by 7' and as it continued [I was] hoping that the learners could see some connection between the multiplication and division questions. However, no one volunteered this info until I specifically asked them, what do you see between the division and multiplication questions, why do you think I have asked you these questions? [ND, Reflective writing]

As this teacher highlights, learners cannot 'guess what's in the teacher's head', they need guidance about what the teacher is interested in. In this case, explicitly asking students about the teacher's questioning strategy encouraged the students to consider how 8×7 and $56 \div 7$ might be connected.

Learners can be encouraged to talk to each other in order to compare answers or to identify for themselves where they have made a mistake. A class were doing long division using the grid method and the 'traditional' method which they were familiar with. The teacher tells the learners:

> … talk to [your] partners and see if you've got the right answers, I don't want the answers, just to know why you got the answer … to consider why you got it wrong in the first place and how could you have corrected it … why did you miss it, how can you try and avoid it in the future?
>
> [ND, Croydon LA/Archbishop Lanfranc School, Entry level 3 to Level 1 numeracy/Supporting Asian families, Topic: Multiplication]

Learners may be asked to say why they think someone worked out a calculation in a certain way. A class of ESOL learners were looking at easy ways to work out 19 + 56. One learner shows how she did it on the board:

19 + 56 =
19 + 50 = 69
69 + 6 = 75

Whilst another comes up and writes:

20 + 56 = 7
76 – 1 = 75

Teacher: Why did she do it like this, why did she add 20?
Learner: It's another one.
Teacher: Is it a nicer number? … added on to 20 and take away one.

[ML, Croydon LA/Archbishop Lanfranc School, Entry level 2 to Entry Level 3 Numeracy/Numeracy and ICT, Topic: Addition]

A key formative strategy, as this teacher highlights, is to encourage learners to assess and evaluate each other's methods and ideas – doing this enables learners to better understand what they themselves 'know'.

Another related strategy is to say less in order to encourage the learners to say more. In the following excerpt of classroom dialogue, the teacher and learners were discussing an aspect of an article on Religion (see Appendix F):

Teacher: What I'd like to work out is how many people there are in the UK … I've just realised we can work it out. … How could we work it out? … We know two in five adults say prayers and 20 million say they pray.

PAUSE

Learner: It's only adults over 18.
Learner: Yes.
Teacher: Oh yes, well can we work out how many adults there are in the UK?

PAUSE

Teacher: We know two in five adults say prayers and 20 million say they pray.

Teacher writes up '2 : 5'

Learner: Is it 7?

Teacher writes up "is it 7" on board.

Learner: 2 to 5
Learner: Is it a ratio?
Teacher: 2 to 5, is it a ratio? [Teacher writes this on board.]

PAUSE

Learner: 2 to 3

TEACHER WRITES UP '2 to 3'

PAUSE

Learner: The 5 is everyone.
Learner: So it's 2 to 3.
Learners: Yes [They don't sound wholly convinced].
PAUSE

Learner: 40%.
Teacher: You could work it out as a percentage ... you just said it.

PAUSE

Learner: 40%.
Teacher: I'm intrigued how you've done it.

Learner: So am I.
[SR, Abingdon and Witney College, Level 2 Numeracy Course, Topic: Ratio, proportion and percentages]

In this section of dialogue, the teacher has discovered a great deal about the learners' mathematical understandings – as have the learners themselves. The teacher's central teaching concern was the relationships at the heart of this ratio problem[8]. Rather than correcting or answering the questions, 'Is it 7?' and 'Is it a ratio?', the teacher writes these up. This strategy, together with leaving pauses for students to respond, allows the learners to talk through the mathematical ideas themselves, thus working out that 'the 5 is everyone', that the ratio is '2 to 3' and contributing the further idea of 40%.

By saying less the teacher has allowed the students to say more and thus reveal more about their mathematical understanding. Davis (1997) refers to this as *interpretive listening*, listening to *what* students say in order to figure out *why* and *what* to do next. Davis contrasts this to the more commonplace practice in mathematics classrooms of *evaluative listening*, where teachers ask questions to which they already know the 'correct' answer and typically give short evaluative feedback to learners' responses[9].

The teacher in the example above was actually interested in using a discussion to find out how these learners understood mathematics. As she commented later, 'Perhaps the implication for adult numeracy is for us to become better listeners' [SR, Reflective writing]. Indeed, towards the end of the extract, rather than a question, she declared her interest in the statement, 'I'm intrigued how you've done it'. The learner's response, 'So am I', indicates to the teacher that the learner needs some support in articulating her method. Typically, in mathematics classrooms, teachers exhort learners to 'Show your working', but fail to communicate why this is important. In the example above, the teacher's statement encourages the student to express an interest in her 'working', a strategy that we believe to be very much more engaging than is the norm in adult numeracy classrooms (or mathematics classrooms more generally). This framing of teaching and learning as a joint collaborative exercise is far from easy to put into practice. One teacher commented in his reflective writing about students' expectations:

> I'm not sure that teenagers know what to expect when they come into a vocational school and I suppose we could reverse that and say colleges do not know what to expect of teenagers when they come to college. Again, EL/L1/L2 students have just come out of ten years of being unsuccessful academically. They are still faced with a lot of sitting down, theoretical classes and not just literacy and numeracy. [MB, Reflective writing]

Students' previous experiences of mathematics classrooms are very often of being 'unsuccessful academically' and involve 'a lot of sitting down'. They will have very limited previous experiences of talk and dialogue in mathematics. Changing such expectations takes time.

[8] The relationships can be expressed as a ratio of 2:3:5 or 20 million adults who pray: 30 million adults who do not pray: 50 million adults altogether.
[9] The teachers in Davis' (1997) study responded 'Almost', 'Nearly' to partially correct responses, then gave clues or made the question 'easier' in order to elicit the correct response.

4.1.3. Dealing with 'difficult' questions: Creating thinking-time for teacher and learners

Classroom talk places considerable demands on the teacher. One way of coping with this is the strategy that we have discussed above of 'saying less, listening more'. This enables a teacher not only to listen to learners' responses but also to think about *how* and *whether* to respond. But adult learners can and do ask some difficult and unexpected questions. During the classroom observations for this study, we have seen learners say emphatically and repeatedly that they do not understand and doing so very much more persistently and forcefully than would be the case in school settings. In part this is because the teachers in this study encouraged this kind of talk. However, responding to these demands is not straightforward. In the Religion[10] activity discussed above[11], for example, learners said repeatedly, 'It doesn't add up. … That's 34 million.[12]' Responding to this, a teacher has to consider not only *what* the learners do not understand but also *how* they do not understand. One strategy for addressing this is for teachers to make time to think *during* sessions. In this case, a two-hour session, the teacher used a tea break to consider how to respond. This 'thinking-time' had an additional benefit in that two of the learners continued working on the problem and one said:

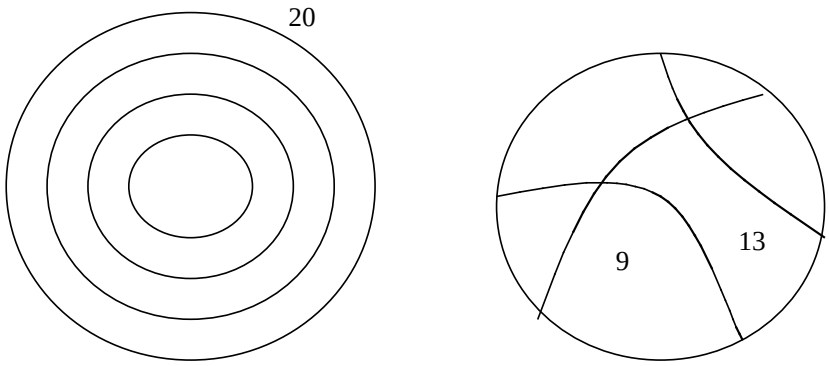
> The 12 million who pray every week includes 9 million that pray every day … So there's 3 million people who don't pray every day … But it still doesn't add up.[13]"

The teacher restarted the session by beginning to draw a Venn diagram, provoking a response from another learner:

> Teacher draws 4 concentric circles.
>
> Teacher: It's easier if you put the 20 million at the outside.
> Learner: No, it's easier if you put the 20 in the middle.
>
> Learner comes out to board and draws a diagram that appears to be some form of partially remembered frequency/Venn diagram [See Figure 1].
>
> Learner: You draw a circle and divide it up like this. Then you put the 9 here, that's the 9 million that pray every day and then you put the 13 here. … I'm not sure how to finish it off.
> Learner: It still doesn't add up.
>
> At this point the Teacher [SR] decided to leave this activity and move on to something else.

[10] See Appendix F for a copy of this article.
[11] The extracts are drawn from this lesson: SR, Abingdon and Witney College, Level 2 Numeracy Course, Topic: Ratio, proportion and percentages.
[12] The students appeared to interpret '20 million Britons aged over 18 who say they pray, 13 million do so at least once a month, 12 million every week and 9 million every day' as describing non-inclusive relationships. So, their calculation was as follows: 13 million + 12 million + 9 million is equal to 34 million not 20 million. Hence, 'It doesn't add up'. Since the 13 million who pray monthly includes those who pray weekly and those who pray daily, a 'correct' calculation would be: 9 million [pray daily] + 3 million [pray weekly but not daily] + 1 million [pray monthly but not weekly] + 7 million [pray less often than monthly] = 20 million [Britons over 18 who pray].
[13] She had not extended this to the 13 million who pray every week. So, her revised (written) calculation was 9 million + 3 million + 13 million = 25 million. Hence, 'it still doesn't add up'.

Figure 1: The Teacher's and the learner's partially competed Venn diagrams[14]



The teacherÕs Venn diagram Learner CÕs diagram

There are several points of interest here. First, we note the learner's willingness to interrupt the teacher and suggest her own approach. Whilst the learner's actual explanation was rather unclear, allowing learners to do this encourages learners to articulate their understandings of mathematics and, thus, enables formative assessment. Second, the learner was willing to make a partial and potentially incorrect suggestion. Third, in our view, this extract highlights how encouraging learners to talk creates difficulties for the teacher: it is not immediately clear how this learner is thinking. The teacher's think-time enabled her to generate a potential diagrammatically-grounded explanation of the inter-relationships, but she needed more time to think through what was difficult for these learners. Finally, the strategy of leaving a problem to consider in another session provides the opportunity for further think-time for the teacher. Indeed, a similar issue happened later in the same session when two learners suggested that 30% was equal to 1/30: the teacher responded by writing this on the board as 'something to ponder' for next week.

This article on religion was an extremely rich task. After observing the session and in discussing this and other sessions with the teacher-researchers, we identified two issues for further exploration and evaluation. The first issue relates to the choice and design of examples. The religion example here was far from straightforward and the information was presented in a complex and somewhat 'messy' form. Problems like this (containing redundant, insufficient and apparently contradictory information) are extremely valuable pedagogically (Boaler 1993; Lave 1992). However, Zaslavsky and Zodik (2007) demonstrate how the particular examples that teachers use help or impede learning. The second issue relates to classroom discussions. All the teacher-researchers that we worked with had, in planning for formative assessment, devoted a significant amount of time to planning questions to use with learners. However, it became clear that organising classroom discussions involves more than questions. Hence, the teacher-researchers will explore strategies for planning discussion and talk for formative assessment.

4.1.4. Dealing with irregular attendance: fostering dialogue across sessions

In all the sessions that we observed for this study, significant numbers of learners were absent, whilst in several sessions new students attended unexpectedly. In

[14] The teacher's and the learner's diagrams are actually very similar, although the learner's diagram contains the 'inclusion' error discussed here. See Appendix F for further information.

one session, an entirely different group of learners turned up, whilst a planned one-to-one session did not take place because the learner did not attend. Whilst this unpredictable level of attendance is far from unusual in adult numeracy classrooms, it does present particular challenges for teachers in creating a classroom environment conducive to formative assessment. One strategy is to formatively assess students quickly through discussion. For example, in the session to which a different group of students arrived, the teacher (MB) had been expecting to teach fractions, but spent the first ten minutes of the lesson negotiating with the group what they needed help with (multiplication):

> Are you all all right with area of a triangle? Don't shout out the answer. I want the whole area. The rectangle is 3 by 4 … 3.5 by 4.5.
>
> [MB, Lambeth College, Electro-technical Technology C&G 2330, Level 2 Embedded Numeracy, Topic: Long multiplication]

As a result, he quickly moved on to written methods for long multiplication, identifying learners' difficulties with calculations involving 3-digit decimals (for example, 3.14×6.25)[15]. The size of the group (five learners) made this quick assessment relatively straightforward.

In most of the sessions that we observed, the teachers and learners discussed and referred back to previous sessions and forward to future sessions. Mercer (2007) argues that this temporal activity is a key element in creating and maintaining classroom dialogue. For example, learners in a family numeracy class[16] were looking at how to adjust the ingredients in a recipe for a smaller number of people. One learner quickly worked out the answer using ratio, something that she 'remembers' learning how to do on a previous course.

But irregular attendance mitigates against this. Hence, an issue that we have identified for further exploration is ways of fostering this by creating narratives across sessions: encouraging learners to tell those who were not present 'what we have talked about last session and what questions and problems we considered' as opposed to what was 'learnt'.

Strategies to encourage classroom talk

- Say less, listen more.
- Listen interpretively rather than evaluatively to learners.
- Identify problems 'to ponder' for a later session.
- Use a variety of interventions, including (but not only) questions.
- Show interest in all learners' responses whether incorrect, partially correct or correct.
- Make space for teacher thinking-time during sessions.
- Choose and plan the examples used in class.

[15] One learner, Learner A discussed above, worked separately to the main group.
[16] CM, Croydon LA/Tunstall Nursery School, Level 1/2,Healthy Living, Topic: Ratio and proportion.

4.2. Peer- and self-assessment: using students to facilitate learning and teaching

As we noted in Section 2, Black and Wiliam (1998a) highlight the importance of peer- and self-assessment. We now examine how this can be enacted and used in adult numeracy settings.

> After a whole class discussion explaining standard form [writing, for example, 389 to 3.89×10^2], Learner C was attempting a worksheet on the topic. The first question asked him to expand powers of 10 (e.g., write 10^3 as 1000). He had successfully and quickly done 10^3 and 10^2 but was stuck on 10^6. When asked how he had worked out 10^3, he said, 'I just know that's a thousand'. With help 'that [10^6] is a way of writing $10 \times 10 \times 10 \times 10 \times 10 \times 10$', he calculated $10 \times 10 \times 10 \times 10 \times 10 \times 10$ using a calculator. As he did so, he counted the tens, 'one, two …' getting 1,000,000, but had difficulty reading the display. Prompted, he asked another learner, Learner D, who had successfully written 10^6 as 1,000,000 and could read this as 'one million' and explained that he knew this was 'one with six noughts. Look you do this by looking at the 6, then writing 1 with 6 zeros'. Learner D had expanded 10^8 incorrectly as 1,000,000,000,000 and said that this was 'lots of noughts. It's just a blur'. Learner D continued with the worksheet and was able to correctly convert 3- and 4-digit whole numbers into standard form. Learner C did not complete the powers of 10 question.
>
> [MB, Lambeth College, BTeC Electronics First Diploma, Level 2 Embedded Numeracy, Topic: Standard form]

> The teacher [MB] is explaining how to convert 3286 into standard form.
> Learner E: Why are you saying 3?
> Learner F: I think of that as three thousand first.
> Teacher: So do I. [Surprised]
>
> [MB, Lambeth College, Electrical installation, Level 2 Embedded Numeracy, Topic: Standard form]

It is extremely important for a teacher to know both Learner C and Learner D's difficulties in order to teach this lesson on standard form. Indeed, had the teacher known this, he might have tackled the lesson very differently, perhaps even focused on a different topic. At the same time, these two learners did talk and help each other during the lesson[17]. Indeed, asking them to compare each other's different methods for solving the problem could have enabled both learners to better understand powers of ten. Learner D's procedural approach appeared to be based on only a limited understanding of powers of ten, whereas Learner C's calculator method was inefficient but based on better understanding. The value of peer discussion is that it enables learners to assess and compare their own and other's strengths and weaknesses. This in turn enables learners to articulate and extend their mathematical understandings.

We found unexpected contributions from learners to be relatively commonplace in the sessions that we observed. For example, in one Healthy Eating session,

[17] This lesson took place in a computer room. In many ways, this was far from ideal as a learning environment, but some of these limitations may actually be used advantageously. For example, the learners were arranged around the edge of the room allowing them all to see each other. As a result, the learners talked to each other during the discussions. All the talk we observed was 'on task' and was encouraged by the teacher.

the teacher had anticipated, on the basis of past experience, that the learners would have difficulty with metric measures. In the event, only one found metric measures problematic, whilst most had some difficulties with imperial measures. This provided an opportunity for the learners to work out for themselves the benefits of the metric system. In a family numeracy class, where most were ESOL learners, learners were categorising and ordering metric and imperial measures according to distance, length, capacity and weight. Some learners were familiar with metric measures, others with imperial measures, from their school days. Working in groups, they shared their knowledge and were able to complete the activity successfully, something that they might have found more difficult had they worked alone.

The second vignette[18] illustrates for us two important benefits of formative assessment. First, Learner F's contribution is valuable for developing Learner E's understanding. Learner F's focus on 'three thousand first' highlights not only a technique for converting numbers to standard form but more significantly provides a potential focus on standard form, the 'order' of numbers and how standard form enables very large and very small numbers to be dealt with effectively and efficiently[19]. Rather than being a 'problem', the very different levels of understanding evident in many adult numeracy classes can actually be an advantage: without different degrees of understanding (including partial ones) organising a rich discussion is difficult. In this case, both learners benefited: Learner E through Learner F's contribution; Learner F by articulating his own mathematical understanding.

Second, Learner F's contribution appears to have enabled the teacher (MB) to understand his own methods better. Teachers can and do learn from learners. In this case, we discussed the incident with the teacher after the lesson and his surprise was genuine. However, it can be useful to act 'as if' surprised in order to value learners' ideas and contributions. Indeed, one important feature of this teacher's classroom culture was that he appeared to value and encourage learners' contributions, questions and interruptions. It is important to recognise that acting 'as if' in this way requires time and perseverance. The formative assessment research from schools suggests very strongly that teachers' planned 'mistakes' can be a very valuable focus for learning. Actually carrying this out is tricky. This teacher found, for example, that the first time he tried this strategy, the learners did not notice the error.

There are many difficulties in adult numeracy teaching, including the sometimes sub-standard learning environment and the at times great variation in learners' mathematical understandings. We do not seek to diminish the very real difficulties that adult numeracy teachers have to contend with. Nevertheless, all the teacher-researchers that we worked with in this project found ways to turn (some of) these constraints into affordances.

[18] Note, although observed on the same day, these are different sessions; Learners E and F were from a different adult numeracy group to Learners C and D.
[19] This in turn is related to Learner D's difficulty: large numbers become 'a blur'.

Strategies to encourage peer- and self-assessment

- Encourage leaner's questions, contributions and 'interruptions'.
- Use 'planned' teacher mistakes, recognising that this cultural change takes time.
- Record and value learners' ideas.

4.3. Formative assessment and talk in ESOL classrooms

In this section, we consider the general issue of encouraging mathematical talk in English for Speakers of Other Languages (ESOL) classrooms, then consider ways of valuing ESOL learners' experiences and working with translators.

4.3.1. Encouraging mathematical talk in ESOL classrooms

ESOL creates significant challenges for the implementation of formative assessment. A central theme in formative assessment is to 'banish the quiet classroom' and encourage learners to talk (Harrison 2006). Yet, if talk itself is the problem, then talking mathematically presents additional challenges. One teacher-research summed up these difficulties in describing one of her lessons:

> Because they found the first lesson difficult … very new and strange. … In the next lesson, I did it a different way. … I used Venn diagrams. They were not language dependent … they have language problems but they are intelligent and they know what to do with them and finally you could start to have discussions around that, talking about people's understanding. So doing a different activity for multiples of 2 and 3, they were more comfortable with the activity … it was a new idea but not completely new … They found the language very difficult. … I showed the learners statements about the 2, 5 and 10 times tables and asked them to talk in pairs about whether the statements were correct or incorrect. … Group discussion is always hard [so I] gave them one piece of paper between two [so] they had to talk … Assessing what they're doing is difficult. It looked like the learners were using reasoning to classify the statements. … I could see they were writing things down and pointing to things, but I couldn't understand what they were saying. It's very difficult because you're looking for cues other than language really as to what they understand, I do find that difficult: how we can get feedback. [ML, Interview]

One strategy, as highlighted by this teacher, is to try using the strategies that are used generally to promote formative assessment. Fostering talk in general is difficult; it is just more difficult in ESOL settings. For example, this teacher-researcher encouraged learners to talk by giving them one piece of paper between two and introduced a 'new … but not completely new' idea, building on the previous lesson. Another is to observe what the learners do: their non-verbal activity. Another approach, again highlighted by the teacher-researcher, is to identify mathematically challenging activities that are not constrained by issues of language. For example, two of the learners described the previous lesson's

number square activity as 'useful but easy', in contrast to the teacher-researcher's assessment of 'difficult' and 'very new and strange'[20]. One possible extension is one the teacher-researchers themselves tackled (and found both challenging and enjoyable) during a training session: to complete a number square jigsaw, in Urdu, and to identify the missing number.

This teacher-researcher described her approach to formative assessment as follows:

> trying to find out about their understanding, you're encouraging them to talk to each other, to talk to you … it relies on you engaging with people. [ML, Interview]

The identification of formative assessment with engagement and the encouragement to talk is important. Hence, another strategy that the teachers have found effective is to encourage learners to talk in a language other than English. For example, in another classroom, we observed a pair of learners collaborating and offering mutual support and benefit[21]. In this instance one learner's English was relatively strong, whereas the other's mathematics was relatively strong. The former learner was part-translating the teacher's questions, part-translating the latter learner's ideas, whilst the latter learner appeared to be challenging the other learner's mathematics.

4.3.2. Making connections: using and valuing ESOL learners' experiences

The teacher-researchers that we worked with believed that adult learners in general, and ESOL learners in particular, have experience that can be used 'as a resource to support each other' [ML, Interview]. Making connections to these experiences is important:

> … relating it to some real life situations and I'd brought in some menus from home that they could actually refer to and I wanted them to work out the VAT and how much that would be …. What they would do and talk about the different maths involved in that and again they tried to do that for themselves. They were divided into groups and had the choice of menus and the best thing was they worked out the VAT and they worked out how much it would be and they used the doubling and halving method. [ND, Interview]

This connection to 'real life situations' can be useful in adapting and tailoring questions to meet the needs of learners. For example, reflecting on her use of questions, the same teacher-researcher commented:

> Why do you think we estimate? What happens when we go shopping? How do you know that you have enough money to spend? [Because] one person stated she never did this as her husband did the food shopping [and] another stated she always used her credit card, other prompts had to be used: How would you check/feel confident if your answer was correct or not? What processes could you use? [ND, Reflective writing]

[20] This mismatch highlights a very real difficulty for the teacher. Although the two learners appeared to find the activity difficult, it may be that the task was not difficult mathematically, but rather the difficulty might be linguistic and cultural. It may be as one learner said to us: 'maths is not [the] problem … some things in English is understanding'. Alternatively, the learners may not understand what sort of answer is expected of them. Pinpointing the actual difficulties is likely to take time and to involve a range of assessment strategies, including observation of the learners' mathematical activity.

[21] CM, Croydon LA/Tunstall Nursery, Family Numeracy/Healthy Eating, Level 1/2 Embedded Numeracy, Topic: Ratio and proportion.

Again, the formative assessment strategies that the teacher-researchers used in ESOL classrooms were not *different* – they were tailored to and by the learners' needs.

4.3.3 Working with translators: communicating with and listening to learners

According to one teacher-researcher having a translator in class could be a 'mixed blessing':

> [It's] helpful [because] she's able to explain to learners what I'm saying [but it is] difficult to know whether she is telling learners what to write rather than helping that person to know [why] they needed to write that number. [ML, Interview]

Translators are not mathematics teachers and translators and, like some classroom assistants, may find some aspects of mathematics problematic themselves. So, just as they do with classroom assistants, teachers need to work with the translators to help them understand the mathematics in order to effectively 'translate' it mathematically. Hence, resources for working with classroom assistants can be useful here (e.g. Aplin 1998).

We have identified a number of relatively well-known mathematical language issues, affecting both learners and translators. For example, in Tamil, some mathematical terms do not translate easily and there appear to be only very formal and mathematical terms for some of the more informal terms that are used in mathematics learning in English. When practising adding and subtraction word problems on the computer, two learners repeatedly got the answer to the following problem 'wrong': 'Emily has 25. Catlin has Emily's and 26 more'. The translator also got the 'incorrect answer': neither she nor the learners understood that 'more' in this context signified addition. Similar confusions related to the terms 'least' and 'counting on'. We note that learners in non-ESOL mathematics classrooms face similar difficulties. Once these difficulties have been identified they can provide an opportunity for discussion.
In the classrooms that we have seen, translators have largely translated the teacher's questions and explanations. Our discussions with teachers suggest that an alternative approach would be to ask the translator to act as the teacher's 'listener', listening to learners and communicating their ideas back. In this scenario the translator becomes a bridge spanning the gap between the language, which acts as a barrier to learners, and the teacher, who is trying to assess the level of learners' mathematical understanding. Such a role is a demanding one, particularly as it runs counter to translators' expectations of classroom roles.

Strategies to encourage formative assessment and talk in ESOL classrooms

- Use challenging activities, some of which are not constrained by language.
- Encourage learners sometimes to talk in languages other than English.
- Observe learners' non-verbal as well as verbal activity.
- Plan for translators in the classroom, just as for classroom assistants.
- Investigate ways of encouraging translators as classroom listeners.

4.4 Formative assessment in embedded numeracy classes

In two of the settings in which the teacher-researchers worked numeracy teaching was explicitly 'embedded': a Family Learning course on 'Healthy Eating' and a series of Electrical Engineering/Electronics courses. On the Family Learning course, numeracy was fully integrated into the Healthy Eating course. In contrast, for the Electrical/Electronics Engineering learners, numeracy is studied alongside their other courses. Hence, these courses are best classed as 'partially embedded' on the NRDC 'embeddedness' scale (Casey et al. 2006, p.14) because, from the learners' perspective, the numeracy was separate from, although applied to, the vocational element of their course. We present two 'vignettes' from our observations of these classes to exemplify how formative assessment can be used in these contexts.

In a family numeracy session as part of a Healthy Eating course, the learners had two public information leaflets about healthy eating: one is a version of the 'Eatwell Plate'[22] showing food categorised into starchy foods, fruit and vegetables, meat, etc; the companion sheet showed how to use 'portions' to create a balanced diet. The discussion was centred around the bread, rice, potatoes, pasta and other starchy foods: the sheet indicated that a healthy diet should include 6 to 11 'portions' of pasta and that a portion of pasta is about 15 grams dry weight, which is approximately equivalent to a heaped tablespoon of cooked pasta by volume; the pasta packet recommends 75 to 100 grams dry weight per person; the teacher has cooked 100 grams dry weight of pasta and rice.

Learner:	So they're saying that these are one portion, so during a day you can have 6 to 11 portions of that [carbohydrates] … That hardly weighs anything [rice] … That's only 25 grams. … I think you can eat as much rice as you like and pasta has more energy.
Teacher:	… but beware, each of these was 100 grams before it was cooked and it's got a lot heavier… So you need to know how much the dry weight is. … 75 to 100 grams as a main course. … Do you want to find out how many portions that would be?
Learner:	So you just divide by 15 to get 5.

[22] See: www.eatwell.gov.uk/healthydiet/eatwellplate/

Teacher: That's a mathematical way.
Learner: I'll measure it out [uses a tablespoon to measure pasta].
Teacher: It's good to do different ways, the maths way and the practical approach.
Learner: 5 [calculated by division by 15 using dry weights].
Learner: 4 and half [measured by volume using cooked pasta].
Teacher: … so this supermarket is recommending 5 portions for a meal.

[CM, Croydon LA/Tunstall Nursery, Family Numeracy/Healthy Eating, Level 1/2, Topic: Ratio and proportion]

We note the complexity of the apparently simple mathematics, in particular, 'portion' has two *different* and *contradictory* meanings: a relatively small non-standard and 'semi-official' 'healthy eating' unit, and a relatively large helping in more 'everyday' usage. Whilst this distinction may seem 'obvious', it is far from obvious in the fast-moving and busy environment of a Family Learning setting. Indeed, very often, as happened in this case, such distinctions only become clear through talking with learners. It occurred in the *moment* of the classroom. A further issue relates to the expectations of the course and the teacher: one of the aims of the Healthy Eating course was to enable learners to gauge the make-up of a balanced meal by eye or by non-standard measures (e.g. a handful). As a result, the teacher-researcher appeared to be expecting *all* the learners to measure the cooked pasta out by volume, just as Lave's (1988) slimmers did in *Cognition in Practice*, and as two of the learners did. Instead, the division question was solved quickly and correctly by the learner, using a standard mental arithmetic method (75 divided by 15) – and this took the teacher-researcher by surprise. Elsewhere in the session, this learner had demonstrated a very good intuitive, 'everyday' feel for size in other contexts (e.g. measuring and estimating the amount of chicken needed for a meal). So, this 'formative assessment moment' could have an opportunity for a discussion about different methods:

- are five and four and a half the same?
- why give both measures?
- which is more appropriate when?

We note in passing a further complexity in embedded settings: the combination of different learning aims. These learners had identified a variety of learning objectives in their ILPs (e.g. to know how to help their children), whereas the course was directed at encouraging healthy eating and the teacher-researcher had an additional aim to identify and interest anyone needing more intensive adult numeracy courses. The questions highlighted above are appropriate to all these aims. However, these competing objectives demonstrate the problem for teachers: making the most of often fleeting formative assessment moments is difficult to do.

The second vignette gives an insight into the potential of formative assessment in a very different setting: an FE college where the teacher was teaching standard form in a very traditionally laid out classroom.

The learners did not recognise 'indices'. As the teacher began writing some up on the board, they said 'Oh yes, powers'.
Teacher: 10 to the power 2 is ten times ten
Teacher writes on the board, starting with 10^2 and finishing with 10^1

$10^4 = 10 \times 10 \times 10 \times 10 = 10000$
$10^3 = \quad 10 \times 10 \times 10 = \quad 1000$

$10^2 =$ $10 \times 10 =$ 100
$10^1 =$ 10

Learner: But you wouldn't say that one, would you [10^1].

Teacher: You would in standard form. That's what standard form means. It's writing the number: [writes: ___. ._____ x10]. There's no 10s and hundreds and thousands [i.e., in SF] 10 to the power zero. This is important. I'll come back to explain this later.

Learner 1: It's 1 because there's no zeroes

Teacher: 10 to the power of minus 1 is 1 over 10 to the power of 1, which means 1 over 10, which equals 0.1. It means one-tenth. Could you write these down 'cos I'm going to keep returning to them. … 10 to the power of minus 2 is 1 over 10 to the power of 2, which means 1 over a hundred, which equals 0.01. It means one-hundredth.

Teacher writes on the board below:

$10^{-1} = 1/10^1 = 1/10 = 0.1$
$10^{-2} = 1/10^2 = 1/100 = 0.01$

Learner 1: We've got a sheet on this… [He produces sheet, see Figure 2, on SI conversion, from Electrical Installations class].

The other learners agree with Learner 1 that they have seen this before.

[MB, Lambeth College, Electrical installation, Level 2 Embedded Numeracy, Topic: Standard form]

Figure 2: SI unit conversions

Prefix	Symbol	Multiple	Number
tera-	T	1.0×10^{12}	1,000,000,000,000
giga-	G	1.0×10^{9}	1,000,000,000
mega-	M	1.0×10^{6}	1,000,000
kilo-	k	1.0×10^{3}	1,000
base unit	-	1.0×10^{0}	1
deci-	d	1.0×10^{-1}	0 · 1
centi-	c	1.0×10^{-2}	0 · 01
milli-	m	1.0×10^{-3}	0 · 001
micro-	u	1.0×10^{-6}	0 · 000 001
nano-	n	1.0×10^{-9}	0 · 000 000 001
pico-	p	1.0×10^{-12}	0 · 000 000 000 001

First, we note that the teacher has discovered through discussion that there is a problem with different terms ('indices'/'powers'). Our main point, however, relates to how Learner 1 makes a connection between the numeracy work on standard form and the work on measures elsewhere on their Electrical Installation course. Typically, teachers 'tell' learners about such links and, of course, making connections explicit is important. But creating opportunities for learners to identify links for themselves is very powerful. There are, indeed, interesting contrasts in how the information is presented by the teacher and in the SI conversion sheet: for example, only particular powers are presented on the SI conversion sheet. It is also clear that the learners are expected to tackle rather larger powers than they are considering in the session[23]. This incident highlights an important aspect of embedded numeracy. Typically, learners are thought to 'learn' mathematics, then transfer and apply it in other contexts. In contrast, Learner 1 has highlighted connections in how mathematics is used and presented in the 'numeracy' and 'applied' settings. Hence, an alternative approach to 'transfer' is to examine how mathematics is translated and adapted in different contexts (Evans 2000).

Fostering 'formative assessment moments' like the ones discussed above is crucial, but this creates two additional tasks for the teacher: how to notice such moments, and how to make best use of them[24]. One way for the teacher to make the most of the possibilities in both these situations would be to find ways to notice such formative assessment 'moments', through planning or through giving oneself time to think during the lesson, and follow them up with the group the next time they meet.

[23] We note that the teacher-researcher's approach here is a familiar one in mathematics classrooms: start from simple situations and progressively make them more complex. This is how standard form is very often taught (with an initial focus on 2-, 3- and 4-digit numbers). The SI conversion sheet highlights *why* standard form is necessary: to deal with very large and very small numbers.

[24] In this case, this was even more difficult. The classroom was very noisy, because it overlooks a large open workshop, where bricklaying and other construction skills are being taught. Hence, just hearing the learners' contributions was hard.

Strategies to encourage formative assessment in embedded settings

- Encourage learners to identify and *discuss* ideas they have met elsewhere: In what ways are these similar? In what ways are these different?
- Follow up ideas in later sessions.

4.5. Individual Learning Plans (ILPs) and Lesson Objectives

In their interviews (30/11/07), the teacher-researchers raised the issue of ILPs and session objectives. All the teacher-researchers valued both ILPs and learning objectives in principle, yet found the actual practice time-consuming, bureaucratic and disconnected from learners' needs. The following comments are typical:

> We have to do the ILPs and they have to write down the lesson objectives. It's a directive from on high.
>
> The ILPs should be a good thing. It's good to think about, but they take a lot of time and time's something we haven't got a lot of. … I think a lot about my students and what they need.
>
> [Teacher-Researcher Interviews]

The learners agree: for example, the learners' own 'learning objectives' are typically very different from what might be expected as 'numeracy learning objectives'[25]. It is very difficult to establish a meaningful and shared learning objective before learning has taken place. Bereiter (1985) refers to this as the learning paradox: how can one talk about what one does not already know? Yet, we know from the formative assessment literature that all too often learners have very little idea of *what* and *why* they are 'learning' something and how important the sharing of learning objectives with learners is (Black and Wiliam 1998a). Our own work elsewhere suggests that one effective approach is the sharing of learning objectives via a process of negotiation with learners during the process of learning (Hodgen and Marshall 2005). As one of the teacher-researchers suggests:

> I used to take the evaluation sheets back at the end of each week but what I've asked them to do is, and this started since the formative assessment project started, was for them to take their ILPs home and evaluate this or reflect upon what they have learnt after they had learned, after they had gone away from my session, they've got a whole week to bring it back … what did they find difficult? That works quite well because they haven't got me saying, 'Did you learn this? Did you think this?' because they've had a chance to learn about it for themselves and they come back with questions for me to ask

[25] For example, 'I want to be able to help my granddaughter with her maths homework.'

or they've evaluated that lesson, because they've had a chance to evaluate that session, because they've had a chance to reflect upon it and within that week they've actually used it with their children or somewhere when they're shopping or whatever. [ND, Interview]

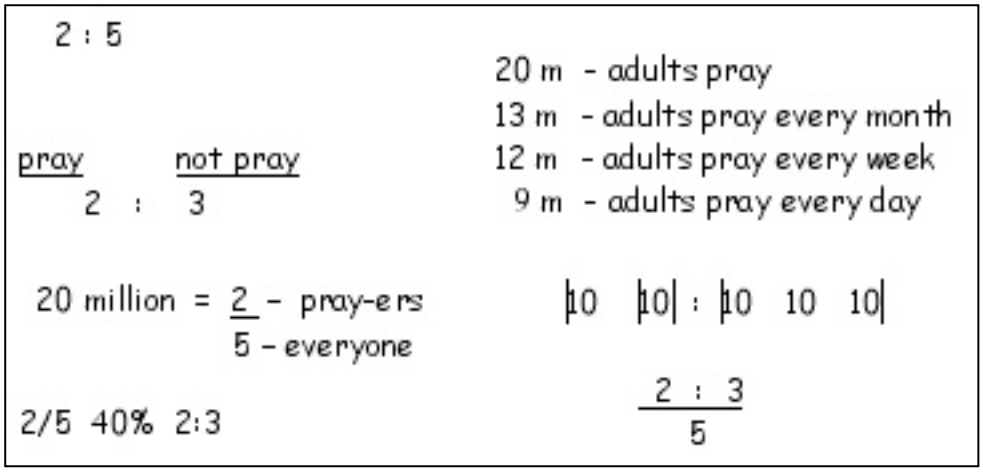
Strategies to make use of ILPs and learning objectives

- Recast the lesson objectives as thinking points. For example, rather than 'standard form', highlight a question: 'Write numbers in standard form?'
- Discuss the lesson objectives part-way through a session, or at the end of a session.
- Negotiate the lesson objectives during the previous session.
- Construct narratives across sessions. Discuss what went on at the beginning and end of sessions. Rather the 'what we have/are learning today', focus on what we have talked about today, what questions and problems have we considered?

4.6 Using representations and tools

One of the striking things about the adult numeracy classes that we have observed is the richness of the representations used by teachers and learners to communicate and support their mathematical ideas. At times, the classroom whiteboard has presented a very full but complicated set of representations. The following is typical:

Figure 3: Representations to illustrate a ratio of 2:5



Making connections is key to learning mathematics (Swan and Swain 2007). Yet, this not only takes time but places demands on the teacher. We have seen a number of potentially valuable strategies. For example, one teacher urged her learners to 'be messy and use lots of space', whilst another encouraged her learners to solve problems diagramatically, thus generating representations.

A further issue is the use of calculators. Calculators are often discouraged because they cannot be used in the National Tests, whilst learners do not feel that they are 'proper maths'. Yet calculators, as we have discussed above, can be a useful formative tool. Learners' expectations are contradictory on the issues of calculators, as one teacher-researcher commented:

> [One learner said to me], 'It's good you are making us do the basics x/divide. I went through school using a calculator and I don't know anything. My aunt is 78 and she knows everything. She will never use a calculator. She helps a 15-year-old nephew with GCSE. He can't understand that someone so old can know everything. … Your brain dies if you don't use it. [But] Teenagers [say], 'why can't we use a calculator?' [and] Hairdressers [say], 'You use a calculator in the real world'.
>
> [MB, Reflective writing]

Strategies to make use of representations and tools

- Give students time to talk through and articulate their understanding of representations. Does it make sense? Can you explain it? What could I use/recognise? Are these saying the same thing?
- Investigate ways of encouraging students to explore and use representations that have arisen during sessions (in order that they can assess their mathematical value).
- Use concept mapping, revisiting concept maps over the year.

4.7 Using summative assessments formatively

Given the timescale for this project, there has been limited time to explore the formative use of summative tests. However, several of the teachers explicitly discussed summative assessments. For example, one teacher-researcher regularly asked her students to construct problems they might encounter in the numeracy test[26]. Learners found this process of question generation difficult and, in particular, they found adapting questions to 'make them harder' problematic. Other teacher-researchers highlighted several tensions concerning summative testing:

- preparing learners to use mathematics in real life *and* to pass the numeracy tests;
- using calculators in class *but not* in the numeracy tests (see above).

However, whilst the issue of summative assessment is of great importance, our suggestions here are more tentative.

[26] SR, Abingdon and Witney College, Level 2 Numeracy Course, Topic: Ratio, proportion and percentages.

Strategies for using summative assessment formatively

- Investigate ways to enable learners to generate and adapt numeracy tests questions.
- Encourage students to develop mark schemes.

5. Is formative assessment effective in adult numeracy classrooms?

In this section, we examine the views of teacher-researchers and learners as to whether formative assessment was effective in adult numeracy settings. A note of caution is necessary in that the timescale of this project is very short for any significant change in teaching and learning practices to take place. The teacher-researchers, for example, largely focus on two aspects, the potential for formative assessment to affect learning and teaching and the ways in which it was encouraging them to re-think their practices. Nevertheless, for these teacher-researchers, formative assessment appears to have resulted in some actual practical changes even over the brief timescale of the project, specifically relating to increases in the amount of learner talk taking place.

5.1. The teacher-researchers' views

The teacher-researchers all felt that formative assessment would make a difference to teaching and learning in their classrooms. However, all saw it as a continuation of their existing practices rather than as something fundamentally new and different. This may reflect our choice of teacher-researchers. So, for example, one teacher commented,

> I have had a gradual change of attitude in learners. Learning feels as if it has shifted from getting the right answer, getting it as quickly as possible (and shouting it first) to becoming a process where all the group is involved in learning (rather than finishing stuff, getting things done, out of the way). [ML, Reflective writing]

One teacher saw formative assessment as a focus for implementing the kinds of 'good practice' in teaching practices promoted by the NRDC and others:

> At the beginning of the project I was perplexed as to what was new about formative assessment because it seemed to me that this was what we had all been exhorted to do. But on reflection I suppose that although it is what we are supposed to do, for various reasons it is not what we actually do. I think that to help us (tutors and students) be more formative assessors what we need are activities that support this. I have found the Standards Units box and the NRDC [Thinking Through Mathematics] materials useful for this. But what is then needed is effective reflection on what the information gathered in means. [SR, Reflective writing]

The first part of this quote makes an important point; formative assessment is an approach to pedagogy in which feedback is central. The last point is also crucial: assessment only becomes formative 'when the evidence is actually used to adapt the teaching work to meet the needs' (Black and Wiliam 1998c).

For all the teachers, the project provided a focus for considering particular aspects of teaching and learning. Several found developing questions and questioning to be valuable. All focused on the needs of particular groups of learners. For example, ESOL learners:

> [I have] investigate[d] the reasons why my ESOL students were having trouble understanding the meaning of the words 'area' and 'perimeter'. In the BSA Initial Assessment paper that we use the students have to calculate the perimeter of the play area. This should be rewritten as 'find the perimeter of the playground'. Thus avoiding the necessity of students having to manipulate the meanings. [ND, Reflective writing]

Initially, several of the teacher-researchers teaching family numeracy felt that implementing formative assessment during these courses would be difficult, because of the short timescale of courses. However, implementation had significant benefits:

> [In] Family Learning when time is short, you tend to just launch into a series of topics, teaching them to a wide variety of people at different levels of learning and sometimes hoping that you've pitched it about right. I have found in some cases now, leaving parents to find out how to tackle a problem, they can teach each other how to do it. This can then cut down on my teaching, as well as giving some the opportunity to refresh their own knowledge. [CM, Reflective writing]

One teacher felt that working with younger adults created particular difficulties:

> Anecdotally we expect adults to be more conservative in their expectations of a teacher's methods. Is this because we are thinking teenagers are articulate A-level students? Looking at Skills for Life students, I would say adults are more open to newer alternative methods. Teenagers, even those coming in at Level 2, have bad experiences of learning and lack of achievement. I would say most of my effort goes into 'crowd control', by which I do not mean shouting down noisy behaviour but by conversation and activities, building up self-confidence and interest in the topic. Even if they are noisy, they are not confident at giving answers in class especially with years of experience of wrong answers. Teenagers are more likely to say 'Tell me' and 'Can we have the worksheets now?'. [MB, Reflective writing]

Implementing change is not easy, as one teacher-researcher comments when considering introducing more think-time during sessions:

> Does this mean altering the pace of the lesson to give the tutor time to consider? It is difficult to reflect to order, there being something unpredictable about insight. So although I like the idea of taking a bit of time out of the class to consider what the students have just said, I wonder if it would just raise my anxiety levels. Maybe it is a matter of getting used to it. [SR, Reflective writing]

5.2. The learners' views

As is typical amongst adult numeracy classes, all the learners that we spoke to spoke very highly of their teachers (Coben et al. 2007). They valued the teacher-researchers' explanations:

> Her learning style is nice and I can find it easy and I can understand her style. She told us about kind of big matters in maths. I understand and I find it quite easy. [Learner Interview]

Learners found some aspects of formative practice useful. One learner referred to one teacher-researchers' practice of comparing learners' methods and responses positively: 'Before, my answer is wrong [now] this answer different' [Learner Interview], whilst another commented after a session discussing different approaches: 'Brilliant! I enjoyed it'. Several learners valued the opportunity to work and talk with other learners:

> She gives us a lot of time to, she thinks we want more time to explain and work together then to work ourselves but sometimes we using time ourselves alone … she thinks if you learn, discuss in two or three in a group, it's good for you, thinking is good. [Learner Interview]

Finally, whilst we emphasise that our conclusions are tentative, we note that they concur with findings of the Improving Formative Assessment project (Derrick 2007).

6. Key findings

Formative assessment practices, as described here, can yield significant improvements in the quality of classroom learning in this sector. Many of the formative assessment techniques developed in other educational settings and highlighted in the literature on formative assessment transfer very well to the adult numeracy classes (e.g. Derrick and Ecclestone forthcoming, Hodgen and Wiliam 2006). We have identified a number of strategies that are particularly appropriate to adult numeracy, which are summarised at the end of this section.

Teachers felt that formative assessment did make a difference to teaching and learning in their classrooms – and that in the long term the benefits would be significant. There were some indications that learners viewed aspects of the approach positively, but the project timescale was too short to fully evaluate the effect on learners and learning.

Formative assessment practices can be developed by teachers if they are given support, feedback and opportunities to learn, extended over several structured training and feedback occasions involving collaboration. Minimally, if teachers are to incorporate more formative assessment, they will need additional structured planning time, particularly in the early stages of implementation. We note, also, that a central feature of our research design was the collaboration between teachers and between teachers and researchers and that there is a great deal of research highlighting the strengths of such an approach (e.g. Black and Wiliam 2003, Spillane 1999). Any policy initiatives aimed at dissemination need to pay careful attention to how this collaboration can be replicated on a wider scale. We note that the teacher-researchers with whom we worked were chosen specifically as effective teachers. Hence, given these were carefully selected teachers, there is a need for further research investigating how formative assessment can be implemented and disseminated more widely with adult numeracy teachers.

There are particular constraints to implementing formative assessment within adult numeracy, although many of these present opportunities as well as challenges for teachers and we have identified a number of strategies to overcome these constraints:

- The combination of (often) fragmentary knowledge and previous mathematical history of learners makes fostering talk and discussion challenging. On the other hand, the greater life experience of adult numeracy learners, by comparison with other learners, creates formative assessment opportunities.
- Adults appear to be much more willing than school students to say persistently that they do not understand. This places significant demands on adult numeracy teachers' subject and pedagogical content knowledge. We have seen adult numeracy teachers being asked much harder questions than KS3 and KS4 teachers are generally asked in school.
- The scope for developing formative assessment strategies over time is limited in Family Numeracy courses which last from 6 to 10 weeks. This is exacerbated by the irregular attendance of some learners. On the other hand, Family Numeracy provides an ideal context for exploring conceptual understandings by asking learners, 'How would you do this with your child?'.

- Fostering self- and peer-assessment presents challenges for adult numeracy teachers, but this study adds further weight to the evidence that learners themselves can be a resource for learning and the implementation of formative assessment.
- Language can be a major barrier to integrating formative assessment techniques into teaching numeracy in some ESOL classrooms.
- Numeracy classes linked to vocational training courses and other 'embedded' settings offer the teacher particular challenges and affordances for formative assessment through drawing out learners' understanding of their vocational area in practical activities and classroom discussions. On the other hand, these settings provide opportunities for learners to identify connections between mathematics/numeracy and applied settings.
- The irregular attendance of learners in some adult numeracy classes means that the aim of creating a classroom culture is more difficult to achieve.

We have also identified a range of strategies to …

… encourage *classroom talk*

- Say less, listen more.
- Listen interpretively rather than evaluatively to learners.
- Identify problems 'to ponder' for a later session.
- Use a variety of interventions, including (but not only) questions.
- Show interest in all learners' responses whether incorrect, partially correct or correct.
- Make space for teacher thinking-time during sessions.
- Choose and plan the examples used in class.
- Create narratives across sessions.

… encourage *peer- and self-assessment*

- Encourage learner's questions, contributions and 'interruptions'.
- Use 'planned' teacher mistakes, recognising that this cultural change takes time.
- Record and value students' ideas.
- Encourage formative assessment and talk in ESOL classrooms.
- Use challenging activities, some of which are not constrained by language.
- Encourage learners sometimes to talk in languages other than English.
- Observe learners' non-verbal as well as verbal activity.
- Plan for translators in the classroom, just as for classroom assistants.
- Investigate ways of encouraging translators as classroom 'listeners'.

… encourage *formative assessment in embedded settings*

- Encourage learners to identify and *discuss* ideas they have met elsewhere: In what ways are these similar? In what ways are these different?
- Follow up ideas in later sessions.

… make use of *Individual Learning Plans (ILPs) and learning objectives*

- Recast the lesson objectives as thinking points. For example, rather than 'standard form', highlight a question: 'Why write numbers in standard form?'
- Discuss the lesson objectives part-way through a session, or at the end of a session.
- Negotiate the lesson objectives during the previous session.
- Construct narratives across sessions. Discuss what went on at the beginning and end of sessions. Rather than 'what we have/are learning today', focus on what we have talked about today, what questions and problems have we considered.

… make use of *representations and tools*

- Give students time to talk through and articulate their understanding of representations. Does it make sense? Can you explain it? What could I use/recognise? Are these saying the same thing?
- Investigate ways of encouraging students to explore and use representations that have arisen during sessions (in order that they can assess their mathematical value).
- Use concept mapping, re-visiting concept maps over the year.

… use *summative assessments formatively*

- Investigate ways of enabling learners to generate and adapt numeracy test questions.
- Encourage students to develop mark schemes.

Appendix A: The research team

King's College London

Professor Diana Coben (Principal Investigator/Project Director)
Dr Jeremy Hodgen (Researcher/Co-Director)
Dr Valerie Rhodes (Research Assistant)

Teacher-researchers

Mark Baxter (MB)
Neelam Dungarwalla (ND)
Miranda Lewis (ML)
Cathy Magee (CM)
Sarah Richards (SR)

Appendix B: Profiles of the teacher-researchers

Mark Baxter (MB)

Mark was originally an art tutor at an HMP establishment. He occasionally taught some numeracy classes and this increased until he became a full-time numeracy teacher. As well as being a numeracy tutor, Mark has worked in a Basic Education department. He was a teacher-researcher on the NRDC project, 'Teaching and learning common measures, especially at Entry level' (Baxter et al. 2006). He had recently transferred to the Engineering Department of Lambeth College, where he teaches numeracy to prepare students for the National Test as well as supporting the students with the maths that they need for their vocational courses. He is also a Visiting Tutor at South Thames College.

Mark has an A-level Maths qualification and a BSc in electrical and electronic engineering.

Neelam Dungarwalla (ND)

Neelham has been teaching adult learners for five years. She is a Family Learning Co-ordinator and a Skills for Life teacher in the work-based environment for Croydon Adult Learning and Training (CALAT) and for the London Borough of Kingston. She has planned, delivered and developed materials for a variety of courses and workshops for Family Learning. These have included Literacy, ICT, Financial Literacy, Healthy Eating and Numeracy. Most of these courses have taken place in schools but some have been delivered in community centres and libraries.

Neelam is taking up a post as a lecturer (part-time) in the Higher Education Department at Croydon College in January 2008.

She has a Certificate in Education and the Numeracy Subject qualification for teaching adults (Level 4; now equivalent to Level 5 in the new National Qualifications Framework); both qualifications were awarded by London Metropolitan University. She also has a City & Guilds qualification in teaching Basic Skills (C&G 9282) in Literacy and Numeracy (C&G 9281) and a qualification from Kenya in teaching children.

Miranda Lewis (ML)

Miranda trained as a secondary Science teacher and worked in this sector teaching Science, for three years. She subsequently transferred to the Primary sector, where she worked for more than ten years (part of this time as a maths co-ordinator). She has taught adults for almost three years. She mainly teaches short 'Keeping Up with the Children' maths courses for parents and short Family Maths courses for parents and children. She teaches courses for CALAT and Sutton College of Learning for Adults (SCOLA). The course which is included in this project is the first ESOL course that Miranda has taught.

Miranda has studied Maths and Further Maths A-levels. She has a Chemistry degree and PGCE in Physical Sciences. She does not have any adult education qualifications.

Cathy Magee (CM)

Cathy trained as a Secondary History teacher and as Primary teacher. She went into adult education to teach literacy originally. She has been teaching for 17 years, of which 7 years have been spent teaching adults. She was a teacher-researcher on the NRDC project, 'Effective Practice in Inclusive Adult Numeracy Teaching' (Coben et al. 2007) and is currently Family Learning Project Manager at Croydon Adult Learning and Training (CALAT) Centre.

Cathy has a maths O-level qualification.

Sarah Richards (SR)

Sarah has a Montessori Diploma for teaching under-7-year-olds and trained as a Primary school teacher. She also has a TEFL qualification.

She has been teaching adults for about 10 years and has taught from Entry level 2 to Access Maths. She also teaches Psychology A-level and a module on the Foundation Degree for teaching assistants at Oxford Brookes University. She has co-written a pre-school teaching manual for use in Ghana and designed courses for parents in maths and English and on becoming a Teaching Assistant.

Her highest maths qualification is GCSE.

Appendix C: Outline of the three teacher-researcher meetings, September to November

Date	Focus	Content
21/09/07	What is formative assessment? How can formative assessment be used in adult classrooms? Developing formative assessment in the context of place value.	Purpose of formative assessment in education. What the research tells us in relation to: • feedback and marking • listening to students • wait-time • motivation and self-esteem • key strategies/techniques • designing tasks. What is different for adults? Rich questioning, estimating, place value and formative assessment. Sharing of place value activities that teachers had used in the past and discussion on how these could be used formatively.
19/10/07	Reflections on implementing formative assessment in the context of place value and other mathematical contexts. Marking and formative assessment. Identifying constraints and affordances in adult numeracy settings.	Adult learners: • experience of schooling • expectations • cultural differences • working together. ILPs. Working with translators in ESOL classes. Examples of activities from teacher-researchers' lessons. How to develop the examples above formatively. Developing questioning techniques. Marking and feedback: • getting learners to think about what done well, what need to work on • learners talking to each other about their work • learners finding errors in their work • learners writing hard questions. *Inside the Black Box* (Black and Wiliam 1998c), *Working Inside the Black Box* (Black et al. 2002), *Mathematics Inside the Black Box* (Hodgen and Wiliam 2006) books given out and discussed.

30/11/07	Issues arising from classroom observation, and discussion strategies used. Reflection on what is formative assessment in the context of adult numeracy. Emerging findings.	Formative assessment in adult numeracy: • Family Numeracy courses very short • fragmentary knowledge of learners • using learners as resources • language proficiency and the mathematical knowledge of ESOL learners • listening to learners • opportunities for learners to talk through their work • learners having the opportunity to talk about different representations in mathematics • thinking spaces for teacher in the lesson • giving learners time to think about a problem. Emerging findings (affordances and constraints): • language as a barrier for ESOL learners, languages and strategies to cope with this • family numeracy constrained because of time frame but an opportunity to ask learners how they would teach this to their own child • vocational numeracy, drawing out learners' understanding of mathematics in their vocational area • willingness of adults to say that they don't understand creates opportunities for learners to talk about their understanding • irregular attendance and how it makes creating a classroom culture more difficult • combination of fragmentary knowledge and greater life experience provides a barrier and opportunity to teachers. 'Assessment for Learning: 10 principles', (Assessment Reform Group 2002) handed out.

Appendix D: Research instruments

Interview questions and prompts

Teacher-researcher interview

Before the interview tell the teacher that you are going to ask them about a lesson that went well and ask them to bring the planning for that lesson. During the interview you will also ask them to focus on one particular learner, so could they bring a piece of their work to talk about. Could they also bring the learners' ILPs.

Interviewer needs to have a piece of anonymised work to show the teacher.

Lesson
(Focus on lesson plan)
I would like to start by asking you to think about a lesson that went really well.
Can you talk me through what happened in the lesson, what did you do?
Why did you think it went well?
How did the learners respond?
What sort of formative assessment was involved?
What kind of questions did you ask? Can you give me some examples?
What have you learnt about learners' learning from the formative assessment work in this lesson?
What do you think the learners have learnt?
Did you record anything from that lesson in terms of assessment?
What will you do next, how will you carry things forward?

Learner
(Focus on a learner's piece of work)
If you could now focus on a particular learner – how do you know about their mathematical strengths and weaknesses?
If we could look at a piece of their work, what sort of feedback or comments have you given to this learner?
Can you tell me why you have done that, what do you hope to achieve?
How does the learner respond?

Assessment
What do you understand by the terms formative and summative assessment?
(Give the teacher a piece of anonymised work) – how would you advise the person who did this?

Marking
(Focus on a learner's ILP)
Could you just talk me through this ILP?
How do you use the learners' ILPs?
And what about the learners, what use do they make of them?

Questioning
What makes a good question in mathematics?

What kind of questions do you ask learners?
Can you give an example?
Do you encourage learners to respond to other learners' answers?
(Prompt: How would you do that? Can you give an example?)
How do the learners respond?
How do you organise that, would the whole class participate?
(Prompt: or would students work in small groups or pairs?)
If whole class activity:
How do you ensure that everybody is involved?
Do you always expect learners to answer orally?
(Prompt: Do you ever ask them to record their answers on whiteboards or paper?)
What do you learn from learners' questions?
And what about their answers?
How do you use that information?

Class
What level are the learners in this class working at?
How do you deal with the spread of attainment and needs?
How did you assess learners in the past?
So how has that changed?
Do you encourage learners to assess their own and each others' work?

Formative assessment project
What do you think about formative assessment?
What do you think its strengths and weaknesses are?
What do you like and dislike about it?
Finally, what do you hope to get out of this project?

After the interview ask the teacher to write a paragraph about themselves.

Teacher-researcher background information
Could you please write a paragraph about yourself to include your age, how long you have been teaching and how long you have been teaching adults, levels of maths you have taught, highest qualification in maths, whether you have or are working towards the new Level 3 or 4 numeracy qualification. Please feel free to add any other information.

Learner Interview

Before the interview ask the learner to bring a piece of their work (something that they found quite difficult?) to talk about, also to bring their ILP.

About you
Could I start by asking you to tell me about yourself?
Did you pass any maths exams at school?
(Prompt: RSA qualification, City & Guilds qualification, NVQ, GNVQ, CSE O-level, GCSE including grade, any other maths certificates?)
Have you passed any Adult Numeracy exams?
(Prompt: Entry Level 1, 2, 3, Level 1, 2)
Are you working towards taking an exam?
Is getting a qualification important to you.
Do you mind telling me how old you are?

School experience
What was school like? And what about the maths classes, what were they like?

Piece of work
Do you think that your maths is improving? How do you know?
Can you tell me about the piece of work you bought with you?
(Probe: Why choose it, whether found it easy or hard/why they found it hard, what did the teacher do to help them understand it.)
What do you/did you need to do next?

This maths class
Why did you choose to study numeracy?
Is the class what you expected it to be?
(Probe the differences)
Has anything surprised you about the class?
What do you like about the class? Is there anything that you don't like?

Lessons
Can you describe what happens in a lesson, what is the teaching like?
(Prompt: whole class, group, paired, individualised work)
What do you think makes a good maths lesson?
What was the best lesson you have ever had?
Does the teacher talk to the class/group about the work that they are doing?
If yes: Do you think that is useful? Does it help you learn?
Does the teacher encourage you to respond to other learners' answers? What do you think about that?

Learning
What are you good at in maths?
And less good at?
(Prompt: How do you know that?)
Does the teacher ask you about the work you are doing?
Why do think that they do that?
Does that help you learn?
(Probe: In what ways?)
How do you know that you are doing well in maths?
What would help you to learn better?

ILP
Tell me about your ILP, is it useful?
(Probe: In what ways?)
How do you fill this in? …know what to write?
Does that information help you with your learning maths?

Appendix E: Research settings

Course provider (Teacher-researcher initials)	Course venue	Course	Length of course	Level of learners	Number of learners[27]	Number of learner interviews
Croydon LA (ND)	Junior school	Family learning (ESOL)	10 weeks (30 hours)	Pre E–L2	7	2
	Secondary school	Supporting Asian families	1 year	E3–L1	9.5	2
Croydon LA (ML)	Secondary school	Numeracy with ICT (Tamil speakers)	1 year	E2–E3	11	2
Lambeth College (MB)	Vauxhall Centre	Numeracy, Electrical Installation (embedded)	1 year	Level 2	8	0
	Vauxhall Centre	Numeracy, Electro-technical Technology C&G2330	1 year	Level 2	14	0
	Vauxhall Centre	BTeC Electronics First Diploma	1 year	BTeC, First Diploma	6	1
Abingdon & Witney College (SR)	Witney Campus	Level 2 Numeracy	1 year	Level 2	5	0
Croydon LA (CM)	Nursery School	Healthy Living	6 weeks (12 hours)	E1–L2	8.5	3

Table 1: Details of the research sites

[27] The mean average attendance over the lesson observations by the academic-researchers.

Miranda Lewis' 'Numeracy with ICT' course and Neelam Dungawalla's 'Supporting Asian Families' course

These courses are held as part of the extended school facility at a local secondary school in Croydon. Classes are held in one of three portacabins and a crêche facility is available during lesson times. Laptop computers are available for learners to use.

Neelam Dungawalla's 'Family Learning' course

This short course is held at a girl's Junior school in Croydon. The learners are parents of children in year three who have just moved up from the infant school.

Sarah Richards' 'Level 2 Numeracy' course

The year-long course took place for two hours weekly on a day when most of the learners also attended an adult literacy course. The sessions took place in a small classroom with several computers. The learners all sat around one large table. The learners ranged in age, although most had adult children and were interested in returning to work. One learner was a tutor elsewhere in the college.

Mark Baxter's "Electrical installations / electrical engineering" courses

These one-hour sessions of three year-long courses took place at Lambeth College. The first was in a very noisy classroom above a building class and the second in a computer room. The learners were studying courses for which they were required to gain a Level 2 numeracy qualification. A third class took place in the library and focused on mathematics identified by the learners' Electrical Engineering tutor.

Cathy Magee's 'Family Learning/Healthy Eating' course

This six-week course took place in the family room of a Croydon Nursery school around some low tables. The learners spent some time with their children in the Nursery and some time on healthy eating activities. Most of the learners had attended Family Learning courses previously and were well known to the tutor.

Appendix F: The religion article

This article from *The Observer* newspaper (Campbell 2007) was introduced by the teacher-researcher as follows: 'I saw it yesterday and thought that it had a lot of interesting numeracy in it'. [SR, Abingdon and Witney College, Level 2 Numeracy Course, Topic: Ratio, proportion and percentages]

RELIGION

A third of adults believe God watches over them

Two in five adults say prayers and one in three believes that God is watching over them, a new poll reveals. Of the 20 million Britons aged over 18 who say they pray, 13 million do so at least once a month, 12 million every week and 9 million every day. Most people (68 per cent) pray for family and friends, 41 per cent to thank God and 25 per cent over world issues.

But just 22 per cent go to church at least once a year.

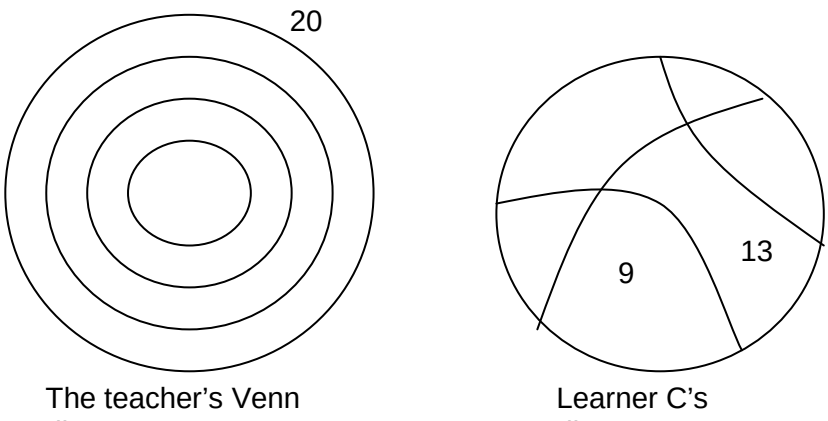
A third of adults questioned think that God will answer their prayers, while 12 million believe that prayer can change their lives or those of their nearest and dearest. London is the UK's least secular area, with 73 per cent of adults praying and one in five attending church at least once a month.

Tearfund, the Christian Aid charity that commissioned the survey, says: 'The results fly in the face of the view that faith is increasingly irrelevant in today's secular society.' Matthew Frost, its Chief Executive, said the report 'demonstrates the prevalence and potential of prayer' and he hoped that more people would pray about issues such as world poverty and climate change.

Describing the relationships diagramatically

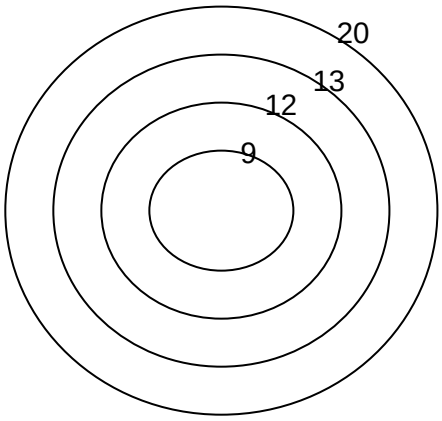
To describe the relationships, the teacher and Learner C each drew a diagram as follows:

Figure 4: The teacher's and the learner's partially completed Venn diagrams

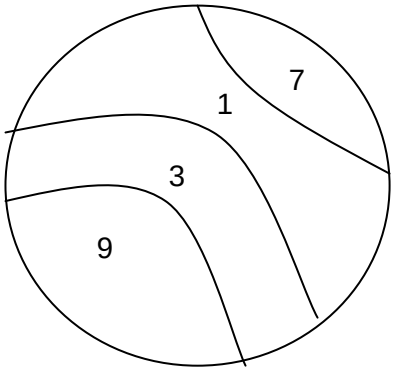


Both the teacher's and Learner C's diagrams are partially complete. Both indicate that the 20 million people who pray is the total and includes the other groups. Learner C's diagram contains an error, because the 13 million monthly pray-ers included the 9 million daily pray-ers. The teacher's and Learner C's diagrams are completed and 'corrected' below.

Figure 5: The Teacher's and the Learner's completed and "corrected" Venn diagrams



The teacher's Venn diagram



Learner C's diagram

In both cases, the 20 million who pray is made up of 7 million who pray but not every month, 1 million who pray every month but not every week, 3 million who pray every week but not every day and 9 million who pray every day. The set of people who pray includes the set of people who pray monthly, which in turn includes the set of those who pray every week, which in turn includes the set of those who pray every day. Hence, the 13 million monthly pray-ers is made up of 1 million who pray monthly but not more often, 2 million who pray weekly but not more often and 9 million who pray daily. Written mathematically:

{20 million pray-ers} $\supset$ {13 million monthly pray-ers} $\supset$ {12 million weekly pray-ers} $\supset$ {9 million daily pray-ers}

We believe that the relationships in this apparently 'simple' piece of mathematics are actually rather complex.

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