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for adult literacy and numeracy

Working mathematics for the 21st century?

A discussion paper on workplace numeracy and mathematics

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Maths4Life
Discussion paper

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For further details see ncetm.org.uk and maths4life.org. The Maths4Life website will be live and maintained until the end of March 2008 when it will transfer to ncetm.org.uk

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Working mathematics for the 21st century?

A policy discussion paper

Contents

1 Background

1 Background

1.1 Scope

This discussion paper examines workplace mathematics in terms of policy priorities and evidence on the changing mathematical demands of the workplace; skill levels; employers' views on different aspects of workplace mathematics; the costs and benefits to employers and benefits to individuals of workplace mathematics; and issues related to teaching and learning. Sections 2–11 present findings from research, policy and practice. Section 12 considers the implications of the findings.

1.2 Methodology

This discussion paper draws upon:

- A Maths4Life meeting which focused on mathematics in the workplace. Dr. Diana Coben (King's College, London) gave a presentation on relevant research. This was followed by a discussion which included consideration of what mathematics in the workplace is and its implications for a range of stakeholders. Participants are listed in Appendix 1. Some participants were international visitors to London South Bank University (LSBU) LLU+ who specialise in mathematics in the workplace.

- Research and inspection findings (see References).

- Policy documents (see References).

1.3 Terminology

Numeracy remains a contested concept (Coben et al., 2003; FitzSimons et al., 2005) and the boundaries between mathematics and numeracy have been much debated. Given the development of functional mathematics in England and research on the increasing mathematical demands of workplaces (see Section 3), this discussion paper uses the term 'mathematics', except when referring explicitly to findings from research, policy and inspection documents which use the term 'numeracy'.

2 Policy

Since the Labour government took office in 1997, a range of policy-related documents has emphasised connections between literacy and numeracy skills and employability, being in employment, productivity and the United Kingdom's (UK's) capacity to compete in a global economy. These policy documents include:

- *Skills for Life* strategy documents (e.g. DfES, 2003).
- The 14–19 White Paper (DfES, 2005).
- The Skills Strategy (DfES et al., 2003) and the Skills White Paper (DfES et al., 2005).
- The Foster review of Further Education (FE) (Foster, 2005).
- The FE White Paper (DfES, 2006).
- *Reducing Reoffending Through Skills and Employment* (HM Government, 2005).
- *The Leitch Review of Skills. Prosperity for all in the global economy – world class skills. Final Report* (Leitch, 2006).
- *World Class Skills: Implementing the Leitch Review in England* (DIUS, 2007)

It is Leitch (2006) who most strongly underlines the need to improve the UK's skills base. Leitch argues that even if the government meets current qualifications targets, including for literacy and numeracy, the UK's skills base will still not be world-class. In Leitch's view, the government should take a more ambitious approach to improving skills. Leitch argues that, if the UK is to have a skills base which is among the top eight in the world, this would require the UK to ensure that:

- 95% of adults have functional literacy (Level 1) and numeracy (Entry Level 3) skills. This would more than treble projected improvement rates.
- More than 90% of the population are qualified to at least Level 2.
- The balance of intermediate skills moves from Level 2 to Level 3.
- More than 40% of the adult population are qualified to at least Level 4.

In 2007 the Department for Education and Skills (DfES) was split into the Department for Innovation, Universities and Skills (DIUS) and the Department for Children, Schools and Families (DCSF). DIUS has announced that it plans to implement these recommendations in the Leitch report. In particular, it has set a target for 165,000 learners to improve their skills each year.

Following the 14–19 White Paper (DfES, 2005) and the Skills White Paper (DfES et al., 2005), functional skills are being developed (Hudson, 2006). The functional skills agenda exemplifies the close policy link between functional mathematics and English, and employment; it is argued that developing these skills will enable young people and adults to engage in employment and citizenship.

The Train to Gain programme has been developed from the Employer Training Pilots (ETPs). Leitch (2006) views Train to Gain, with Learner Accounts and Apprenticeships, as key to improving the UK's skills base. Train to Gain stresses that businesses can remain competitive by improving their employees' skills levels. Through a system of brokers, Train to Gain aims to provide advice to businesses on training needs and find appropriate training courses to improve workforce skills levels. Through Train to Gain, the government funds the cost of advice and the training of employees taking literacy, language and numeracy (LLN) qualifications and a first full level 2 qualification (DfES et al., 2005). In return, employers are expected to allow employees time at work for training. Training beyond Level 2 can be facilitated, but the business is expected to fund it.

The Skills White Paper specifies that training should be delivered flexibly, including in the workplace, and stresses the role of Union Learning Representatives (ULRs) in addressing learning and skills needs (see Section 11).

The LSC funded Apprenticeship Programme, which includes a focus on literacy and numeracy skills, is the main work-based route for young people to gain employment skills. Leitch (2006) argues that Apprenticeships are key to delivering work-focused intermediate skills. As part of 14–19, work-based learning for 14–16 year olds, within which the acquisition of literacy and numeracy skills is important, is being expanded (DfES, 2005; DfES et al., 2005).

The focus on work-related literacy and numeracy is based on the argument that improving literacy and numeracy skills will lead to increased productivity (Leitch, 2006). Evidence for this is examined in Section 6.

3 Demand for mathematical skills

3.1 Increased demand for mathematical skills

It is claimed (e.g. Wolf, 2005) that, because of the 'knowledge economy' and an increased focus on flatter organisational structures in which multi-skilled roles and team working tend to be important, many workplaces increasingly need more workers with good mathematical skills. Hoyles et al. (2002), for instance, underline that there is growing demand for intermediate level mathematical skills and applications in the workplace. Workers may need to use other skills, such as communication skills and team working, in conjunction with mathematical skills (Hoyles et al., 2002). Mathematical literacy is increasingly important (Hoyles et al., 2002). Wolf (2005) underlines that workers at all levels of an organisation need an appropriate level of mathematical literacy. Hoyles et al. (2002) highlight three dimensions to mathematical literacy:

- **The component skills.** These can include, for example, often multi-step calculation and estimation; interpretation of different representations of numerical data; extrapolating trends and monitoring models across different types of data; recognising anomalous effects and wrong answers; and communicating mathematical judgements clearly and concisely (Wolf, 2005).

- **The connections between the skills required and the changing context of business.**

- **The importance of Information Communications Technology (ICT).** Wolf (2005) argues that the proportion of workers for whom ICT is essential at work rose from 31 to 40% between 1997 and 2001, and that this percentage is higher in some sectors, such as transport.

Hoyles et al. (2002) make the point that there is a growing need for hybrid skills, such as good technical and analytical knowledge combined with effective communication skills, and that there is a shortage of such skills.

In a current Teaching and Learning Research Programme (TLRP) project, Professors Hoyles and Noss are building upon the concept of mathematical literacy, using the term 'Techno-mathematical Literacies' (TmL), to conceptualise mathematics as it exists in modern technology-based workplace practices (http://www.tlrp.org/proj/Workplace.html).

3.2 Jobs for low skilled workers

Whilst there is increasing demand for workers with intermediate mathematical skills, there is some evidence that there will also be more jobs for low skilled workers, as Wolf (2005) highlights. Researchers (e.g. Wolf, 2005; Ananiadou et al., 2004) have made the point that the care and service sectors, where 'soft' skills are important, are growing rapidly. It is reasonable to assume that many low skilled jobs require some mathematical skills (e.g. cleaners need to understand proportion to assess how much cleaning fluid they need for different amounts of water). Leitch (2006) underlines that employers tend to concentrate a disproportionate amount of training upon highly skilled workers. Wolf (2005) argues a case for focusing more training on low skilled workers.

4 Skill levels

Although there is a range of methodological and conceptual issues with survey data (Coben et al., 2003), surveys have consistently found that many adults have low levels of numeracy. The 2003 *Skills for Life* survey, for example, estimated that about 15 million adults have numeracy skills at or below Entry Level 3 and that, of these, 6.8 million have skills at or below Entry Level 2 (DfES, 2003a). Men have higher levels of numeracy than women, even after controlling for differences in education and employment (DfES, 2003a). However, many adults do not recognise that they have numeracy needs (DfES, 2003a; SfLQI, 2006).

Wolf (2005) outlines that 80% of the 2014 workforce and 60% of the 2024 workforce are already in the labour market. This suggests that it is important to ensure that employees in the labour market whose roles have mathematical demands have appropriate skills to carry out those roles effectively.

5 Employers' views

5.1 Overview

This section explores evidence on employers' perceptions of issues related to mathematics and the workplace. It draws on three sources of information: the annual Learning and Skills Council (LSC) National Employers Skills Survey (NESS) (LSC, 2006), a Confederation for British Industry (CBI) survey of employers' views on functional skills (DfES, 2006) and an Adult Learning Inspectorate (ALI) survey of workplace numeracy (ALI, 2006a). There were 74,385 respondents to the NESS survey and 140 to the CBI survey. 73 businesses contributed to the ALI survey.

5.2 The National Employers Skills survey

5.2.1 Overview

The annual LSC NESS (LSC, 2006) states that it is the largest, most comprehensive source of information on skills issues affecting employers in England. The NESS 2006 reports on skills in relation to job vacancies, the existing workforce, new recruits to the labour market and workplace training. This section summarises evidence from the NESS 2006 on skills issues and explores the extent to which skills issues are related to mathematics.

5.2.2 Skills shortages among job applicants

LSC (2006) defines skills shortages as when employers indicate that hard-to-fill vacancies (HtFVs) are created by applicants not having the required skills, experience or qualifications for the role in question. Employers reported experiencing skills shortages among applicants for a quarter of all vacancies in 2005. Skills shortages varied according to role, sector and region. The NESS 2005 (LSC, 2006) reported a higher than average incidence of skills shortage vacancies (SSVs) in the manufacturing, primary (e.g. agriculture) and service industries (LSC, 2006). The percentage of employers with SSVs was highest in Yorkshire and the Humber.

Overall, technical and practical skills (present in 53% of all SSVs), followed by customer handling skills (38%), oral communication skills (35%), problem solving skills (34%) and team working (34%) were the most common areas in which employers reported that applicants lacked skills. Employers reported that applicants lacked numeracy skills, in relation to 23% of all SSVs. Numeracy skills were reported to be among the main skills lacking in 41% of SSVs in sales, 33% of SSVs in elementary professions (i.e. occupations such as cleaners, labourers and bar staff etc.) and 29% of SSVs in administration, in comparison with only 16% of SSVs in management (LSC, 2006).

5.2.3 Skills gaps in the workforce

Skills gaps are defined in LSC (2006) as when employers report that some of their employees are not fully proficient in their role. In LSC (2006), a minority of employers (16%) reported that their employees were not fully proficient in their role, compared with 23% of employers in 2001. A small percentage (6%) of the workforce were reported as having skills gaps. In line with previous surveys, employees in unskilled and semi-skilled occupations were most likely to be described as having skills gaps. Sales, customer service and elementary positions accounted for 39% of all reported skills gaps (LSC, 2006). Overall, larger establishments had a higher incidence of skills gaps. The incidence of employers reporting skills gaps varied by region and was highest in Yorkshire and the Humber.

In identifying the nature of skills gaps, employers most commonly highlighted team work (present in 48% of skills gaps) and customer handling (46%), followed by technical and practical skills (44%), oral communication (42%), problem solving (40%) and written communication (29%). Employers reported that numeracy skills were part of 21% of skills gaps. Lack of numeracy skills was more common than average among plant and machine operatives (present in 28% of skills gaps), elementary occupations (26%), personal services (21%) and sales (20%).

5.2.4 Interpretation of data on skills shortages and skills gaps

These figures therefore suggest that, in the view of these employers, numeracy skills represent an important, but not the key, skills shortage among applicants and skills gap among employees. The extent to which there are reported issues with numeracy skills varies by sector, role, size of business and region. This suggests that workplace mathematics provision should be targeted carefully to where need exists.

To some extent, it is unwise to take the data on skills shortages among applicants and skills gaps among employees at face value. First, it is not known how these employers reached judgements about numeracy skills or the extent to which judgements about numeracy skills were related to specific skills required in the role in question. Second, because mathematical skills are integrated with other skills, such as problem solving, group work and technical and practical skills, in the workplace (see Sections 3 and 8), skills shortages in other areas may impact upon the extent to which workplace tasks involving mathematics are carried out effectively.

It could be argued that, to some extent, it is unsurprising that skills shortages and gaps exist, given the changing nature of work (see Section 3). This is particularly the case as there may be a time gap before workplace training is adapted to reflect workplace changes.

5.2.5 Young people recruited to the labour market

31% of employers recruiting 16 year old school leavers, 24% of employers recruiting 17 or 18 year old school leavers and 12% of employers recruiting graduates found these employees poorly prepared for the workplace (LSC, 2006). 11% reported that numeracy skills were lacking among 16 year old school leavers, 8% among 17 and 18 year old school and college leavers and 2% among graduates. It is therefore only a relatively small percentage of employers who perceived that numeracy was an issue among young workforce entrants.

5.2.6 Workplace training

The NESS (LSC, 2006) did not provide evidence specifically about workplace mathematics training. 65% of establishments had provided training over the 12 months prior to the NESS 2005 (LSC, 2006). 61% of the total current workforce had received training, indicating that a significant minority of the workforce did not receive training. 71% of employers who provided training, provided some off-the-job-training (training which takes place away from the employee's immediate work position, whether elsewhere on work premises or outside the workplace). More staff in lower skilled occupations received on the job rather than off the job training. 45% of employers had a training plan. Within the NESS, it would seem relevant to collect data specifically on workplace mathematics provision.

5.3 Confederation for British Industry survey

5.3.1 Important mathematical skills

In a recent CBI survey of private sector employers' views about priorities for functional skills (DfES, 2006), the following were cited as important mathematical skills for the workplace: multiplication, mental arithmetic, interpreting and responding to quantitative data, percentages, fractions, decimals, ratios, measurement, spotting mathematical errors, odds and probability. Mental arithmetic was most frequently cited (by 32% of employers surveyed). It would be challenging to cover this range of skills in a workplace mathematics course. For provision to impact upon job performance, it would seem important to target teaching to specific skills required in specific workplaces.

5.3.2 Assessment

50% of employers in the CBI survey claimed that they tested applicants' numeracy skills. A wide range of tests was used, including those designed in house. Thus the judgements of different employers on numeracy skills are based on different criteria. The extent to which judgements are comparable may therefore be open to question.

5.3.3 Skills of non-graduate recruits

Whilst a significant minority of employers (19.5%) reported that new non-graduate recruits frequently had problems with numeracy, the majority (55%) of employers reported that they experienced problems with the numeracy skills of non-graduate recruits only 'occasionally' or 'hardly ever'.

5.3.4 Context

The CBI report highlights the importance of context in workplace mathematics in a range of ways. It states that 'functional skills are about the abilities to tackle practical, everyday tasks in the real world' (DfES, 2006: 4); underlines the importance of teaching mathematical concepts through their practical application; and demonstrates through a series of detailed case studies the relationships between individual workplace contexts and the mathematical skills required. However, the report does not focus on the implications of the workplace context for curricula and pedagogy (see Section 8). It could be argued that the report therefore does not acknowledge some of the complexities involved in enabling employees to apply skills effectively in workplace contexts.

5.3.5 Pattern of demands

Slightly less than a third (31%) of employers thought that the mathematical demands of their workplace would increase in the next five years, whilst the majority (59%) thought that they would remain the same. 19% thought that the mathematical demands of their workplace would diminish in the next five years.

5.4 The Adult Learning Inspectorate survey

5.4.1 Background

In 2006, the ALI conducted a survey of workplace numeracy, using ALI inspection findings and fieldwork with 73 businesses (ALI, 2006a). ALI sent out 207 postal questionnaires, of which 53 were returned. ALI conducted the same questionnaire with a further 20 employers by telephone.

5.4.2 Scale of need

Findings from the ALI survey conclude that a large minority of employers surveyed believed that employees' numeracy skills were an issue.

5.4.3 Level of skills required

On the whole, employers surveyed perceived that employees need Level 1, not Level 2, numeracy skills for the workplace, though some employers also highlighted the need for higher level mathematical skills.

5.4.4 Provision

The large majority of employers surveyed did not know about funding for *Skills for Life* training, though they recognised the value of *Skills for Life* provision. About one in five employers surveyed reported sending employees to numeracy provision. Employers in the ALI survey expressed a range of concerns about numeracy provision: the perception that the provision tended not to reflect workplace needs and context; lost production time through staff attending training; and protracted negotiations to set up courses. The ALI (ALI, 2006) survey concludes that workplace numeracy provision should remain an important strand of *Skills for Life.*

5.4.5 Publication

The ALI survey was published as a supplement to Talisman 56 in November 2006 (http://www.ali.gov.uk/News/Talisman/Past_issues/issue56).

6 Costs and benefits to employers

6.1 Research on costs to employers

The limited amount of UK data on the cost to employers of employees' poor literacy and numeracy skills cites costs of £165,000 a year to firms with over 50 employees and up to £500,000 a year to larger companies (Ananiadou et al., 2003). However, Ananiadou et al. (2003) argue that this evidence, based on a study conducted in 1992, is out of date. Second, the evidence is methodologically flawed, as claims were based on statements by only a small proportion of interviewees.

6.2 Research on benefits to employers

Ananiadou et al. (2003) report that those employers who have promoted literacy and numeracy provision have been positive about this area of work. However, they (2003, 2004a) underline that, overall, there is an absence of UK evidence and very limited international evidence on the benefits to employers of workforce literacy and numeracy training. The authors call for longitudinal research, containing individual and firm level data, on the effects of improving literacy and numeracy skills. This gap in the evidence is, at least to some extent, being addressed by a current Economic and Social Research Council (ESRC) Teaching and Learning Research Programme (TLRP) (http://www.tlrp.org/proj/Workplace.html) project led by Professors Wolf, Evans and Bynner on the intermediate and longer term outcomes, including on workplace productivity, of workplace interventions designed to improve adults' LLN skills (http://www.tlrp.org/proj/Workplace.html).

However, there is far more existing evidence that workforce training in general, rather than literacy and numeracy provision in particular, can have a positive effect on firm performance and is associated with lower staff turnover and increased organisational commitment (Wolf, 2002; Ananiadou et al., 2003). Ananiadou et al. (2004a) underline the risks of extrapolating from findings on workforce training in general, to the impact of specific forms of training, such as workplace literacy and numeracy.

Thus there is a tension between the lack of existing, high quality research on the impact of workplace literacy and numeracy and the policy emphasis on literacy and numeracy skills and productivity and other associated benefits to employers. This underlines the importance of:

- Ensuring that future policy development reflects the findings from current research, when available.
- Where there are still gaps in the evidence base, commissioning further research.

7 Research on costs and benefits to individuals

Parsons and Bynner (2006), using data from the 1970 Birth Cohort Study (BCS) on men and women at the age of 30, found that poor numeracy rather than poor literacy was associated with low economic well-being. For example, women with poor numeracy, irrespective of their standard of literacy, were less likely to be in full time work than women with competent numeracy. If in work, they were more likely to be in semi-skilled or unskilled jobs.

In broad terms, these findings are not dissimilar to findings from Ananiadou et al. (2004a). Ananiadou et al. (2004a) argue that whether or not people have numeracy skills below Level 1 impacts upon earnings and employment rates, even when other factors that may affect earnings and employment have been taken into account (Ananiadou et al., 2004a). However, in their view this does not mean that improving individuals' literacy and numeracy skills will lead to improved earnings and employment for these individuals. Instead, Ananiadou et al. (2004a) argue that current policy on skills acquisition is based on extrapolating from evidence on the associations between skills levels and employment and earnings the point that, if other adults reach similar skills levels, they will enjoy similar benefits. In contrast, Ananiadou et al. (2004a) argue that there is a lack of evidence on the impact of improvements in individuals' literacy and numeracy skills and that there is even an albeit limited amount of national (e.g. Jenkins et al., 2003) and international (e.g. Ekstrom, 2003) evidence which counters the policy assumption above.

There is evidence on individuals' gains from workplace training in general (Ananiadou et al., 2004a), in terms of wages, particularly where the training is employer- provided. Employees participating in LLN programmes also tended to respond positively to programmes and to the tutors/trainers. However, it would be unwise to make claims about individuals' gains from literacy and numeracy training, from evidence on workplace training in general.

The current ESRC TLRP research on workplace-related literacy and numeracy interventions discussed above should provide evidence on when and how programmes impact upon adults' skills levels and a range of other outcome measures (http://www.tlrp.org/proj/Workplace.html).

The NRDC report *New light on literacy and numeracy* (Bynner and Parsons, 2006) found weak, but statistically significant correlations between poor basic skills performance by parents and poor test performance by their children. The correlation was strongest at the lower levels of parental literacy and numeracy.

Another NRDC report, soon to be published, *Illuminating Disadvantage* (Parsons and Bynner, 2007 forthcoming) further examined the outcomes of the same parents and in particular explored the differences between those with lower skills (Entry 2 or lower) and those with higher level skills. The report notes that those with the lowest levels of literacy and numeracy reported that as children they received little support or encouragement in relation to education. The research also shows that parents with low skills were less likely to read to their children and had fewer books in the house. Consequently their children were less likely to read for pleasure. Children of such parents were less likely to report that they enjoyed school. Boys in particular were most likely to have stunted aspirations.

8 Teaching and learning issues

8.1 Existing provision

Ananiadou et al. (2003, 2004a) underline that there is an absence of evidence on the extent and nature of workplace LLN programmes; no comprehensive data base exists. Whilst there have been fewer workplace numeracy than workplace literacy programmes, Wolf (2005) indicates that the number of workplace numeracy programmes is likely to grow, because of increased demand for mathematical skills.

8.2 Adult Learning Inspectorate evidence

ALI inspection evidence indicates that standards of work-related learning (not just workplace numeracy programmes) have improved rapidly. Both the Chief Inspector (ALI, 2006b, 2005) and the Chair of the ALI Board (ALI, 2006c) describe work-based learning in glowing terms. The Chief Inspector's Annual Report 2005–06 (ALI, 2006b) demonstrates that, of the 263 work-based learning providers inspected by the ALI, only 12% were inadequate. This is half the proportion reported in ALI (2005). Over 50% of grades awarded were grades 1 or 2 (ALI, 2006b). This contrasts with figures for 2001–02, when only 17% of grades awarded to work-based providers were grades 1 or 2 . This indicates that standards in work-related learning, as assessed by the ALI, can improve rapidly.

8.3 Context

Axiomatically, workplaces vary greatly. Workplace context is important in mathematical literacy, as discussed in Section 3. Researchers such as FitzSimons et al. (2005) have underlined the importance of context in workplace mathematics, arguing that the characteristics of individual worksites influence the mathematical skills required and how skills are used. Studies of workplace mathematics have been conducted in contexts as diverse as the National Health Service (NHS) in the UK (O'Hagan, 2005) and chemical handling and spraying in Australia (FitzSimons et al., 2005). For example, O'Hagan (2005) explores how nurses often have to calculate and measure under pressure, in noisy environments. Mathematical demands include, for instance, counting tablets which came in packs potentially of different sizes, measuring drugs in liquid form and estimating how much coffee a patient had drunk.

FitzSimons et al. (2005) argue that different numeracy skills are required in different strands of the chemical industry. For example, in warehouses, workers have to understand and use number recognition systems. In contrast, a complex set of numeracy variables is used in preparing, applying and handling chemicals. Workers need a range of numeracy skills: addition, subtraction, multiplication, division, ratio, proportion, measurement and estimation, using prior experience and pre-existing data. Chemicals have to be calculated and measured, taking into account factors such as the time of day, the time of year, the weather and economic and legal contingencies.

FitzSimons et al. (2005) demonstrate how other skills, such as common-sense, team work, problem solving, communication, planning and organising are potentially integrated with numeracy skills, in numeracy-related workplace tasks.

8.4 Context, curriculum and pedagogy

The discussion of workplace context above points to how, as argued by researchers (e.g. FitzSimons et al., 2005; Nunes et al., 2003; Hoyles et al., 2001), the mathematics skills required in the workplace differ from those taught in formal, classroom-based mathematics. These differences have implications for curricula and pedagogy. FitzSimons et al. (2005) emphasise that authentic problem solving, using real or simulated tasks, must be at the heart of workplace numeracy and recommend that workplace artefacts, such as graphs, charts and labels, are used in teaching and learning.

Because workplace mathematics is context-dependent, transfer of skills across contexts is important, though not straightforward (FitzSimons et al., 2005). FitzSimons et al. (2005) underline that, because teaching cannot cover all relevant contexts, metacognitive skills must be taught as part of workplace provision, to help learners to transfer the numeracy skills learnt, across different contexts in the workplace.

Some researchers have argued that the concept of transfer is extremely problematic. Evans (2002; 2000, discussed in Coben et al., 2003) addresses issues about transfer by arguing instead for the translation of knowledge across contexts. This involves meaning-making which is often teacher-facilitated, to enable learners to take into account contextual differences.

8.5 Mathematics practitioners

Developing curricula and pedagogies for workplace mathematics therefore requires sophisticated understanding of how mathematics and other skills inter-relate in the workplace, and of how context shapes the skills required. Skilled professionals are needed to design and deliver workplace mathematics programmes. However, there is a national shortage of qualified and skilled mathematics practitioners (Hudson, 2006).

8.6 Context and motivation

Brittan and Grief (2005), in their study of numeracy embedded in Entry to Employment (E2E) engineering, underline that the workplace context may have had a positive effect on the motivation to learn numeracy of trainees in their study. Brittan and Grief (2005) argue that the workplace helped to reduce these trainees' anxiety about mathematics which, it would appear, had been fostered in previous classroom contexts.

8.7 Formal and informal learning

The inter-relationships between context and workplace mathematical skills and the resulting differences between classroom and workplace mathematics also point towards the potential interplay of formal and informal learning, in equipping employees and potential employees with mathematical skills for the workplace. As part of the ESRC TLRP, a team led by Professor Alan Felstead is exploring the relationships between formal and informal learning in the workplace (http://www.tlrp.org/proj/phase111/felstead.htm). It is important that findings from this project are drawn upon to inform appropriately understanding of workplace mathematics.

8.8 Take up and retention

Work-related mathematics provision can be on or off the job, on work premises or outside the workplace and within and outside hours of work. These potential differences have implications for take up and retention. For example, NRDC research on literacy and numeracy in the NHS indicated that, unsurprisingly, some NHS employees found it difficult to juggle work and domestic responsibilities, to attend provision to which they had been recruited through work, but which took place outside work hours and at a distance from their workplace and homes. In some cases, this led to drop out from courses (Hudson and Lopez, 2004). This is not dissimilar to findings from other NRDC research; the initial phases of a longitudinal study on the effectiveness of workplace LLN provision indicated that, on the whole, take up and retention rates tended to be low. The authors linked these low rates to practicalities, such as employees' shift patterns, as well as to the organisation's learning culture (Ananiadou et al., 2004b).

8.9 Organisational strategies

Wolf (2005) makes the point that the success of workplace literacy and numeracy is in part likely to depend upon the extent to and ways in which the training is located within the organisation's wider learning and training development strategy and overall business strategy. Interestingly, according to the 2005 NESS (LSC, 2006), only just over half of employers (55%) had a training plan.

8.10 The role of schools

FitzSimons et al. (2005) argue that workplace numeracy has implications for the school curriculum and pedagogy. However, differences between the classroom and the workplace may suggest a case for limits to the role of schools in preparing young people for the workplace.

8.11 NRDC research

A range of NRDC studies reports findings which are pertinent to the teaching and learning of workplace mathematics and numeracy. Relevant NRDC research includes:

- The effective practice studies, in particular *Effective Teaching and Learning. Numeracy* (Coben et al., 2007).
- A review of research on adult numeracy (Coben et al., 2003)
- Ongoing NRDC research into Skills for Life teachers.
- A forthcoming (2007) report on the Skills for Life workforce for Lifelong Learning UK. The work was conducted in partnership with the London Strategic Unit for the Skills for Life workforce and SQW Limited.
- A literature review of teacher education in adult literacy, numeracy and ESOL (Morton et al., 2006).

9 Qualifications and the workplace

Current policy places considerable emphasis on qualifications. 55% of employers in the CBI survey (DfES, 2006) used formal qualifications as part of their selection processes. Hoyles et al. (2002) note that, for non-professional roles in workplaces they researched, GCSE mathematics was a common requirement. There is funding available for employees' first full level 2 qualification. Funding mechanisms also mean that there is pressure on providers for their learners to gain qualifications (Wolf 2005). Participants in the Maths4Life discussion on mathematics in the workplace questioned the extent to which some learners in the workplace wish to gain qualifications and whether, in some instances, there is therefore a tension between the government's, employers' and providers' aims, in comparison with what employees want.

Furthermore, the National Tests at Levels 1 and 2 do not test numeracy skills in specific workplace contexts, in a sustained way. Given the importance of context in workplace mathematics, as argued in Section 8, workplace mathematics courses leading to the National Test may therefore enable employees to achieve a nationally recognised qualification, but may not equip employees with the skills to carry out mathematics-related workplace roles. On the other hand, because National Vocational Qualifications (NVQs) are contextualised to different sectors, where NVQs involve mathematical skills, they may provide some evidence on capacity to use mathematics in the workplace.

10 Current research

Knowledge on workplace mathematics is developing rapidly. A range of relevant current projects has been funded through, for example, the ESRC TLRP (http://www.tlrp.org/proj/Workplace.html). These projects, some of which have been referred to earlier in this discussion paper, include:

- Improving Incentives to Learning in the Workplace: Rainbird, Evans, Hodkinson & Unwin (2000–03).
- Learning as Work: Teaching and Learning Processes in the Contemporary Work Organisation: Felstead, Ashton, Bishop, Fuller, Jewson, Lee & Unwin (2003–08).
- Understanding the System: Techno-mathematical Literacies in the Workplace: Hoyles & Noss (2003–07).
- Enhancing 'Skills for Life': Adult Basic Skills and Workplace Learning: Wolf, Evans, Bynner & Jupp (2003–07).

Readers can find further details, including publications to date, on the TLRP website (http://www.tlrp.org/proj/Workplace.html).

It is important that evidence from these projects on the effectiveness and impact of different approaches to workplace learning is used to:

- Inform appropriately understandings of mathematics in the workplace.
- Identify remaining gaps in the evidence on workplace mathematics.
- Commission further research where necessary.

11 Union Learning Representatives

ULRs are recruited from within the workforce. They work with employers and colleagues in the workplace to promote learning and to raise workforce skills (http://www.dfes.gov.uk/learning&skills/pdf/GUIDE.pdf).

Through the Trade Union Congress (TUC) representative at the Maths4Life seminar, evidence was collected on three examples of workplace mathematics provision which have ULR involvement. The companies involved were Boots Industrial (Nottingham), DHL (Tamworth) and Siemens (Lincolnshire). Provision at Boots and DHL started at the beginning of 2006, whilst the Siemens courses have been running since the autumn, 2005. By September, 2006, 31 of the Boots employees had opted for discrete numeracy provision leading to the National Test and 10 had gained the National Test. The DHL employees study literacy or numeracy embedded in ICT. The numeracy course is based around the spreadsheet package Microsoft Excel. 10 employees can be released for each course and there are reports of waiting lists to attend numeracy. By September 2006, the third course had just started and 11 employees had gained the numeracy National Test at Level 1 and 11 at Level 2. At Siemens, up to 30 employees can study literacy and numeracy at any one time. Employees study numeracy first, and then move on to literacy. By September 2006, 21 employees had gained the numeracy National Test at Level 1 and 27 at Level 2. In these three examples, it would appear that the ULRs have played an important role in promoting numeracy provision to employers and employees.

12 Implementing policy

The links made in policy documents between literacy and numeracy skills, productivity and economic prosperity; Lord Leitch's (Leitch, 2006) challenge to the skills agenda; evidence on increasing demand for mathematical skills in the workplace (e.g. Hoyles et al., 2002); and evidence on skill levels (e.g. DfES, 2003) create powerful drivers for workplace mathematics.

Whilst surveys of employers (LSC, 2006; DfES, 2006; ALI, 2006a) report issues with applicants' and employees' numeracy skills, it is important to set issues in context. First, the extent to which employers are concerned about employees' skills varies across and within the surveys discussed. Second, evidence from the NESS 2005 (LSC, 2006) indicates that, on the whole, more employers were concerned about the absence in applicants and employees of other skills, such as team work and problem solving, than about a lack of mathematical skills. Third, when employers' reports of the absence of broader skills, beyond mathematics, are set against research (Hoyles et al., 2002; FitzSimons et al., 2005) demonstrating how skills such as team work and problem solving are involved in mathematical tasks in the workplace, this may suggest that addressing these skills shortages and gaps is as significant, if not more so, than addressing issues with mathematical skills. Fourth, evidence from the NESS 2005 (LSC, 2006) underlines that reported issues with skills varied by region, sector and role and therefore highlights the importance of targeting provision carefully.

This discussion paper underlines that, although there is a policy emphasis on upskilling the current and potential workforce, there are gaps in the evidence base on the impact of workplace mathematics provision on productivity and on a range of benefits to individuals. Ongoing research, including research specific to work-related literacy and numeracy (e.g. the work of Professor Wolf, Evans and Bynner, ESRC TLRP) and also broader research on workplace provision (e.g. that of Professor Felstead, ESRC TLRP) should address some gaps in existing evidence. It is important that future policy development on workplace mathematics is informed by findings from this research. If necessary, further research should also be commissioned to address any outstanding gaps in the research base.

Whilst there are increasing demands in workplaces for mathematical skills, including mathematical literacy and techno-mathematical literacies, not all 21st century workplaces require higher level mathematical skills. The majority of employers in the CBI survey (DfES, 2006) did not perceive that the mathematical demands of their workplaces would be increasing. In some sectors, numbers of low skilled jobs are likely to increase (Wolf, 2005). These points suggest that there should be an appropriate balance between higher and lower level mathematical skills in workplace provision.

The research of Hoyles et al. (2002) and FitzSimons et al. (2005) crystalises the complexities of workplace mathematics by underlining first, the importance of context. Second, in the workplace, mathematical skills should be integrated with what are often much broader skills, such as group work and common-sense. Third, metacognitive skills are important in workplace mathematics. Fourth, ICT is increasingly significant. Existing research therefore underlines that sufficient resources should be available for the careful planning, piloting, delivery and evaluation of workplace mathematics programmes. Their research also raises the question of whether, given the shortage of mathematics teachers, there are sufficient numbers of qualified and skilled practitioners to teach workplace mathematics. If workplace provision leads to qualifications such as the Skills for Life National Test, consideration should be given to how teaching and learning may enable employees to gain a nationally recognised qualification and also to carry out effectively mathematics-related tasks in the workplace. This could help to address the concerns of some employers, expressed in the ALI survey, about the lack of relevance to the workplace of some numeracy provision.

In planning workplace provision, practicalities such as when and where learning takes place should not be overlooked, because of potential impact on take up and retention. Evidence suggests that ULR involvement, as exemplified in policy documentation and in the TUC examples (Section 11), can facilitate the development of workplace mathematics programmes.

The responses of employers across the NESS 2005 (LSC, 2006) and the CBI (DfES, 2006) and ALI (ALI, 2006a) surveys demonstrate that many employers have engaged with workplace mathematics. It is important that employers have an appropriately developed understanding of workplace mathematics. Whilst the CBI survey underlines the importance of teaching mathematical skills through their 'practical application', the report does not recognise fully the complexities of this. In the CBI survey, employers highlighted a wide range of mathematical skills which they consider are relevant to the workplace; a realistic approach should be taken to how much it is feasible to teach on a workplace programme. The CBI survey also reveals that employers assess applicants' numeracy skills in a wide variety of ways. A nationally recognised assessment tool should be used, to add validity to employers' judgements about applicants' and employees' mathematical skills. To maximise employees' access to workplace mathematics, it should also be ensured that all employers are aware of funding opportunities available as part of *Skills for Life.*

Evidence in this discussion paper points to the importance of different stakeholders working together, so that potentially conflicting perspectives may be drawn upon systematically, to develop workplace mathematics provision so that it is relevant to and for the 21st century.

References

ALI (2006a) **Talisman Numeracy Supplement** Issue 56 November (London, ALI).

ALI (2006b) **Annual Report of the Chief Inspector 2005–06** (London, ALI).

ALI (2006c) **Chair's foreword. ALI Annual Report and Accounts 2005–06** (London, ALI).

ALI (2005) **Annual Report of the Chief Inspector 2004–05** (London, ALI).

Ananiadou, K., Emslie-Henry, R., Evans, K. and Wolf, A. (2004) **Identifying Effective Workplace Basic Skills Strategies for Enhancing Employee Productivity and Development** (London, NRDC).

Ananiadou, K., Jenkins, A., and Wolf, A. (2003) **The Benefits to Employers of Raising Workforce Basic Skills: A Literature Review** (London, NRDC).

Brittan, J. and Grief, S. (2005) **Case study two. Doing as learning: 'It's not like doing maths at school – here you know it's to do with what you're doing'** (London, NRDC).

Bynner, J and Parsons, S. (2006) **New Light on Literacy and Numeracy** (London, NRDC)

CBI (2006) **Working on the Three Rs. Employers' Priorities for Functional Skills in Maths and English** (London, DfES).

Coben, C. with Colwell, D., Macrae, S., Boaler, J., Brown, M. and Rhodes, V. (2003) **Research Review. Adult numeracy: review of research and relevant literature** (London, NRDC).

Coben, D., Brown, M., Rhodes, V., Swain, J., Ananiadou, K., Brown, P., Ashton, J., Holder, D., Lowe, S., Magee, C., Nieduszynska, S. and Storey, V. (2007) **Effective teaching and learning. Numeracy** (London, NRDC).

DfES (2006) **Further Education Reform: Raising Skills, Improving Life Chances** (London, DfES).

DfES (2005) **14–19 Education and Skills** (London, DfES).

DfES (2003a) **Research Brief 490. The Skills for Life Survey. A national needs and impact survey of literacy, numeracy and ICT skills** (London, DfES).

DfES (2003b) **Skills for Life – The national strategy for improving adult literacy and numeracy skills -. Focus on delivery to 2007** (London, DfES).

DfES, DTI, HM Treasury and DWP (2005) **Skills: Getting on in business, getting on at work** (London, DFES).

DfES, DTI, HMT and DWP (2003) **21st Century Skills: Realizing Our Potential** (London, DfES).

FitzSimons, G. and Mlcek, G. (2005) **Adult Literacy Research. Learning numeracy on the job: A case study of chemical handling and spraying** (Adelaide, NCVER).

FitzSimons, G. E., Mlcek, S., Hull, O., and Wright, C. (2005) **Learning Numeracy on the Job: A case study of chemical handling and spraying** (Adelaide, NCVER).

Foster, Sir A. (2005) **Realising The Potential. A review of the future role of further education colleges** (London, DfES).

HM Government (2005a) **Reducing Reoffending Through Skills and Employment** (London, TSO).

Hoyles, C., Wolf, A., Molyneux-Hodgson, S. and Kent, P. (2002) **Mathematical Skills in the Workplace. Final report to the Science, Technology and Mathematics Council** (London, Institute of Education).

Hoyles, C., Noss, R. and Pozzi, S. (2001) Proportional reasoning in nursing practice in **Journal for Research in Mathematics Education, 32**(1) (pp. 4–27).

Hudson, C. (2006) **The implications for post-16 numeracy and maths of the Smith and Tomlinson reports, the 14–19 White Paper and the Skills White Paper** (London, NRDC).

Hudson, C. and Lopez, D. (2004) **Final report. Evaluation of the Skills for Life and Health regional pilots** (London, NRDC unpublished report).

Jenkins, A. and Wolf, A. (2005) 'Employers' selection decisions: the role of qualifications and tests' in Machin, S. and Vignobles, A. **What's the good of education? The economics of education in the UK** (Princeton NJ, Princeton University Press).

LSC (2006) **National Employer Skills Survey 2005. Key Findings** (Coventry, LSC).

Leitch, Lord S. (2006) **The Leitch Review of Skills. Prosperity for all in the global economy – world class skills. Final Report** (London, TSO).

Morton, T., McGuire, T. and Baynham, M. (2006) **A literature review of research on teacher education in adult literacy, numeracy and ESOL** (London, NRDC).

O'Hagan, J. (2005) **Decisions That Count in health and social care: a problem solving approach to making good mathematics / numeracy decisions** (London, unpublished NRDC report).

Parsons, S. and Bynner, J. (2006) **Does Numeracy Matter More?** (London, NRDC).

Parsons, S and Bynner, J. (2007 forthcoming) **Illuminating Disadvantage** (London, NRDC)

Roberts, C., Shrubshall, P., Grief, S., Baynham, M., Gidley, N., Eldred, J., Brittan, J., Cooper, B., Windsor, V., Castellino, C and Walsh, V. (2005) **Embedded case studies** (London, NRDC).

SfLQI (2006) **Skills for Life Quality Initiative Research Resources** (LSC).

Wolf, A. (2005) **The Change Agenda. Basic skills in the workplace. Opening doors to learning** (London, Chartered Institute of Personnel and Development).

Wolf, A. (2002) **Does education matter?** (Penguin).

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