Numeracy for adults

Building skills with online learning links

New Zealand Government

Literacy, language and numeracy research

This report forms part of a series called Literacy, language and numeracy research.
This series covers research on teaching and learning in literacy, language and numeracy and analyses of international surveys on adult literacy and numeracy.

Authors:

Gill Thomas and Jenny Ward
Maths Technology Ltd
PO Box 33
Dunedin 9054

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1 INTRODUCTION

Data from the Adult Literacy and Life Skills (ALL) survey provides a detailed and valuable picture of the literacy and numeracy skills of the New Zealand adult population. A significant number of New Zealand adults have low levels of numeracy, with 51 percent below level 2 (Satherley, Lawes & Sok, 2008a), the level regarded by experts as being the minimum required for adults to meet the "complex demands of everyday life and work in the emerging knowledge society" (Walker, Udy & Pole, 1996, p. 1). These levels are of concern as low numeracy has been found to be associated with higher rates of unemployment, lower incomes and restricted career opportunities (Satherley, Lawes & Sok, 2008b).

In addition to the effects felt by individuals when numeracy skills are low, the skill levels of the workforce also affect our nation's economy. While the labour-force demands of a modern economy are complex, it is clear that if New Zealand is to improve or maintain its position in the world economy it must develop a workforce with high levels of generic and technical skills (Satherley, Lawes & Sok, 2008b).

Within the New Zealand context there is an opportunity to provide numeracy for adults as a part of existing training programmes. The most effective models for achieving this are referred to as "embedded" and involve incorporating aspects of numeracy learning into vocational training (Casey et al., 2006). Embedded approaches "combine the development of literacy, language, and numeracy with vocational and other skills. The skills acquired provide learners with the confidence, competence and motivation necessary for them to succeed in qualifications, in life, and at work" (Roberts et al., 2005, p. 5).

While embedding has been established as an effective method of developing numeracy, "the 'mechanics' of embedding literacy and numeracy are challenging" (Industry Training Federation, 2009, p. 9). In particular, the Industry Training Federation found that it was difficult to design programmes that would be effective for the differing numeracy levels of learners, and many tutors felt threatened, unprepared and under-resourced to support learners to make numeracy gains.

This research sought to identify an efficient and cost-effective way to strengthen the numeracy of workers undertaking a vocational qualification. The research comprised three major phases:

- The identification of critical factors that enable the provision of effective numeracy training through a review of international literature.
- An investigation of one industry training organisation (ITO) as a context for adult numeracy learning. This resulted in the identification of an appropriate group of workers to take part.
- Case studies investigating an approach using online learning activities with five workers in the concrete industry.

This report summarises the findings from this research, and is structured in three sections representing the main phases of the project.

2 LITERATURE REVIEW

A review of the wider literature on how adults develop their numeracy expertise was carried out. The review identified four sets of research-based understandings that informed the researchers' approach to strengthening the numeracy of adults. These understandings are summarised in the bulleted points that follow.

The full review and reference list for sections one to three of this summary are available at www.educationcounts.govt.nz/publications/tertiary_education/51931/1.

2.1 How adults develop their numeracy expertise

- Adults engage in learning for their own larger purposes. These purposes are associated with their roles in society as workers, family members and community members.
- Adult learners develop expertise by building on their existing knowledge, skills and experiences.
- Adult learners develop their numeracy most effectively in contexts that have meaning to them. As learners develop their expertise, their increasing awareness of their knowledge and skills allows them to apply them in a wide range of contexts.
- Mathematics anxiety is experienced by many adults. This makes it difficult for them to access their working memory and think logically and results in lower course completion rates.

2.2 The features of effective embedded numeracy provision

- Where vocational tutors and numeracy specialists work as a team, learners are more likely to stay in training and complete qualifications.
- Successful approaches to embedding numeracy clearly link numeracy and vocational components of the course.
- Effective assessment in programmes where numeracy is embedded makes use of learning progressions to provide direction for teaching programmes and to monitor progress toward learning goals.
- Embedded numeracy provision is facilitated by appropriate organisational policies, management structures, resourcing, and working conditions.

2.3 Managing and sustaining change to achieve effective long-term embedding of numeracy

- Organisations are more likely to develop and maintain effective approaches to embedding when the value of numeracy is understood and it is viewed as an integral part of vocational training.
- Teaching materials are important tools that can substantially influence the content and enactment of instruction.

- Professional development programmes can be effective in improving tutor practice and learner performance.

- Assessment data provides valuable information that can be used systematically to improve programmes.

2.4 The role of ICT in the development of adult learners' numeracy skills

- The use of ICT enables the development and delivery of effective learning resources.

- Previously established principles for effective instruction underpin the successful use of technology for teaching and learning.

- The use of ICT can make learning more appealing, increasing learner motivation and persistence.

- Use of ICT can open new networks of support for learners as learning is taken out of the classroom and into other environments such as the home.

- ICT can be used as a means of making learning more accessible to adults because learning can take place at any time and in any place.

- ICT provides a cost-effective way of developing the skills of learners currently at level 2 of the Adult Literacy and Life Skills survey.

3 THE CONTEXT OF NUMERACY LEARNING

The Building and Construction Industry Training Organisation (BCITO) is the organisation appointed by the Government to develop and implement industry qualifications for the building and construction sector. As such, they directly face the challenges involved when workers with low numeracy levels are working towards industry standard qualifications.

The researchers worked directly with the BCITO to analyse and describe the context for numeracy learning within one of their certificate-level qualifications. The level 2 and 3 concrete qualifications were selected as a focus as they were currently under review.

The main method of instruction within the concrete qualifications entails apprentices working through workbook tasks. Workbooks contain all the information apprentices are required to learn, and are set out in unit standards, each of which focuses on a different aspect of the course. Each unit standard presents the necessary theoretical information for apprentices to read, and then sets out a number of related tasks, some of which are used for assessment purposes. In general, apprentices complete workbook tasks independently, outside of work hours, and if they have difficulty can consult their employer or a BCITO Training Advisor for assistance.

The BCITO employs Training Advisors to monitor the qualifications within the industry and these people were surveyed to further understand the place of numeracy within the concrete qualifications. Results showed that each advisor was responsible for approximately 120 apprentices on average, with the majority of apprentices (90 percent) coming from the carpentry sector. In general, advisors visited each apprentice about four times a year, and spent approximately an hour with the apprentice at each visit. Training advisors reported that they filled a wide variety of roles to support apprentices but considered monitoring apprentices' progress on the qualification to be their most important role. Other tasks identified as important were moderating assessments, assisting apprentices to complete workbook tasks, checking work logs, and pastoral care.

Advisors reported using mostly informal strategies such as discussion and observation to identify apprentices having difficulty with numeracy. Key observations reported as indicating difficulties with numeracy were incomplete maths units, or apprentices' experiencing difficulty in working on these units. The three numeracy tasks most commonly identified by advisors as difficult for apprentices were performing calculations without a calculator, estimating and measuring angles, and calculating values using formulae.

Most advisors were positive about the proposal to use online tools to support apprentices in developing numeracy skills. The majority of advisors (77 percent) thought the learning links approach would be moderately or very useful. Some advisors expressed concern about student motivation and access to online resources.

In discussion with the BCITO, two employers were invited to participate in the research. They each identified a group of target workers for the case studies. This group comprised five workers in the concrete trade: two were working on concrete qualifications with the BCITO, though not attending training courses, and three were not currently enrolled in courses but were considered to be representative of concrete workers in general. As these workers were not being actively supported to meet the numeracy demands of either the qualifications they were working towards or the workplace more generally, they were ideal participants to trial the online approach. All five of these case study participants will be referred to as workers throughout the remainder of this report.

4 BUILDING NUMERACY SKILLS WITH ONLINE LEARNING LINKS

4.1 Mapping the numeracy demands

The numeracy demands of workbook tasks were mapped against the adult learning progressions following the process described in *Teaching adults to make sense of number to solve problems: supporting the learning progressions* (Tertiary Education Commission, 2008b). This identified the specific numeracy demands of the concrete certificates. Three of the adult learning progressions were identified as most relevant: measurement, place value and proportional reasoning (Tertiary Education Commission, 2008a). Tasks within the workbooks required numeracy skills from steps 3 to 6 on these progressions and apprentices would need to be placed at the top step of these progressions in order to appropriately meet the numeracy demands of the qualification. For example, the qualification required apprentices to accurately measure to the nearest millimetre, which is located at step 3 in the measurement progression, and they also needed to understand and apply ratios (in particular, the water to cement ratio), which is located at step 6 on the proportional reasoning strategies progression.

Initial assessments were carried out with each of the five case study participants and their current understandings were mapped against the adult learning progressions to identify areas in which their skills were insufficient to meet the demands of the qualification. Assessment tasks were taken from resources associated with the adult learning progressions (Tertiary Education Commission, 2008b; Tertiary Education Commission, 2008c) and examples included estimating and measuring the weight of a phone book, and describing solutions to number problems. Each assessment took the form of an individual interview and lasted for approximately 40 minutes.

Areas in which the workers' numeracy skills were found to be insufficient varied, but the most common areas were conversion between units of measure (four workers), calculating fractional amounts and percentages (four workers) and knowledge of tenths and hundredths in decimal numbers (three workers). This knowledge is required to read scales accurately.

The following section describes in detail the way the learning links approach was used to improve numeracy skills. The process is described by highlighting the experience of one worker (Jade), who can be considered representative of the group.

4.2 Highlighted case study: Jade

Jade is a 20-year-old apprentice currently studying for a National Certificate in Concrete Construction with strands in Sitework, Pre-cast Concrete, and Placing and Finishing. Learning objectives within each of the three learning progressions were identified for Jade based on results from his initial assessment. This resulted in four major focuses for his learning:

1. Knowledge of hundreds in whole numbers and tenths and hundredths in decimal numbers. This knowledge is required to read scales accurately (place value progression).

2. Conversion between units of measure, for example litres to millilitres or grams to kilograms (measurement progression).

3. Telling the time: using analogue and 24-hour digital clocks, converting from 12- to 24-hour time and vice versa (measurement progression).

4. Calculating fractional amounts, for example one-quarter of 64 (proportional reasoning progression).

A variety of online learning activities were selected to meet the numeracy needs of the five workers. Suitable sites were those which meet a set of criteria based on research evidence on the effective use of ICT to develop adults' numeracy skills:

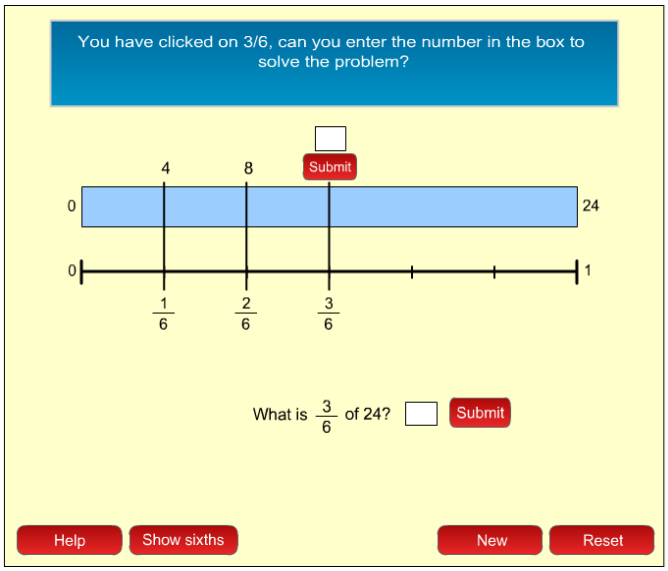
- The content of the learning activity is pitched at the "gap" between the worker's current knowledge/skills and the numeracy they require to successfully complete the qualification (Mellar et al., 2007).

- The learning activity requires users to be active in their learning, promoting the development of reasoning skills rather than the ability to recall information (Cromley, 2000).

- The learning activity requires users to complete cognitively demanding tasks (Swain & Swan, 2009).

- Immediate feedback is provided to the user. This clearly informs them whether the answers they are providing are correct and ideally provides meaningful feedback and guidance on how to improve performance (Australian Flexible Learning Framework, 2009; Lister, 2007).

- The site is accessible and easy to use, with minimal text and appropriate use of audio, video, photos and diagrams (Quality Improvement Agency for Lifelong Learning, 2008).



Example learning link: the fraction bar

The diagram above illustrates one of Jade's online learning activities: the fraction bar. This activity aims to develop the ability to calculate fractional amounts and supports the learner's thinking by enabling the user to split the total amount into a variety of fractional parts. The learner is directed through the process and immediate feedback is provided. The site provides additional learner support through the help file, which provides both instructions on how to use the tool and information on how to proceed in finding a solution to the problem.

In total, 16 online learning activities were selected for Jade. These focused on developing the knowledge and skills identified in the four major focuses for his learning. Nine sites focused on developing Jade's knowledge of whole numbers, tenths and hundredths. Tasks on these sites involved reading a variety of scales and modelling decimal numbers using number lines, abacus and fractions. Three sites focused on developing his ability to tell time and these required Jade to investigate an analogue and digital clock, which were synchronised, watch animations explaining how to tell the time (both analogue and digital) and practise reading clocks and converting from analogue to digital time. A game which involved converting from 12- to 24-hour time as quickly as possible was also included. The final four sites focused on developing Jade's ability to calculate fractional amounts. These activities involved supported practice and an interactive learning object designed to teach fractional concepts.

Jade owned a computer but was provided with a broadband internet connection to enable him to participate. He was sent links to four online learning activities by email each Monday and he worked on these independently over the course of the week. His instructions were to spend at least half an hour working on the activities, three times a week, and he completed a log of the work he did. He spent a total of 11 hours and 25 minutes working on the activities over four weeks, an average of 2 hours and 50 minutes a week. This was longer than most of the other participants, who spent an average of 6 hours and 36 minutes in total, or 1 hour 40 minutes per week. Jade explained that he spent longer than he was required to because he "had time on his hands and was looking for something to do".

Jade worked on the activities at home, usually when he had just returned from work. He established a daily pattern in which he first worked on the activities, and then moved on to look at other sites on the computer. This was consistent with the other case study participants, who all found different ways to slot the learning into their daily and weekly routines. For example, one worker spent time on the activities every week night while his partner cooked dinner, one worked with his brother on the activities three nights a week after *Shortland Street*, and one

worked around his teenage daughters, who dominated the computer in the evenings. Overall, two of the workers spent time on the activities daily, two completed them three times a week as instructed and one did the work in one longer session each week. The flexibility of the approach enabled the workers to structure their learning to fit in with their existing commitments.

Jade received plenty of support from his girlfriend with the work he was doing.

> *We sat at the computer and did it together. She teaches me little things and I teach her little things; it's given her some skills as well.*

When questioned about the support he received from his girlfriend, Jade commented, "I could have emailed you but it's easier when someone's right there." Jade's girlfriend also extended his learning into their everyday routines, asking him at various times to read the analogue clock to practise his skills. In terms of assistance from the researcher, Jade received a minimal amount, only once asking for help, when he was having difficulty using a password to access a site. This pattern was consistent with the other case study participants. In total, three of the five workers acknowledged receiving support from family and friends in their home environment as they worked on the activities.

A final assessment showed that Jade had made progress in three of the four focus areas of his learning. More specifically, he moved from steps 2-3 to step 4 on the measurement progression and from step 3 to step 4 on the place value progression. He developed the ability to:

- read scales accurately by applying his increased knowledge of place value
- convert between units of measure, for example converting from 1,400g to 1.4kg
- tell the time using analogue clocks
- tell the time using 24-hour digital clocks
- convert between 12- and 24-hour digital time and vice versa.

Jade was able to identify accurately what he had learnt. He clearly described his increased ability to read scales:

> *Volume, like how to measure it…say you got like a litre, and then a litre and a half and then two litres and you got the bits in the middle…the wee lines going up, if you know what I mean. Some of them you multiply them by 5, going up…there's different amounts between different lines.*

Jade's progress was consistent with that of the other case study participants, who each moved one or two stages in one or two of the learning progressions. The key skills gained by workers varied but included the ability to calculate fractional and percentage amounts, an increased knowledge of addition and subtraction basic facts, the ability to solve multi-digit multiplication and division problems mentally and the ability to add and subtract fractions. As with Jade, other case study participants were also able to identify and describe their own progress.

Jade described how he uses his new skills, both at work and at home. He explained that because he can now read a tape measure he has started wearing his glasses at work and has become more accurate in his measurements:

Mostly what we use here is a tape measure; we measure how big the area of the panels are. I've started wearing my glasses. I never used to wear them 'cause I wasn't sure how to read the tape. I used to keep stuffing things up; usually I was about 5mm out with some of them.

At home Jade has made use of his ability to read scales by weighing the ingredients for some muffins he made, and because he can now read the analogue clock for himself he no longer has to ask his girlfriend for the time.

I used to say to my girlfriend, "What's the time?" She'd say, "You can see it," and I'd say, "But I can't read it." Now I can read it for myself.

He has also stopped having to ask his girlfriend to read the Sky Television timetable for him. As it is written in 24-hour time he previously used to ask her help to find out what time certain programmes were on. He commented, "Now I know you just take off 12."

Although Jade had not yet found anything he had learnt useful for his BCITO workbooks, this was because he was currently focused on practical components of the qualification. He was anticipating using his new knowledge in a unit he had coming up on mixing concrete.

There's one unit I haven't gone through yet, mixing concrete, and you need to have a certain amount of quantities of each different chemical to make the mix. I haven't done that one yet. I saw it and it looked too hard; I put it in the too hard pile. But what I've learnt probably will be useful for that.

In line with the results from Jade, all of the other workers reported using their new knowledge, with examples provided for both home and work situations. These included:

- One worker reported he now uses less raw product at work as he is able to accurately measure out additives to concrete mixes, such as water-proofing agent. His previous practice was to add more than enough to ensure the mix was satisfactory, although he admitted this would cost the company more than necessary for ingredients.

- One worker became more accurate at calculating the amount of dye required for each batch of coloured concrete. Each shade is prepared using a percentage weight of the total cement in the mix, for example 5 percent, 10 percent or 15 percent. He previously used to estimate the amount required but can now calculate this accurately.

- One worker increased his ability to add, and as a result was able to keep a running tally as he did his grocery shopping and avoid having to put items back once he got to the checkout.

- One worker was able to save himself a trip to the garage in the weekends by applying his new ability to measure volume accurately to mix his own two-stroke for his chainsaw.

All of the workers reported using the skills and knowledge they had learnt in very context- and task-specific ways, even though the online learning activities were not set in these particular work or home contexts. They were able to transfer the skills and knowledge they developed online and apply them to a range of situations and tasks.

In the final interview all of the case study participants were questioned about the merits of the approach and all thought it would be successful. Jade identified that "most people these days have a computer" and would be prepared to spend the time it takes to work on the online activities; "three-quarters of an hour is nothing out of your day". He also thought the approach had the potential to provide another avenue of support for apprentices:

> *It would be good to have another place to go to for help. The only other person we can go to is the boss and he's usually busy.*

Jade's employer agreed that the learning links approach had great potential as a means to support and develop the numeracy skills of concrete apprentices:

> *It's a great model for the future. It would be great for employers as well, to know that the apprentices had support. I try to give them all the help I can with their workbooks but there are lots of other jobs that compete for my time.*

5 CONCLUSION AND RECOMMENDATIONS

The learning links approach shows promise as a cost-effective way to increase the numeracy skills of adults in vocational training.

- All five workers made significant progress, independently, in a small number of hours and a short time frame.
- All of the workers were able to transfer their new knowledge and skills to various tasks, both at work and in the home.

Clearly identifying where workers' skills were insufficient to meet the numeracy demands of the qualification and directing learning at this "gap" appears to be key to the success of the approach.

- The learning progressions for adult numeracy enabled this approach.
- Workers may be at different starting points on the progression towards the required numeracy knowledge and skills but learning must start from their existing understandings.

Further investigation of the approach seems warranted on the basis of the success of this small-scale investigation. In particular, the scalability of the approach could be explored. In this regard, several requirements need to be met to enable the approach to be successfully applied to any qualification and scaled up. These include:

- clear identification of the specific numeracy demands of the qualification
- an effective method to identify apprentices with skills that are insufficient to meet the specific numeracy demands of the qualification
- clear and specific identification of the required numeracy for tasks within existing learner resources. This would enable learners to be directed to online learning activities from within these resources
- clear identification of the progression of learning towards any required numeracy. The learning progressions for adult numeracy provide a useful framework for this process
- quality online learning activities. These need to cover the required content, use cognitively demanding tasks, provide immediate feedback and guidance, and be accessible and easy for adult learners to use. The establishment of a bank of appropriate activities that can be used by large numbers of learners would be most cost-effective
- workers need to understand the purpose of the online activities; they need to know that they are developing the numeracy knowledge and skills required for the qualification. Clear identification of the purpose of learning will increase learner motivation.

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