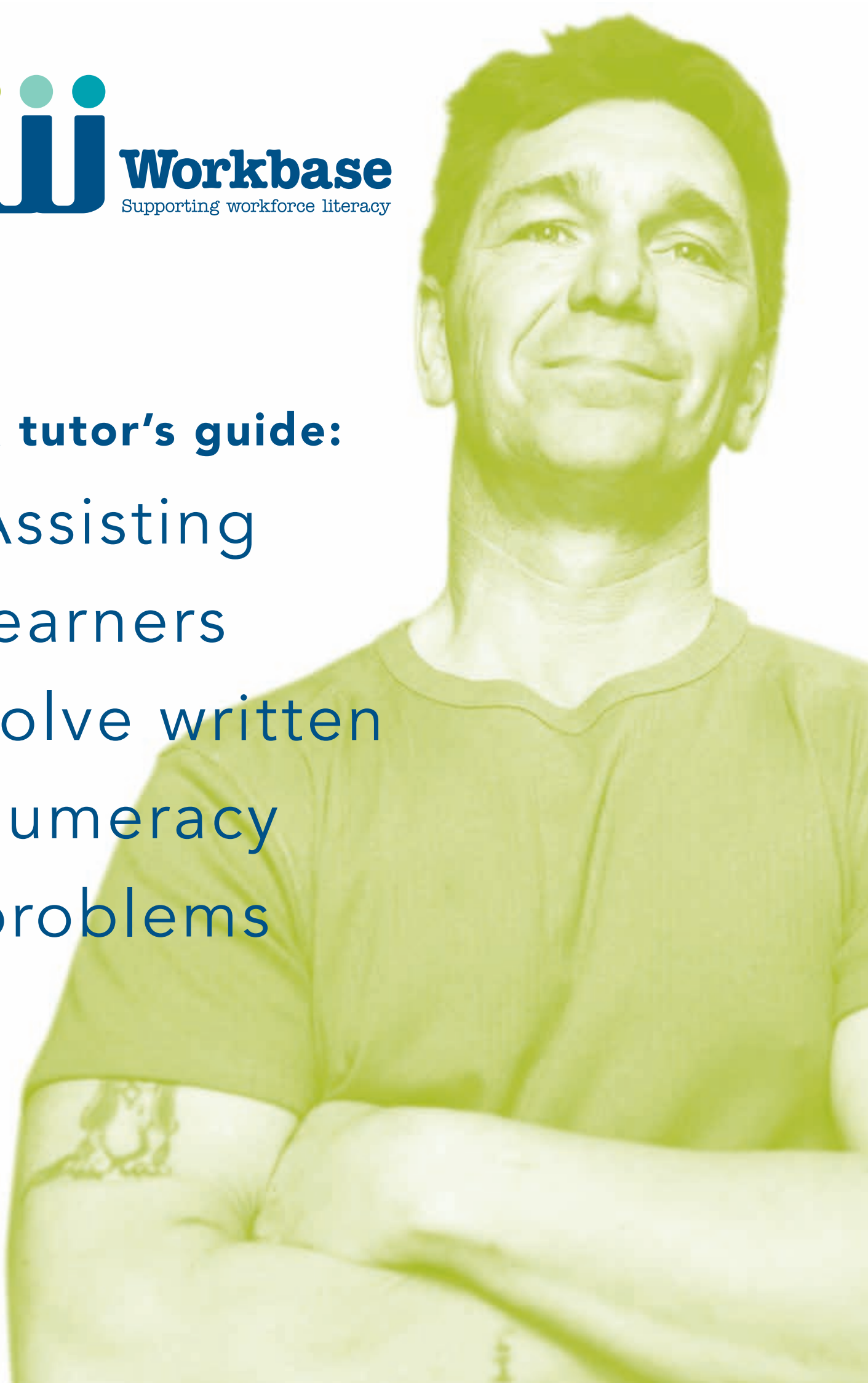


A tutor's guide:
Assisting
learners
solve written
numeracy
problems



Workbase: The New Zealand Centre for Workforce Literacy Development provides resources and professional development to support foundation learning for adults.

Written by: Susan Reid and Ginnie Denny

Publication date: September 2003

Reprint: November 2005

ISBN 1-877352-10-1

ISSN 1176-5348

In writing this guide Workbase drew significantly on material from Robyn Pigozzo, University of Southern Queensland with prior permission.

Workbase acknowledges funding from the Tertiary Education Commission for this guide.

Contents

Page

Introduction	5
What is Newman's error analysis process?	6
How to carry out a Newman's interview.....	7
Developing the curriculum to meet the learner's needs	8
Case study 1	9
Case study 2	10
Case study 3	11
Case study 4	12
Case study 5	13
Case study 6	15
Case study 7	16
Case study 8	17
Additional reading and other useful resources	18

Introduction

Written assessment of numeracy problems is commonly used in the tertiary education sector. Sometimes this is because the unit standards require it, for example:

- 8489: Solve problems which require calculations with numbers
- 8490: Solve problems using calculations with numbers expressed in different forms.

However, written assessment is often used because it is an efficient method when assessing a large group of learners. If learners are unsuccessful in the written assessment then there is the possibility that they could be assessed orally.

It is important that tutors understand the impact written assessment can have on learners who have low levels of foundation skills.

Written assessment places a higher communicative demand on the learner in that it requires them to:

- read the problem
- understand what the problem is asking them to do in terms of the maths embedded in the problem.

Often learners can do the maths embedded in a written numeracy problem if it is presented to them as a number problem. When learners have low levels of English language or reading comprehension this creates another barrier to accessing the maths in the written problem.

Tutors can assist learners working with written numeracy problems in a number of ways. The first is by ensuring that the problems you develop are written as clearly as possible (there is more about this later in the guide). Another is to explicitly relate the numeracy that learners do in their daily lives to the written numeracy problems. This emphasis on teaching is sometimes difficult to achieve when you are working in an environment where there is pressure to achieve outcomes. However, attending to explicit teaching of these numeracy skills will pay off for your learners.

In addition this guide provides a process tutors can use when your learners are experiencing difficulties with written numeracy problems. It will help pinpoint where your learners' strategies are not working and this in turn will help inform your teaching practice.

What is Newman's error analysis process?

This guide describes Newman's error analysis process which was developed by an Australian language educator, Anne Newman, in the mid-1970s. Newman's process identifies the sequence of steps involved in solving written mathematical problems. The sequence forms a hierarchy, so if your learner cannot do one step, they are not able to go onto the next steps.

According to Newman, learners solving a written numeracy problem go through the following process. They:

- read the question
- understand what has been read
- choose the right method in relation to the problem
- use the appropriate skills to solve the problem
- write down the answer in the manner required.

Failure to do any of these things brings about an incorrect result.

However it is important to understand that there are also other possible reasons for learner error:

- A poorly worded question.
- Carelessness on the part of the learner.
- Lack of motivation on the part of the learner.

These last two reasons can occur at any time during Newman's process.

Newman's error analysis process involves interviewing learners, using a series of questions that probe for the exact error that your learner is making. Newman's process also emphasises the importance of language in mathematics and provides an excellent opportunity for you and your learner to get together on a one-to-one basis. However, it is really important that you resist the temptation to show your learner how to do the problem. Direct intervention with your learner may get them through a particular assessment but it will not help your learner to develop their numeracy skills or to do a similar assessment at a later time.

How to carry out a Newman's interview

Schedule an interview with your learner in a private situation to talk about their numeracy. During the interview ask your learner to attempt the problem again, showing what they did at each step. While they are doing this, you ask your learner a series of questions. The answers to the questions reveal the type of error being made and the stage at which the breakdown occurs.

At the same time as you are focussing on your learner's cognitive processes (e.g. learning through concepts and problem-solving), you can also focus on their metacognitive processes (monitoring and guiding the problem-solving process).

As a tutor, you do this by asking your learner certain questions which relate to their confidence in addressing the problem.

These are the questions you should use in your interview. Metacognitive questions are shown in italics and underlined.

Question	Stage
1. Read the question to me. <u><i>How confident are you that you can do this problem?</i></u>	Reading
2. Tell me what the question is asking you to do.	Comprehension
3. Tell me the method you can use to find an answer to the question.	Transformation
4. Show me how you worked out the answer to the question. Explain to me what you are doing as you do it. <u><i>Do you know you are right? Why?</i></u>	Process skills
5. Now write down your answer to the question. <u><i>How confident do you feel about the answer?</i></u>	Encoding

If an incorrect answer is given to a question, then the error is classified according to where the first breakdown occurred. For example, if your learner can read the question but can not explain what the question is asking them to do, then the error is occurring at the Comprehension stage.

It is important to realise that this technique is not a learning approach but a method to identify what the learner knows already and the critical stage where they are making errors.

A tutor's guide:

Assisting learners solve written numeracy problems

Learners may often return to earlier stages of the hierarchy when attempting to solve problems, for example, re-reading the question. Sometimes they might self-correct, in which case it is still worth going through the process and confirming what they did differently the second time around that meant they got the correct answer. This makes explicit for your learner the strategies that they have, and how they can use them to be successful.

But even if the steps are revisited it is likely that the breakdown will occur at the same stage. If learners get really frustrated then they might start making errors at earlier stages as they attempt the problem over and over again.

It is important to distinguish errors made because of poor question design. This is something tutors always need to consider. If significant numbers of learners are answering the same question incorrectly, then it is likely that your question is the issue. In this case talk to another tutor or someone you trust to give you critical feedback. Be prepared for them to tell you that your question needs to be reworded.

Research using Newman's error analysis process showed that the majority of errors occurred in the Comprehension or Transformation stages rather than in the Process stage. This underlines the importance of careful teaching at each stage of any learning process.

Developing the curriculum to meet the learner's needs

Once you have analysed your learner's skills using Newman's process, you can develop an individual learning plan to address the errors your learner is making. Analysis of these plans can also inform changes to teaching plans.

If you use written numeracy problems as part of your initial assessment process and you identify that a learner did not complete any written numeracy problems correctly then you might consider using the Newman's procedure with that learner at an early stage. This way you can discover whether it is a maths issue or a reading comprehension issue or both.

In this situation you can incorporate the Newman's interview questions into the interview you have with your learner to identify their learning goals so you can develop their Individual Learning Plan.

On the remaining pages is a series of case studies. They show how the Newman's process was used with different learners. Each case study includes suggested future teaching for each learner following the interview.

Case study 1

Seepa works in a plastics factory. She is working on an industry training programme. She had no problems completing the assessment for Unit Standard 8489: Solve problems which require calculations with numbers. You have given her some practice problems for Unit Standard 8490: Solve problems using calculations with numbers expressed in different forms. She has got all of them correct but she has not shown her workings out on some of them. This will prevent her from being assessed as competent. You take the first problem and discuss it with her.

“In one day the factory produces 380 buckets but 10% are rejected because of pinholes. How many buckets are rejected?”

Seepa can easily read and comprehend the question (Reading and Comprehension). She has the correct answer – 38 buckets. But when you ask her to tell you the method she used to find the answer (Transformation), she says she crossed the zero off at the end of 380, because when she was in school in Samoa her teacher taught her that that was how you divided by 10. Seepa cannot really explain why she does this, but she can explain the place value of various numbers e.g. 380 is three hundreds, eight tens and zero ones.

Further questioning shows that Seepa understands the relationship between common fractions and percentages but does not know how to calculate percentages either on paper or using a calculator. To be assessed as competent in Unit Standard 8490, she has to be able to do this in relation to this particular question. Because of these specific requirements Seepa is having difficulties at the Transformation stage of Newman’s process.

Suggestions for future teaching

- Affirm current strategy she is using (for example, changing percentages into common fractions). Also see <http://www.bbc.co.uk/skillswise/numbers/fractiondecimalpercentage/>
- Highlight what she is doing in relation to crossing out the zero.
- Confirm relationship between fractions and percentages.
- Explain language associated with percentage.
- Show how to calculate percentages using a calculator and on paper.
- Practise percentage calculations.
- Discuss application to other contexts e.g. home, community (teaching for transfer).

Case study 2

Shelley works on her parents' dairy farm. She is working towards a National Certificate in Agriculture (Level 3).

As part of that qualification she is doing some work in preparation for assessment against Unit Standard 19143: Perform calculations for primary production situations.

You have given her some written problems about calculating area. The first one is:

"The calf pen you feed the bobby calves in measures 15 metre by 11 metres. What is the area of the pen?"

This is Shelley's answer.

$$\begin{array}{r} 15 \\ + 11 \\ + 15 \\ + 11 \\ \hline 52 \text{ metres} \end{array}$$

Shelley is able to show she can understand the question (Reading and Comprehension). However, when asked to describe the methods, she describes finding the perimeter of the pen rather than its area.

Further questioning reveals that Shelley has never had to work out calculations of this type before and she cannot recall doing this sort of calculation at school. Shelley has difficulties at the Transformation stage of the Newman's process.

Suggestions for future teaching

- Affirm understanding of perimeter and show formula.
- Discuss relationship between perimeter and area (metres and square metres).
- Discuss the formula for calculating area. See <http://www.bbc.co.uk/skillswise/numbers/measuring/>
- Incorporate practical examples from Shelley's current context. If necessary build models and use graph paper.
- Practise application of formula.
- Discuss application to other contexts, for example, sheds, barns, gardens, paddocks.
- Discuss other formulae she may need to use e.g. calculating volume, flow rates.

Case study 3

Vinny works in an engineering factory and is completing some practice problems before assessment against Unit Standard 8489: Solve problems which require calculations with numbers. He answers most of them correctly but is struggling with the following problem: "A standard pallet can hold 600 kilograms of weight. A steel tool case weighs 10 kilograms. How many tool cases can be put into the pallet?"

You ask him to read the question to you (Reading) and he has no difficulty. You ask him what the question is asking him to do (Comprehension) and he explains he needs to find out how many lots of 10 kilos go into 600 kg. When asked what method or operation he would use (Transformation), Vinny is unsure.

If a similar thing happens with your learner it is worthwhile to check whether they are able to do the problem using numbers alone. In Vinny's case you would give him this number problem:

$$600 \div 10 =$$

You might want to check that they recognise the alternative ways of presenting a division problem e.g.

$$10 \overline{) 600} \quad \text{or} \quad \frac{600}{10}$$

If there is still difficulty in recognising that the question is a division calculation, it might be helpful to take your learner out to look at the actual things they have to work with, in Vinny's case a pallet and a tool case. If you cannot work with the actual things, use something to create a model e.g. blocks.

Suggestions for future teaching

- Affirm comprehension of the problem.
- Discuss the relationship between subtraction and division (fast form).
- Discuss the relationship between multiplication and division (reverse operation).
- Check knowledge of times tables. See <http://www.bbc.co.uk/skillswise/numbers/wholenumbers/>
- Teach basic division (single digits) using blocks or similar objects.
See <http://www.bbc.co.uk/skillswise/numbers/wholenumbers/> and scroll down to division.
- Move to larger problems that are authentic to the workplace.
- Discuss application to other contexts e.g. home, community (teaching for transfer).

Case study 4

Vao wants to work in a factory. He left school in Samoa early and wants to achieve his National Certificate in Employment Skills. He has been assessed as competent in Unit Standard 8489: Solve problems which require calculations with numbers and Unit Standard 8490: Solve problems using calculations with numbers expressed in different forms. He is now doing some work in preparation to be assessed against Unit Standard 8492: Use standard units of measurement.

One day you ask him to use a tape measure and measure the width of a desk.

Vao measures the length and reads 800, instead of 1800 millimetres or 1.8 metres. He has not understood the basic English measurement terms and has not recognised, when using the tape, that it went past the first metre mark. Further questioning confirms that Vao has used only the imperial system of measurement and is not entirely sure of the English terms for length, width and depth.

Vao has not understood your question (Comprehension) because of his lack of knowledge about the English term "width". This affected the Transformation stage of the problem. However, your additional questions have shown he would also have had issues with Process because he does not know how to read the tape measure.

Suggestions for future teaching

- History of metric system.
- Relationship between imperial system and metric system.
- Basic units of metric system.
- Language relating to measurement, for example, length, width, height, depth.
- Language relating to linear measurement in metric system – millimetres, centimetres, metres, kilometres. See <http://www.bbc.co.uk/skillswise/numbers/measuring/lwc/>
- Relationship between place value, decimals and metric system.
- Language of measuring instruments, types, and how to use them.
- Practise estimating and then measuring common workplace objects and writing the results.
- Discuss application to other contexts e.g. future work, home, community (teaching for transfer).

Case study 5

Troy has been doing some work experience as a packer in a cheese factory. He has been offered a permanent job there and is very keen to take it. However, he also knows that he will have to do a written test as part of his job interview. He knows that this test will involve tallying product that he packs. He asks you to help him by writing out some problems so he can practise before his interview. You develop this problem for him.

This is the tally sheet showing how much cheese has been packed on your shift. What is the total amount your shift pack in the 12 hour period.

Pack tally sheet		
Day shift 13/10/05		
Time	Line 1 kg	Line 2 kg
7 am	51.5	117.5
8 am	52.25	127.25
9 am	69.00	130.00
10 am	37.25	132.00
11 am	15.25	131.00
Noon	52.5	25.00
1 pm	57.5	17.00
2 pm	62.25	51.75
3 pm	67.25	75.25
4 pm	74.25	84.25
5 pm	74.5	91.75
6 pm	29.5	103.25

Troy can read and understand the question (Reading and Comprehension). He knows the right method (addition) to find the answer to the problem (Transformation).

However the amount he gives you 4074 kg is not correct.

You ask him to do the calculation again and he comes up with another different answer that is still not correct.

This time you ask him to show you how he worked out the answer and explain each step to you as he does it. Troy gets out his calculator and enters in the figures. Sometimes he forgets to put in the decimal point which makes a significant difference to the answer. Troy is having difficulty at the Process stage.

At the end you ask him if, before he started to use his calculator did he estimate what the answer would be so he would know when he did a calculation whether it was correct or not or whether he might have entered some figures incorrectly. He doesn't understand what you mean.

Suggestions for future teaching

- Discuss estimation with Troy. Talk to him about why it is important in tallying to have an estimate of what the answer would be.
See <http://www.bbc.co.uk/skillswise/numbers/wholenumbers/whatarenumbers/rounding/>
- Ask if Troy uses estimation in any other contexts e.g. budgeting. Use current real life examples as a platform to transfer concepts into this next contexts.
- Find out what strategy Troy currently uses for estimation (rounding to whole numbers etc.).
See <http://www.math.com/school/subject1/lessons/S1U1L3GL.html>
- If he needs to learn a method discuss usual methods of rounding (up to 5 round down, 5 and above round up).
- Get Troy to practise rounding the figures on the tally sheet.
- Encourage him to write his "rounded" figures down. Encourage Troy to use pen and paper to do estimation. Write estimate down.
- Get Troy to do calculation of actual amounts while you watch him. Emphasise importance of checking the number he has entered especially when there is a decimal point involved.
- Check he knows how to use CE button on his calculator.
- Develop more practice problems until Troy is confident and competent at estimating and then accurately calculating.
- Teach him how to use memory functions on his calculator if that assists him.

Case study 6

Jenny is enrolled in a horticulture course. She is doing really well and her tutors think she is ready to get a job. One of the tutors has been giving the whole class written problems about mixing chemicals and fertilisers.

Jenny finds ratios very difficult and is losing her confidence about her ability to get a job if she cannot understand ratios. She comes to you with a problem which she can't work out. This is the problem.

"You have to mix up some spray. The instructions say mix 1 part herbicide concentrate to 3 parts water. You need to mix 5 litres of spray. How much herbicide concentrate do you use?"

Jenny can read and understand the problem (Reading and Comprehension).

Jenny has worked out her answer using a fraction, saying that the fraction of herbicide concentrate to water is $\frac{1}{3}$. She works out that a third of the spray will be concentrate – 1.666 litres and the rest will be water. This is incorrect. The fraction she is using should be $\frac{1}{4}$ (the ratio is 1:3). Therefore the correct answer is that Jenny will use 1.25 litres of concentrate to 3.75 litres of water. Jenny has chosen the correct method (Transformation) to work out her problem, however, the fact that her fraction is wrong means the Process is incorrect.

When you ask her how she mixes chemicals on the course she says that she only mixes one lot of chemicals and she uses a special container to measure the chemical which she always mixes in the same bucket.

Suggestions for future teaching

- Discuss with Jenny the differences between fractions and ratios (a fraction is a part of a whole or a group where a ratio compares two quantities).
See http://www.eduplace.com/math/mw/background/5/11/te_5_11_fractions_ask.html
Also see <http://www.bbc.co.uk/skillswise/numbers/wholenumbers/ratioandproportion/ratio>
- Build on the process she was using showing her that the fraction she was using was in fact the ratio but the fraction of the spray is $\frac{1}{4}$.
- Check whether Jenny uses ratios in any other contexts e.g. cooking, diluting cordial.
- Build on existing knowledge by making a formula for the ratio she currently works with (measure concentrate container and bucket in terms of litres/millilitre and represent it as a ratio).
- Practise reading labels of different containers and get Jenny to articulate them as ratios.
- Develop lots of examples so Jenny can get lots of practice at calculating different quantities using different ratios. Include examples of increasing and decreasing the amounts mixed.
- Check that Jenny is clear on how to articulate the ratios as fractions and vice versa.

Case study 7

Arnie has been unemployed for a long time because of a chronic injury. He is now recovered and enrolled on an Industry Partnership course in preparation for a new career as a truck driver. As part of his course Arnie has to complete written problems as part of Unit Standard 64: Perform calculations for the workplace.

The written problem he is working on has two parts.

Part A

You are delivering a load of timber. You take 3 hours to travel the 171 kilometres to the building site. Work out the average rate of speed for the journey.

Part B

Your boss asks you to do a delivery to the same site. This time he needs you to fit the delivery in between 1100 hours and 1300 hours. Work out the average rate of speed you would need to do to complete the trip in the timeframe allowed.

Arnie can do Part A of the problem and correctly calculates the average rate of speed over the 3 hours is 57 kilometres per hour.

However, when it comes to Part B Arnie has a number of questions. He can read the question (Reading) but doesn't understand it all. One issue is that he doesn't understand the 24 hour clock used in the problem. Also he is not totally confident that his understanding of how to apply the rate formula he used in Part A is correct for Part B. Arnie has difficulties at the Comprehension stage.

(This is not an uncommon situation particularly with people who are returning to formal learning after a number of years. In this situation it is important to quickly reinforce Arnie's success by taking out the part of the problem that is causing the issue - 24 hour clock - to underline that Arnie knows the right approach to the problem.)

Suggestions for future teaching

- Rewrite Part B of the problem by taking out the reference to 24 hour time and substituting 12 hour time. Get Arnie to calculate the answer using the rate formula he used in Part A.
- Calculating time using the 24 hour clock is used in the transport industry and should be explicitly taught. See <http://www.bbc.co.uk/skillswise/numbers/measuring/time/timesanddates/>. Also <http://www.bbc.co.uk/skillswise/numbers/measuring/time/calculatingtime/>

Case study 8

Charlie works in a wood-processing factory. One of his roles is as a health and safety representative. Increasingly, information about workplace incidents is being presented in a range of different sorts of graphs – bar graphs, pie graphs, line graphs and mixed graphs. While Charlie has been able to guess information in pie graphs based on his experience, he realises that he is struggling to read and understand other forms of graphs. As part of his collective employment agreement Charlie has to be assessed against Unit Standard 8491: Read and interpret information presented in tables and graphs. He is working on some practice problems. One of the problems is about a graph showing off work injury rates for the last three years. Charlie has to identify the rates for various months during the three-year period plus identify any trends over the last two years that relate to a specific initiative undertaken at Charlie's work.

Charlie can read the problem (Reading) and answer some of the specific questions about rates. However, he doesn't understand the question about trends because the vocabulary is new to him. He is having difficulties at the Comprehension stage.

When you show Charlie a table with some health and safety statistics on it, he is able to read this easily. He says that he is used to reading tables, because he has to do that all the time at work to adjust the saws for different products and types of wood.

Suggestions for future teaching

- Show Charlie how graphs are created on a computer (Excel, PowerPoint) and how they start with a table.
- Explain the similarities and differences between a table and a graph.
- Explain the different types of graphs (pie, line, bar, mixed line and bar graphs) and what they are used for. See http://www.bbc.co.uk/skillswise/numbers/handlingdata/graphs_and_charts/
- Explain that graphs show movements, trends and distributions (create a vocabulary list around graphs).
- Explain that bar, line and mixed graphs have a vertical (top to bottom) and horizontal (left to right) axis.
- Name the vertical and horizontal axes (Y and X). Show that it is opposite to how they appear in the alphabet, for example, first axis (vertical) is Y and the second axis (horizontal) is X.
- Explain about the point of origin (where vertical and horizontal axes meet) and how it is represented by 0, meaning origin and also the number zero.
- Explain about titles, keys and common abbreviations.
- Explain that graphs usually show how many and often use percentages.
- Explain how they are used to present, in a condensed way, a lot of data in workplaces e.g. about production, health and safety, quality, leave, statistics.

A tutor's guide:

Assisting learners solve written numeracy problems

- Discuss the concept of trends. Look up in a dictionary and link it to trends in other aspects of Charlie's life (sport, kapa haka etc.).
- Without looking at the graph activate Charlie's prior knowledge about off work injury rates over the last three years.
- Using Charlie's prior knowledge get him to look at the graph and identify how the graph lines show the trends he is aware of.

Additional reading and other useful resources

Reading

What's the Problem? For Adults Who Like a Challenge Solving Word Problems

This Canadian article contains a series of word problems. However, the real value in the resource is the analysis the author has done in relation to the word clues that can be used when teaching the language of addition, subtraction, multiplication and division.

See <http://www.nwt.literacy.ca/adultlit/problems/problems.pdf>

Resources

You can borrow additional resources free from the Workbase library. Contact info@workbase.org.nz.

General numeracy resources are available on the New Zealand Literacy Portal
see <http://www.nzliteracyportal.org.nz/Numeracy/>

Asking numeracy questions in a written form is commonly used within the tertiary education sector in New Zealand. Numeracy questions increase reading demands on learners which may have an impact on learners with foundation learning needs.

A tutor's guide: Assisting learners solve written numeracy problems is designed for tutors using written problems to assess adult learners' numeracy skills.

A tutor's guide: Assisting learners solve written numeracy problems provides tutors with a practical approach to analysing learners' difficulties solving written numeracy problems and also provides suggestions about teaching strategies to help overcome learners' difficulties.

A tutor's guide: Assisting learners solve written numeracy problems contains an easy to use step by step process which enables tutors to identify precisely where their learners are having difficulties. Eight case studies provide real life examples to illustrate how the process is used to identify difficulties.