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ABSTRACT

The six articles in this issue tackle topics that relate to the role and function of numeracy in adult life. "Reading Comprehension in Written Mathematics Problems" (Sue Wareham) examines the levels of reading ability required of numeracy students and offers strategies to help students with limited reading skills. "Can Ordinary People Do Real Maths?" (Joan O'Hagan) tackles the issue of "real" math through a review of historical, philosophical, and cultural perspectives on the nature of mathematics and considers the consequences for tutors and students. "Numeracy: A Core Skill or Not?" (George Barr) reviews the place of numeracy within recently established core skills frameworks. "Sorting Out Statistics: Confessions of a Numeracy Tutor" (Sarah Oliver) considers the place of statistics in life and in the curriculum. "Learning Contracts in Higher Education: Towards Confidence in Developing Numeracy Skills" (Ian Beveridge, Gordon Weller) describes the development of numeracy support for Access (a program which attracts a lot of single parent mothers, housewives with older children, and non-mainstream groups) and higher education students at Luton College, England. "Effective Provision of Literacy and Numeracy Instruction for Long-Term Unemployed Persons" (Joy Cumming), an article that reviews the provision of employment-related courses in Australia, evaluates the features of good practice in both literacy and numeracy, and considers the most effective approaches in developing numeracy skills. (YLB)

Viewpoints

A Series Of Occasional Papers On Basic Education

16. Numeracy

ALBSU
The Basic Skills Unit

Viewpoints

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16. Numeracy

Introduction

In the current debate about standards of basic skills, the focus is often on the nature of adequate literacy skills. However, the role and function of numeracy in our lives deserves equal consideration. What numeracy skills are needed in adult life, in or out of the work context? What linkage is there, or should there be, between the development of literacy and numeracy skills. Is numeracy a 'core skill' and, if so, to what extent? Is numeracy about skills or applications? Many of the issues that are raised by these questions are tackled by the authors in this *Viewpoints*.

Sue Wareham examines the levels of reading ability required of numeracy students and offers strategies to help students with limited reading skills. Joan O'Hagan tackles the issue of 'real' maths through a review of historical, philosophical and cultural perspectives on the nature of mathematics; and considers the consequences for tutors and students. Ian Beveridge and Gordon Weller describe the development of numeracy support for Access and Higher Education students at Luton College. George Barr reviews the place of numeracy within recently established core skills frameworks. Sarah Oliver looks behind the pie chart to consider the place of statistics in our lives and in the curriculum. Finally, in an article that reviews the provision of employment related courses in Australia, Joy Cumming evaluates the features of good practice in both literacy and numeracy. She considers the most effective approaches in developing numeracy skills.

Contents

Reading comprehension in written mathematics problems

Sue Wareham

Sue Wareham is a part-time tutor who works in Adult Education. She teaches literacy and numeracy at several centres in south east Essex. She is involved with the initial training of volunteers locally and the in-service training of ABE tutors in the county.

The ability to solve problems is at the heart of mathematics. Mathematics is only 'useful' to the extent to which it can be applied to a particular situation and it is the ability to apply mathematics to a variety of situations to which we give the name 'problem solving'. However, the solution of a mathematical problem cannot begin until the problem has been translated into the appropriate mathematical terms. This first and essential step presents very great difficulties to many pupils – a fact which is often too little appreciated......'

Paragraph 249. 'Mathematics Counts'

Why do students come to classes to improve their numeracy skills?

In my experience, working in Adult Education, students come to ABE groups wishing to improve their numeracy skills for a wide variety of reasons: to support the maths content of other courses such as book keeping, navigation; to apply their new skills to a hobby such as dressmaking or woodwork; to help their children with homework; to improve their job prospects or cope with the demands of promotion; to pass a skills test for entry into a profession such as the fire service or police; and lastly but perhaps the most important of all to improve their own self-image. This wide variety of aims and needs poses special difficulties for the tutor in terms of class organisation and management.

Management difficulties

In many ABE classes numeracy is taught within a predominantly literacy group and this presents special problems to the tutor. There may be insufficient numeracy students within the group to offer mutual support in the form of discussion. The tutor may feel obliged to match the student with a volunteer and provide worksheets or textbooks for their use. In the absence of volunteer help the student may have to work alone with the occasional support of the tutor. Indeed students who join the group with a short term specific aim, perhaps of passing a skills test for employment, may prefer to work alone.

Many areas of further education basic skills, including numeracy, are taught using flexible learning methods, perhaps with a workshop style of delivery. It is possible that this method of organisation occasionally places greater reliance on printed texts as teaching resources than perhaps the tutor would wish.

This special organisation and its reliance on either published materials or those prepared by the tutor raises several points which may be worth considering. Could the selection or adaptation of numeracy texts be an influencing factor in the students's understanding of the topic and in particular affect his skills in solving word problems? Perhaps there are also factors outside the text which affect success which should be considered such as maths anxiety, poor experiences at school, fear of failure and especially fear of encountering 'trick' questions.

Why are we obliged to make use of written arithmetic problems?

In order to become competent with everyday numeracy skills the student needs to meet many different applications of arithmetical operations. The application of some of these skills by adults in everyday life, those of mental arithmetic, estimation and the practical use of money does not often require the use of pencil and paper or necessitate translating the problem into words. Other situations, however, do require the recording of the number operations involved such as planning a budget or checking a bank statement. In order to extend the students' range of application of the basic concepts we offer practice in everyday situations by using arithmetic word problems. However we should remember that in real life situations we set our own problems according to the task in hand and these problems are rarely written down in words or sentences. Admittedly there is no substitution for the real life task and in many groups it is possible to maintain a very practical approach for example in a 'Plan, Shop, Cook and Eat' group. However for reasons of organisation mentioned above in groups of students with mixed purposes and aims the tutor is often reliant on texts to give the student the necessary depth and breadth to practise his skills. It seems especially appropriate to examine those aspects of a text which may promote or hinder success.

Solving a word problem

The procedure for solving an arithmetic word problem appears to fall into several stages. At a literal level the reader must read, comprehend and extract the relevant information from the text. He must interpret the meaning of the problem and identify the arithmetical processes needed to solve it before proceeding.

It is the early stages of this process, that of reading comprehension, which I propose to concentrate on in this paper.

How do we read a maths worksheet or a page from a maths textbook?

When presenting students with a worksheet or a page from a maths textbook we are expecting a variety of reading skills from them. The text may contain an exposition which could be a statement of the topic and its related concepts. There may be an explanation of new vocabulary, a new method or notation. The reader must read and absorb these items. There may be examples which the reader has to puzzle out and relate to the topic. There will be instructions which the reader must interpret and act on. After reading the exercise the reader must formulate a plan of action for solving the problem. He then moves outside the text to carry out his task. The above reading tasks all require close reading but there may be other parts of the text on the page, which may add points of interest or extend concepts, but which do not require such close reading. Nevertheless this part of the text still has to be read, assessed and possibly discarded as not useful to the task in hand. The page will also contain signals, such as headings, question and page numbers, which guide the reader around the page. These are not read in the conventional way but guide the eye, perhaps by identifying or clarifying parts of the text. In reading such a text the student is making use of his skills in reading everyday English but in addition to this he has to recognise each word or symbol and attach meaning to it. The reader must be active, the text informs, instructs and requires action. The reader must respond to the text by solving the problems presented. The text may also contain data, charts and diagrams. The reader must interpret these to build up a meaningful picture of the text.

How do we read a specific arithmetic word problem?

Reading a word problem is perhaps similar to reading notices, instructions or directions. The purpose of the reading task is for a specific outcome, to correctly solve a problem. All the information the reader requires to solve the problem must be in the text.

In a piece of prose writing the reader makes use of the redundancy in the text to aid prediction. In an arithmetic word problem the redundancy in the text is reduced giving the reader less opportunity to predict and necessitating more intense reading. While reading a prose text the reader has the opportunity, by making predictions and using redundancy in the text, to change direction, rethink and to decide if his previous predictions were right or wrong. A word problem gives the reader no opportunity to do this because there is less surplus information in the text. Because the language of the word problem is compact, application of the usual reading skills such as making use of context cues and grammar, is severely limited, if not impossible. The written maths problem can allow for no ambiguity of interpretation. If it does then you may get the wrong answer. Every word is valuable to the reader. It must be read, interpreted and its relevance to the problem assessed.

For example: 'Four brothers are left money in an aunt's will. The eldest has £200 and the others each have £100. How much money did the aunt leave in her will?

The word **each** is crucial to the correct solution of this word problem. If the word is omitted, ignored, regarded as irrelevant or just not understood, then the problem will not be correctly comprehended.

The mathematical language of numbers is very precise while the verbal language of the written problem is less precise. This inevitably raises problems of interpretation of the written language into the more precise language of numbers.

For example: three times two plus four

$3 \times (2+4)$ OR $(3 \times 2) + 4$

How can we assess the reading difficulty inherent in an arithmetic word problem?

Using a readability formula requires at least 100 words of text. Clearly this is an inappropriate way to assess the reading difficulty presented by an individual word problem. The formula cannot be validly used in this case. In fact, research by Katharine Perera[2] has shown that because of the terse and condensed prose used in the writing of these problems, readability scores, which have been carried out using mathematics text books, suggest that these books are easier to read than they really are.

Perhaps what is needed then is to examine what aspects of the language cause reading difficulty so that appropriate strategies may be used in the writing of the problems, by the tutor, in order to increase readability.

Sentence length is often used as a measure of sentence difficulty. In a prose or narrative text it is very often the case that a long sentence is harder to read, particularly if there are several clauses in it. Research reviewed by Perera[2] indicated that:

> "It does not always follow that difficult sentences will always be identifiable by their length; short sentences may be harder than long ones. If length were a true measure of complexity, then all sentences of the same length would be of equal difficulty."

The author explains in this paper that readability formulae do not take into account word order. Theoretically all the words in the passage under test could be listed in random order and the same reading level score would be obtained. Perhaps then problems may be caused to the reader by the **order of words in a sentence and its grammatical complexity.**

For ease of reading the simplest sentence structure is the basic subject, verb, object or subject, verb, adverb.

For example: Oranges cost 12p. I bought 2 oranges. An additional advantage of this structure is the focus of the reader's attention on the subject of the sentence which comes first in the word order.

Also at this level of complexity are simple arrangements of these structures into questions or instructions.

For example: What is the total cost? This basic structure can be extended by the use of adjectives, participles, conjunctions and also by the use of the passive tense.

For example: 2 oranges were bought. The complexity of the sentence is increased by the use of subordinate or comparative clauses.

For example: Carpet, which costs £10 per square metre, is to be laid in a room 10m long by 6m wide. Perera also advises caution in the use of ellipsis in constructing sentences. Ellipsis occurs when the reader has to mentally supply words in a gap left by the writer. The tutor who perhaps is attempting to simplify a lengthy problem may unwittingly increase the reading difficulty.

For example: One packet of cigarettes has five in it and another (packet of cigarettes) has four. How many cigarettes are there altogether? In some cases it may be better to recast the sentence rather than employ ellipsis. The writer of questions perhaps should also aim to develop a *flow* of language in the sentences and avoid the technique the reader has to employ in the following example, repeating the stem of the sentence.

A man had £6.00. He spent £4.45. How much has he left? Give the answer a) in pounds b) in pence.

Research carried out by Riley[3] into the semantic structure of arithmetic word problems indicates that sentences expressed in different ways are not equally difficult to understand although they require the same arithmetic operation to solve them.

For example: a) Joe had three cigarettes. Then Tom gave him five more. How many cigarettes does Joe have now? (b) Joe had some cigarettes. Then he gave five cigarettes to Tom. Now Joe has three cigarettes. How many cigarettes did Joe have in the beginning?

Thus the ease of solution of a problem is affected by variables such as the length of the problem, its grammatical complexity and the order of statements in the problem. The syntax employed in the writing of a problem may affect the student's comprehension but another factor which should also be considered is the vocabulary used in the writing.

How can the reader cope with unfamiliar words in a written problem?

When a student reads a word problem she brings to the text her knowledge of the world and her knowledge of language. To make sense of a word or phrase the reader will make use of the context, syntax of the text and her previous experience.

Pimm[4] gives the example of a student who was asked to explain the mathematical term 'on average'. The student replied, "It's what hens lay on." Further investigation revealed that the student had read somewhere, 'Hens lay on average 300 eggs per year'. Indeed, the student was justified in the meaning he assigned to the word from the sentence he was relating it to from his previous experience.

Words which are infrequently used, or are perhaps unfamiliar to the reader because they occur only in a mathematical text, can make it difficult for the reader to extract enough clues from the context to clarify meaning. An additional consideration may be that if a word is familiar to a reader in one context, with one meaning, it may be unfamiliar when used with a different, less common meaning. For example, the word 'mean' is used in a mathematical context as a synonym for average whereas in everyday English the word may be used differently.

For example: I don't know what you mean.
He has a mean look about him.

The clarity of language, both verbal and written, is crucial to a student's understanding of the task in hand. In a class situation it may be useful for the text to be discussed by the student and tutor but in some group situations this is just not possible. Perhaps then a student's difficulty with comprehending a written task or problem may be aided by developing his understanding of the register of mathematics, its similarities to and differences from ordinary English, that is written English used outside the mathematics context.

The learning and teaching of numeracy involves the use of both everyday English terms and more specialised mathematical words. Kane[5] introduced the terms Ordinary English and Mathematical English to help analyse the special nature of written mathematics. He says that: 'Mathematical English and Ordinary English are sufficiently dissimilar that they require different skills and knowledge on the part of readers to achieve appropriate levels of reading comprehension.'

As mentioned earlier in this article mathematics sometimes uses words or phrases which a student may encounter verbally or in an English text and assigns its own specialised meaning to them. The word product, for example, is used in an everyday sense to refer to consumer goods or the items made by industry. In arithmetic the word has a more specialised meaning. A student who is unaware of the specialised meaning of words such as these may have difficulty comprehending the text if there are insufficient context clues to help him.

The Cockcroft Report[1] states that:

> 'The policy of trying to avoid reading difficulty by preparing workcards in which the use of language is minimal or avoided altogether should not be adopted. Instead the necessary language skills should be developed through discussion and exploration.'
>
> Paragraph 311

In a class situation where numeracy group work is possible it may be valuable for the group to discuss the different words they use to express a numerical problem.

For example: 10 - 8 take away
less than
subtract
minus

A comparison could then perhaps be drawn between these words and other expressions which also imply subtraction.

For example: Bread reduced by 2p today, buy now!
What does the word deductions mean on my wage slip?
If I buy a new bicycle now the shop will give me a discount.

This discussion could then be extended, if appropriate, to examine the use of the word 'difference', to mean subtraction in an arithmetic question and its use in everyday English. The answer to the question: 'What is the difference between 27 and 6?' depends on whether the word difference is interpreted in an everyday English sense or in its more specialised meaning in arithmetic. In arithmetic it means subtraction. In an everyday interpretation the difference between 27 and 6 could be that one has two digits and the other one, or that one is an even number and the other odd.

Mathematics uses words with a high technical content. Many mathematical terms have semantic roots in the classical languages, Latin and Greek.

These words can cause particular difficulty to students as they may only be encountered in the mathematical text and often it is not easy to deduce meaning from them. Introducing the roots of words new to the student may be a productive way of generating interest in the topic by relating it to history.

An interesting example of the links the mathematical word may have with ordinary English may stimulate the memory for later recall.

For example: bisect

'bi' means two	'sect' means cut
bicycle two wheels	section
biceps	dissect
bigamy	sectional

How can the tutor help the student predict the meaning of unknown words?

As previously discussed, the brevity of the language used in the writing of a word problem can cause difficulty for students if they encounter unfamiliar words. Earp[6] found that care must be taken with even the simplest words when writing problems. He presented secondary school children with a simple homemade worksheet on fractions. Pupils were asked to complete both phrases

______ parts shaded

______ equal parts

Most students correctly completed '3 parts shaded' but several alternative answers were offered for '______ equal parts'. Some students suggested 2, presumably referring to the unshaded sections. Others suggested 3, three parts are shaded and these are three equal portions. This is thus a valid answer. Some suggested five, referring to the whole figure. Obviously the intention of the writer in the phrase 'equal parts' was not clear to the reader.

In reading a prose text a competent reader will usually determine the plain sense, that is get the gist, of the passage fairly quickly. Then, more slowly, by asking questions of the text and drawing inferences the reader begins to comprehend the implications of the message. He gradually builds up a meaningful whole and makes sense of the passage. It is this meaningful message which tells us that, for instance, the word **read** should sometimes rhyme with **bead** but that in another context it should rhyme with **bed**. It is not what our eyes see that tells us which is which but the message in our heads.

> 'The brain tells the eye more than the eye tells the brain.'
>
> Frank Smith[7]

If an ambiguity of meaning arose in a prose text the reader would search for clues to clarify his interpretation by re-reading, looking at the context and perhaps analysing the syntax. In these very terse expressions '______ parts shaded', '______ equal parts', not only is the reader expected to react promptly to the text by filling in the answers on the sheet but he has to do this without a richer context to help him. The exact comprehension of the text, as in all arithmetic problems, is vital for obtaining an accurate answer. Earp suggests providing a richer context by writing:

> 'The shape has been cut into ______ equal parts and ______ of the parts have been shaded.'

An example offered as an introduction to a worksheet such as this would also aid comprehension.

Thus it may be helpful if the tutor extends the context of the question to give the student more opportunity to predict the meaning of unknown words.

For example: A loaf cost 65p yesterday. Today it is reduced by 2p. What will I pay?

If the student is unfamiliar with the word **reduced** there are no clues in the sentence to help him. Perhaps the question could be extended to:

> A loaf cost 65p yesterday. Today it is **cheaper**. It is **reduced** by 2p. I will pay 2p **less than** I did yesterday. What will I pay?

The meaning of the unfamiliar word reduced can perhaps now be predicted by using the clues of **cheaper** and **less than**.

Does the context in which a problem is set affect comprehension?

Research by Rees and Barr[8] concluded that using a familiar context in arithmetic questions aided adult students. They posed two questions to a group of students whose ages ranged from 13 years to 57 years old. The first question was a pure arithmetic one, not set in context.

Pure question Find the average of 15, 17, 18·25 and 15·75

The second question required the same arithmetic operation to solve it but the question was set in context.

Context question The weekly wage of four teenagers is £15, £17, £18.25 and £15.75. What is the average weekly wage?

The results (shown on the next page) indicated that having a question set in context improved the performance of all students in the study. However, the improvement was most noticeable in adult students, where there was a 14% increase in the success rate.

Results of the study:

	% Correct		
PURE	49%	24%	56%
CONTEXT	54%	31%	70%
AGE	13-14	13-14	19-57
	mixed ability	slow learners	TOPS trainees

These results suggest that having a purpose, preferably a familiar one which the student can relate to the real world, improves his performance. This relevance of purpose also, of course, applies to reading comprehension which is improved if the student can see that the reading task is purposeful. We should also consider perhaps that an arithmetic problem which is done for its own sake to be marked by the student or tutor as right or wrong may induce feelings of pointlessness, anxiety and fear of failure. In the real world we are less exposed to right and wrong situations, there are more grey areas. The tutor may thus wish to consider the motivation of the student when seeking relevant contexts for questions. Students may wish to use their numeracy skills for employment purposes, such as ordering materials, checking invoices and calculating VAT. Others may need help to extend their numeracy skills to enable them to understand recipes, instructions for beer making or other hobbies, as well as the everyday tasks of shopping and money management. Whatever context the question is set in the knowledge of the arithmetic principles needed to solve it must be sound. The ability to transfer skills learned to be used in many and varied contexts is perhaps what the tutor and student would together wish to develop.

How can the tutor help?

Working with adults, we build on the student's present knowledge and past experience. If a student can do a sum such as 8 + 3 this could be used as a basis of a problem construction task. If the answer to the problem is known there is less anxiety in the situation. In reversing the problem solving situation, by asking the student to actually compose the problem, the student will feel more secure. Moving from a word problem to a solution is a step into the unknown, fraught at every stage by the possibility of error. Asking the student to compose his own problem may help to remove this fear of the unknown.

TASK 8 + 3

Find a problem to match the sum. Think about:

- getting a wage **increase**
- food prices **rising**
- putting on weight
- buying **extra** milk.

TASK 14 - 2

Find a problem to match the sum. Think about:

- **losing** weight
- bus fares **going down**
- sale prices, everything **reduced**
- spending money, having **less** in your purse or wallet
- smoking **fewer** cigarettes.

A conscious use of vocabulary which implies addition or subtraction may provide a useful discussion point.

If this strategy is used, the student, as the author of the problem, is then in the best possible position to read and interpret it. Writing texts aids our understanding and analysis of the texts we read. Indeed at a fundamental literacy level a tutor may make use of this language experience approach in the teaching of reading. The method seems to lend itself also to composing, analysing and solving arithmetic problems.

Pages of sums, although providing reinforcement of newly learned concepts, do not aid in the application of skills. A student who perhaps needs support with reading may be helped, after the initial concept has been introduced and reinforced using numerical examples only, by offering a written problem with limited words. The problem could be presented in such a form that inaccurate reading will not affect the correct solution of the problem.

For example: student and tutor play the card game pontoon. The numerical skills needed are addition and subtraction. The purpose of the game is to have a hand of cards totalling as near to 21 as possible. When the tutor is certain that the student is competent with the numerical skills needed, a written worksheet of the format below could be introduced.

Worksheet

These are the cards in my hand.

What is my score? 8 3 4

Inaccuracy in reading the problem should not affect the correct solving of it.

For the student who can read well but has difficulty comprehending the appropriate numerical skills required to solve the problem other strategies may be useful. A range of problems needing the same arithmetic skill to solve them, but expressed in a variety of ways, could be presented to the student. The student could then decide if, for example, addition or subtraction is needed without actually doing the problem.

For example: To find an answer what do I need to do?
My bus fare costs 30p. It goes up by 5p.

Talking through the problem with a tutor or another student may clarify the course of action necessary. The tutor may then wish to vary the approach and offer questions with a choice of two skills.

For example: To find an answer do I need to add or subtract?
The petrol tank in my car holds 6 gallons of petrol.
It has 3 gallons in it now.
How many gallons do I need to fill it up?

The tutor's role in developing and using techniques to aid the student in interpreting the text and solving the problem seems to be crucial. A judicious use of hobbies and life skills matched to the student's interests and needs can be invaluable, in the development of understanding and the application of skills learnt, to the student's life.

When preparing worksheets, the tutor may also wish to consider the effect which the layout of the text, the size of print and the position of diagrams may have on comprehension. It is also clear that discussion and oral work should play a prominent part in establishing and reinforcing any concepts formed before they are applied to a suitable and relevant context. The adult student will find it easier to solve a problem which he can relate to his own experiences. It is also important that the mathematical concepts should be presented in varying contexts to extend the versatility of the student's skills in problem solving.

The degree to which the syntax and vocabulary of the question can influence the problem outcome should also be considered when writing questions for students. The simplest, most straightforward form of expression should be chosen and where possible students should be encouraged to compose their own questions. The differences between reading a mathematical text and an English text are considerable in the extra demands the mathematical text makes on the reader. The student's reading task is made more difficult by the economy of writing in the text which makes prediction of unfamiliar words difficult. The mathematical text allows for no ambiguity and demands an instant response from the reader in the form of solving the problem. We should be aware that we are asking so much more of a student than just the arithmetic calculation. Indeed once the problem is understood, its translation into the appropriate mathematical symbols and working out a solution may itself not be so straightforward.

For example: I have 60p. I give John half of it. How much do we each have?

$\frac{60}{2}$ $\qquad 2\overline{)60}$ $\qquad \frac{1}{2}$ of 60 $\qquad 60 \div 2$

Translating the written word into arithmetic symbols is yet another major step for the student.

Summary

Student Difficulty	Tutor Strategy
Unfamiliar words	Provide stronger context cues
Ambiguity of meaning	Provide stronger context cues Develop understanding of mathematical register Discuss use of words in arithmetic problems
Technical words	Controlled introduction of new words Make a glossary of terms Repeat definitions Verbal reminders Marginal comments on worksheets Examine semantic roots Use new word in several contexts
Confusion of word meaning	Discuss compare everyday words with those words used in a special way in arithmetic Choose oral language carefully
Length of sentence	Several short sentences preferable to one of high concept density
Order of words in a sentence	Begin the sentence with the subject Use the present tense if possible Avoid inferential statements
Grammatical complexity	Avoid use of subordinate and comparative clauses Choose simple sentence structure
Lines of print too long	Line break the text
Inadequate signals for eye movements	Bolder question numbers Use of colour, simple diagrams Diagrams positioned near to relevant text
Inadequate legibility	Increase size of type/writing Increase spacing between words Use lower case where possible
Confusion between typed digits and letters	Handwrite 1's and l's
Too much print on the page	Write individual questions on cards
Unfamiliar/Inappropriate context	Give students initiative in choosing context – maximise motivation Give opportunity for practice in different contexts Ensure context relates to familiar everyday tasks Encourage students to write their own problems
Fear of failure	Re-inforce understanding of numerical concept Increase confidence by using group work Maximise enjoyment Create a supportive, relaxed atmosphere Use any mistakes constructively Build in self-checking devices

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Can ordinary people do real maths?

Joan O'Hagan

Joan O'Hagan has taught mathematics and numeracy in schools (very briefly) and in Further and Adult Education. She now teaches in Fircroft College of Adult Education, Birmingham. Some students on the one year residential course are maths-phobic, and some need to reach GCSE-equivalence. Sometimes it's the same person. . . .

This question matters to me for several reasons:

- Queries are still raised both inside and outside ABE about the academic legitimacy of ABE maths/numeracy (Is working out what train to catch to get to an ALBSU training event for 11am real maths?)
- Tutors, perhaps especially those who have come to adult numeracy/maths work through adult literacy, have difficulty in reconciling what they see as the need for mathematical rigour with the kind of adult-student-centred approach they tend to adopt (How do you build on adults' previous learning experience when a great deal of it has been negative? How do you build on their previous knowledge when a great deal of it is confused? How do you avoid the trap of constantly telling students they've "got it wrong"?).
- Some tutors, perhaps themselves unconfident about their own mathematical ability, are concerned that they may be short-changing students by giving them access only to a second-rate, hand-me-down type of mathematics – and these tutors may be painfully aware that these students may already have been and felt short-changed by educators before in ways which relate to their gender, ethnic origin, or class.
- Some ABE students want to follow up their initial, generally numeracy-based work with a broader, richer mathematical diet – can we help them prepare for this by encouraging them to do "real" maths early on? And some students want, from their first contact with adult provision, to have this rich mathematical experience.

These issues arise in a climate where the debate in the seventies and eighties about adult-centred process has been largely overtaken by a debate about measurable outcomes; against a background where increasingly, nothing moves unless it's assessable – (i.e. nothing gets funded unless it's assessable), in a situation where ALBSU has taken a strong lead on accreditation with a scheme (Numberpower) which also operates as a curriculum driver. We all need to be clear about what constitutes "good" or "real" or even "really useful" mathematics.

In this article I'm describing a line of thought in which I am trying to weave together into a coherent position what I've read about philosophy of mathematics with what I've seen and heard when adult students (including myself) are learning and doing mathematics. I am logging a personal learning journey which I made in an ad hoc, fairly unstructured manner – I drifted into philosophy of mathematics. I stumbled across Lakatos, and then thought I could see connections with multiculturalist and feminist epistemology. I know now that school teachers have been thinking along somewhat similar lines – Paul Ernest (1991 and 1992) has written at length about similar questions as they arise there. The journey for adult tutors has, however, different signposts and requires analysis of different material; so it has been well worth doing; but the process has reminded me that adult tutors are still too isolated from each other and from school-teachers. I am very glad therefore, to be able to write this article, and I'd like to echo Diana Coben's (1992) call for a forum for adult numeracy/maths research.

I'm also aware that I'm not dealing directly or fully here with questions about **how** "basic" adult students learn maths, about the psychology of the process. I am mainly interested here in whether their processes are to be taken seriously as potential sources of "real" mathematics.

Nor am I trying to have the last word on whether students should be encouraged to stop doing "numeracy" and do "real" maths. I want to increase students' options, not curtail them. And anyway, maybe it's possible, perhaps even preferable, to use "real" mathematical thinking in a numeracy curriculum.

I'm reminded of a story told to me by my mother. She reported a lively discussion among her friends about value for money in washing-up liquids (a classic Numberpower situation). They were all willing to accept that super-concentrated liquids wash more dishes than the cheaper (per ml) varieties, and that the cost per dish worked out less with the super-concentrated ones. Therefore, said her friends triumphantly, we should buy the super-concentrated ones. Full Numberpower marks to them. My mother pointed out however that the way in which they, all of them doing small amounts of dish-washing at a time, consumed the liquids, was crucially different from the TV advert household. She suggested that there is a minimum amount of liquid which you use each time – function of the size of the hole in the lid and of the squeeziness of the plastic bottle – and she suspected that this minimum amount of the super-concentrated stuff was far more than was needed at each washing-up session, whereas the minimum quantity of the ordinary ones was sufficient. Therefore, she hazarded, you were wasting the advantage of the super-concentrated liquids by in effect under-using them. Super-concentrated manufacturers (like mustard makers) were making money from the stuff you threw away. It seems to me that she, without a number in sight, had embarked on a good piece of mathematics; her friends were doing good Numberpower numeracy. And clearly the key consumer insight was the mathematical, not the numeracy one..........

So what is "real" maths?

Classical views (for thoughtful analyses of these views see, for example, Davis and Hersh 1980 or Ernest 1991) of the nature of maths tend to be very prescriptive and absolutist, centring on the idea of formal proof as the key to both describing and doing legitimate mathematics. Proofs are to be built up into unassailable fortress-like structures; the legitimate public language of mathematicians is about attacking and defending positions; and there are absolute truths of mathematics waiting to be either discovered or invented. And accounts of mathematics education allied to these positions tend to be concerned with education as authority-based transmission of culture. To the ABE tutor, accustomed to encouraging students to build on, and to analyse and generalise from, their shared experiences, these models offer little.

Truth through proof?

A brief look at these absolutist positions highlights the importance of the issue of proof as a test used by professionals of whether they are doing mathematics at all or doing it well; and therefore as an issue which adult students and educators need to look at.

A Platonist view holds that mathematical objects are real – as real as any other ideas. They exist independently of the efforts of people to know about them. The task of the mathematician is to know these objects: to understand for example the nature of space.

Euclid described his discoveries about one of these real mathematical entities – space – as a process of relentless deduction of theorems from a number of axioms about the real world which he felt were so self-evident that they did not need to be justified. When exploration of alternatives to one of these axioms generated non-Euclidean geometries through the Euclidean method, the link between the Euclidean method and the truth value of its proven theorems was broken. Some mathematicians moved away from belief in geometrical axioms as the basis for all mathematics, whilst holding onto the hope that Euclidean method could be applied from a different starting point to the problem of underpinning mathematical thinking. Number was chosen as the new basis, but this in turn proved to be problematic when it became necessary to introduce irreconcilable ideas about infinite sets. Frege tried to base mathematics on logic alone, but ran aground on Russell's paradoxes about self-referential sets. Russell then worked with Whitehead to try to reconstitute set theory in such a way that it did not lead to such paradoxes. Unfortunately, the system became so tortuous that Russell gave the project up – "Having constructed an elephant upon which the mathematical world could rest, I found the elephant tottering, and proceeded to construct a tortoise to keep the elephant from falling. But the tortoise was no more secure than the elephant, and after some twenty years of very arduous toil, I came to the conclusion that there was nothing more that I could do in the way of making mathematical knowledge indubitable." (Russell, Portraits from Memory). Yet another attempt to put maths back onto a respectable basis was made by constructivists, who started from the belief that natural numbers are given to us by fundamental intuitions; and who say that real maths consists in using only something called the finitary method on these objects to create other objects – no objects which cannot be created by this process exist as valid mathematical objects. This solves the problem of the infinities more or less by pushing it off the stage. Hilbert's formalism, based on constructivism, also tried to resolve the Russell antimonies by sidestepping the Platonism question with a declaration that maths wasn't about anything in particular, it was to be defined as a method of manipulating ideas. Unfortunately Godel's theorem wrecked Hilbert's programme by establishing that it was impossible to prove consistency within arithmetic without recourse to methods from outside the system.

For the non-professional mathematician, these absolutist positions give very little hope of admission to the fraternity. At best, mathematics seems to be do-able only by people with long rigorous years of training; at worst it is actually impossible. The adult educator working with students at a basic stage, feels disinclined to encourage them to embark on activity which would lead, after twenty years of very arduous toil, to disappointment. Perhaps we should, after all, encourage ABE students to narrow their horizons and do "numeracy" instead of "maths"?

The failure so far of absolutist stances might on the other hand give the ABE worker grounds for optimism; at least she doesn't have to try to attain the unattainable absolute: though the optimism is short-lived if she is thus sucked into a suffocating epistemological vacuum.

Are alternatives available?

Some alternative epistemologies.

Lakatos

Imre Lakatos's (Lakatos 1976) attempt to resolve the problems generated by adherence to absolutist views about the nature of mathematics and of proof starts from an acceptance that mathematics may not be preservable as an infallible system, even in principle.

and that this aim of philosophers of mathematics is best abandoned. He doesn't feel though that this is a position which is limiting in any sense – on the contrary he dislikes formalism because it "denies the status of mathematics to most of what has been commonly understood to be mathematics, and can say nothing of its growth" [Lakatos, op.cit. p2]. He was interested in recognising mathematics as a creative activity, engaged in by fallible people who make observations about real or mathematical objects, guess a generalisation, work with other people to try to falsify it in a Popperian sense, and build a proof of the conjecture. He uses "proof" in a pre-Euclidean sense, as meaning a "thought experiment which suggests a decomposition of the original conjecture into subconjectures or lemmas, thus embedding it in a possibly quite distant body of knowledge" [Lakatos, op.cit. p9] and suggests that a major function of attempts at proof-building is to help improve a conjecture even where, in fact especially where, no Euclidean "proof" of that conjecture is found. He is prepared to give up the idea that proofs ultimately prove anything in favour of this idea that the process of proof-building improves thinking. He maintains that by this process of publication and analysis the mathematical knowledge generated in the subjective domain of an individual's mind transforms and becomes objective knowledge.

Proof-building – style and function

The process of proof-building involves the generation of sub-conjectures or lemmas, and the subjection of them to a process of attempted refutation. But this attempted (Popperian) falsification is a positive process: there is always the strong possibility that whilst sub-conjectures or lemmas may be refuted by local counterexamples, and the main conjecture by global counterexamples, this may lead to the creation of new mathematics, or at least to a much deeper understanding of the original conjecture. After all, "Columbus did not reach India but he discovered something interesting" [Lakatos, op.cit. p14]. Although the cultural relativists referred to later might have something to say about the Eurocentricity of that remark). An apparently fatal counter-example may be seen either as a malignant monstrosity, or it may be a wonderful opportunity to clarify and define the scope of the earlier thinking, to think laterally, to open up new areas and ideas, to move on from the first conjecture or problem to a more enlightening one. Defensive formalist or logicist thinking on the other hand may lead the mathematician into retreating into an unnecessarily safe position, throwing out the baby in an attempt to resist contamination from polluted bathwater; or may lead to the sort of endless revision and refinement which gets the thinker no closer to certainty, and behind which lies the realist nightmare that mathematical objects may be infinitely complex and therefore incapable of description by finite minds working with finite language.

Informal mathematics

Lakatos' ideas about informal mathematics are crucial here. He asserts that informal proofs are valid, that they are not just "formal proofs with gaps"; he shows us, (Lakatos 1976) and comments extensively on, the genesis of an informal proof of Euler's [$V - E + F = 2$] theorem for polyhedra. This proof is arrived at by a **group** of students who take an initial conjecture and subject it to a process which allows them to use their intuition, which values and uses the dynamics of idea generation within a group, which positively encourages an atmosphere in which speculations are freely made, which uses peer scrutiny to deepen the group's understanding of the original conjecture and which expects and values "unexpected" outcomes in that it generates **new** mathematics. This is a kind of proof, a kind of activity, which, in my judgement, adult students find satisfying, because the prover is engaged in a process of the creation for herself of new knowledge and maintains ownership of the knowledge throughout. This definition of mathematics, and this heuristic, have a great deal to offer to adults, wearied as they often are by mathematical experiences which demand that they subscribe to "truths" of which they feel no ownership. And if this is mathematics, I would wish to encourage students to do it, and I would wish them to gain credit for doing it.

Lakatos however doesn't give us much guidance about where the initial conjectures come from: I turn now to related epistemologies which comment on the nature of mathematics and of proof from a sociological perspective.

Multicultural considerations

Proof in Vedic Mathematics

Another way of thinking about tests of the acceptability of mathematical conclusions lies for me in my experience of the techniques of Vedic mathematics. Vedic mathematics is a system based on the Vedas, Indian manuscripts dating from around 1000 BC, and has been made accessible in this century by Sri Bharati Krsna Tirthaji (1965). I was learning (in an ILEA adult education evening class taught by Andrew Wright at The Polytechnic Of North London) Vedic algorithms for whole number multiplication and division, and I found after some practice that I was seeing the answers to problems before I'd worked through the Vedic algorithm; as I checked my answers by going through the algorithm I came to rely more and more on my initial judgement and less on the algorithm, which became sometimes merely a second way of checking my first, confident answer. I felt I was becoming intuitive about the answers to numerical problems, and was surprised at this. My teacher agreed that surprise was a fairly common experience among Western trained people. I then found that Pratyagatmananda Saraswait [in his foreword to Tirthaji's 1965, p.13] talks about conscious or unconscious mathematical thinking, and allows that "even some species of lower animals are by instinct gifted mathematicians: for example the migratory bird which flies thousands of miles off from its nest-home, and after a period, unerringly returns". He later insists that when you are called upon to prove, you must have recourse to logic, but he has distinguished clearly between doing mathematics and proving mathematics – it is legitimate to claim to know before you have proved, and indeed, "proving" is not a necessary part of the mathematics; it's merely something that you may (or may not) be "called upon to do". The suggestion is that this style of proof is embarked on as a way of convincing sceptical western mathematicians of the validity of the methods, although the proponents do not feel this is always necessary for them.

I have found direct echoes of this issue when working on Vedic mathematics with maths phobic adults. The introduction of one of the simplest Vedic algorithms has inspired students to work together to create ideas about how to extend and develop the algorithm, to express and test the ideas, to see mathematics as a human artefact rather than as a set of rules which rain down on unfortunate students from some great epistemological height, and to think about whether/when they hve created or proved mathematical ideas.

Relativism

This perspective on cultural translation of ideas is echoed by George Joseph (1992) where, tracing the development of Greek and Western mathematics from Indian and Chinese origins, he talks about the claim that mathematical proof began with the Greeks and that earlier maths can be dismissed, as Kline does, as "scrawlings of children just learning to read" (Kline, 1962, quoted in Joseph op.cit.). He points to a different kind of (inductive) proof in Egyptian and Mesopotamian mathematics he argues that this method of piling example on example was culturally more relevant and acceptable to those mathematicians and to the communities for whom they were creating mathematics than a Western style deductive proof would have been. Joseph, and later Bishop [1990, p51], also suggest that mathematical ideas may be created and should be understood within that context, and that we should resist the easy temptation to get involved in crude comparisons across cultures and oppositional ways of deciding between ideas. Bishop, for example, talks of the cultural dependency of Euclidean ideas on an atomistic and object-oriented view of space, (points, lines, planes, solids) in contrast to a Navajo idea of space as neither subdivided nor objectified and where everything is in motion. This could be expected to produce a different kind of geometrical ideas. This kind of relativism, and this lack of trust in the Euclidean method opens up ways of viewing mathematical ideas and methods which have until recently been seen as outside the Western paradigm.

Feminist epistemologies

More strands in this piece of epistemological weaving comes from feminist ideas which argue in various ways for a form of relativism which is not however weakly subjective. Griffiths [Griffiths and Whitford 1988, p9] argues that to separate feeling from knowing is to run the risk of distorting scientific knowledge. I am reminded of how often adults are blocked because although they may see, even subscribe to a classical proof of an idea, they can't reconcile that with their feelings about it and so they don't really know or believe the idea. If the conflict is not resolved they are likely to operate on their gut feelings rather than on their (to them) empty and unconvincing intellectual conclusions; and mathematical knowledge is thus distorted. Seller (1988) suggests that an epistemology which has some democratic features offers the prospect to ordinary people of arriving at valid propositions in a finite time. She links this with an argument [op.cit. p182] that "the ultimate test of a realist's view is their acceptance by a community", and maintains that "it is not that every individual's unexamined and undiscussed experience is true, much less her opinions, but it is only *through* examining and discussing individuals' experiences that we can do what the realist called finding truth, what the relativist calls contributing to the structure of reality". Walkerdine (1989, p37) suggests that the domination by male thinkers of the mathematical stage is related to a view of and a need for unassailable truth through proof; and that this is an unnecessary restriction. These insights are useful in clarifying further the nature of knowledge as something generated from individuals' subjective realities, which when mediated through discussion, become objective knowledge.

There is another aspect to this discussion about gender which relates to the discussion about different mathematical truths arising from different cultures. Work by Mary Harris (e.g. the Common Threads exhibition) and Claudia Zaslavsky (1973) suggest that women and men arrive at the same mathematical truths, although by different, gendered, routes. This is quite different from what has been suggested earlier about for example the nature of ideas about space in different cultures; and perhaps the question should remain open here. What the two perspectives have in common is the idea that very differing experiences may lead by differing ways to mathematical truths, and that an appropriate learning style includes the examination of all these experiences.

Where does this leave basic maths students?

- Students are Lakatosian when they are adventurously engaged in investigational mathematics.
- They are Platonists when they are defending the study of maths against people who are more interested in, for example, literature – they say that they are finding out true facts about the universe, which is more than can be said about story-tellers or literary critics.
- They also resort to Platonism when the going gets rough – when they find abstraction difficult they often ask me what it's all for, insisting that it must relate to some piece of real knowledge about real things in the real world, although they actively enjoy abstraction when they're being successful at it.

- They are enthusiastic cultural relativists when they are working on Vedic mathematics, or Mayan or Igbo counting systems, or embroidery patterns.
- To the extent that they are confident of their own judgement, they are happy conventionalists – although they are often surprised to find themselves in this state – and indeed I think of this as an indicator of confidence and of mathematical maturity.
- They sometimes "succumb" to formalism when, in the first flush of relief at being able to handle "x" they don't want to use "x" for anything, they just want to push it around a lot.
- Some unconfident students are heartily opposed to the adversary method, feeling that they will never be able to venture any thoughts if they are to be immediately criticised, however gently. Lakatosian-style discussion however, with its respect for everybody's ideas and its delight in unexpected outcomes, is a much more attractive proposition. (Other students with about the same amount of confidence welcome the security of knowing that someone else, but it must be someone whose academic authority they respect, will immediately "put them right" if they have strayed from truth. I think this split happens in most adult learning, and I feel that significant learning growth has happened when students can choose comfortably to operate in different styles at different times).
- ABE students deciding in learning groups whether to add or subtract numbers to solve a problem are conventionalist mathematicians. They are following a Lakatosian schema in which, by the "incessant improvement of guesses by speculation and criticism, by the logic of proofs and refutations" [op.cit. p5], their mathematics is validated by agreement among the learning and practising community. By the same argument, students being **trained** by us to "do" word problems or to fill out cheque stubs are not. Study circles such as I have seen operating at Walk In Numeracy and at Fircroft, where students often carried out mathematical projects without appealing to outside authorities (teacher or textbook) for proof-approval, were mathematizing. I have often been called in by a group to discuss the second stage of a piece of work, where they were quite sure they had dealt with the first part satisfactorily – although I had provided no solutions, they had not found any from outside the group and the mathematics was new to them. If it be objected that they are too inexperienced a group to legitimise their own behaviour, I need only point to the dilemma of professional mathematicians who may be working within equally limited groups – John Von Neumann [quoted in Davis and Hersh, 1980, p18] estimated in the 1940s that a skilled mathematician might know ten percent of what was available. If we allow that the professionals are mathematizing, we must allow that ABE students are too.
- Lakatos and the relativists legitimize a practice which can start with naive guessing – although inductive guesses may be more fruitful. This means that a legitimate and very fruitful starting point for students can be their own guesses about mathematical objects. Better still is a combination of such naive guesses with guesses which arise from even limited observations of special cases. Androgogical practice, where the experiences of individuals can legitimately be taken as starting points, and where part of the aim of the exercise is to take that experience, explore its meaning, generalise from it, and test that generalisation by comparison with the experience of other people is thus validated.
- Students can feel entitled to move around a topic, following promising lines of thinking without feeling that they ought to know where they're going before they get there (this last is the stultifying trap waiting for the Euclidean mathematician, who is relatively uninterested in theorems which arise incidentally on the way to the proof of a theorem which has been ascribed prior value). Students are spared the long and linear march towards a pre-ordained truth, since to mathematicize well, it is positively important to look down all the interesting by-ways which appear. Mathematical thinking can thus be student-led, can reflect their interests, their culture and their experience; and can, by application of the creative process of proofs and refutations, improve the skills of the thinker.

And how do things look for the tutors?

- The tutor has a clear role in helping students to arrive at initial conjectures by drawing on previous experience; the tutor is not put in the uncomfortable position of constantly carping critically at this experience, since the relativistic epistemologies suggest that knowledge and understanding will emerge from critical evaluation by students of this experience. The tutor's role here is to encourage students to express their current understanding of ideas, even if she feels that this understanding is incoherent, internally contradictory and just plain "wrong". Given a clear agreement in the learning group that **all** ideas are to be critically evaluated, tutors can escape from the pressure to follow the expression of an "incorrect" idea by an immediate denial or correction.
- The tutor's role then becomes that of the teacher in Proofs and Refutations – to chair the discussion, to be willing to contribute insights from her own experience, to help students keep track of the discussion, to be sufficiently experienced to make connections which students are not yet ready to see, to be skilful in deciding when to suggest these connections to students; and very importantly, to provide from that wider experience, Popperian falsifiers against which students can test their conjectures in a finite time scale.

Tutors cannot always of course hope to chair high-minded (or even entertaining) Lakatosian discussions, we often resort to absolutist heresies themselves (we get it absolutely wrong!), and we have to keep at least half an eye on the summative assessment around the corner. Students cannot always courageously express and scrutinise ideas. So what? Real mathematicians aren't consistent about their methods either – being, according to Cohen and Dieudonne [Davis and Hersh 1980] realists on weekdays and formalists on Sundays.

For me as an adult numeracy/maths tutor, trying to make a synthesis/analysis of the varied strands of my experience, this initial exploration of a fallibilist philosophy of mathematics and of mathematics education has been a foray into fertile territory. Cultural relativism, validation of informal mathematics, accreditation and sympathetic analysis of adults' prior learning, seeing students create mathematics before my very eyes – what more could I ask for? And now I know it's **real** maths too?

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Numeracy: A core skill or not?

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Introduction

This paper addresses some of the issues involved when looking at numeracy and trying to decide whether it is a core skill or not. The issues that are seen as critical in making a decision on this question are the definition and specification of numeracy and the potential for transfer of skill from one context to another.

Numeracy together with communication skills, has always been seen as an essential ingredient in a core skill framework. Many different core skill frameworks have come and gone in the past few decades. Tim Oates (1992) provides a brief background and chronology to the current developments in core skills in post 16 education and training and his previous work gives an even more detailed history of core skill developments (Oates, 1990). Historically numeracy is seen as an essential core skill, but of late it has been relegated to group two by the National Curriculum Council (NCC, 1990) although more recently it has regained its central status from the National Council for Vocational Qualifications (NCVQ).

Numeracy is frequently seen as an area that people lack confidence in and find difficult to master. Employers frequently report that their employees are innumerate and that education has failed the workforce in not preparing it for industry and commerce. Testing on adults frequently shows that some aspects of number are found to be difficult by the population as a whole.

The Cockcroft Report (1982), however, which looked at, among other matters, the mathematics required in further and higher education, employment and adult life generally, stated:

> 'We have found little evidence that employers find difficulty in recruiting young people whose mathematical capabilities are adequate.'
> (para 46)

There is clearly a perception problem here. Employers may not find it difficult to recruit young people who are mathematically capable (presumably this is interpreted as having the potential), but there are frequent complaints from employers about the skills that young people have (ie what they can do). Hence the core skills movement! The Cockcroft report also states that:

> 'Few subjects in the school curriculum are as important to the future of the nation as mathematics ...'

Numeracy is seen to relate to mathematics since many of the concepts and skills are part of the subject and yet it is also seen as being something more than mathematics. But how is numeracy defined?

Definitions of Numeracy

Numeracy has often been defined by a list of significantly computational skills such as *add and subtract whole numbers*. Sometimes numeracy is defined around basic life skills as by the Adult Literacy and Basic Skills Unit (ALBSU, 1993) in the numeracy standards for Numberpower. ALBSU define four skill areas, as:

- handle cash or other financial transactions accurately, using till, calculator or ready reckoner as necessary
- keep records in numerical or graphical form
- make and monitor schedules or budgets in order to plan the use of time or money
- calculate lengths, areas, weights or volumes accurately using appropriate tools, eg rulers, calculators, etc.

Sometimes numeracy is defined more qualitatively as by the CBI (1989):

> 'Application of Numeracy – understand, interpret and use effectively numerical information whether in written or printed form; identify which form of numerical communication is most effective (maps, flowcharts, models) for a given situation depending upon recipients; use numerical based approaches to solve problems.'

The National Curriculum Council (1990) has a similar definition; they say:

> 'The following outline descriptions provide a basis for further development....

Numeracy includes the ability to:
- understand and interpret numerical data presented in a range of forms;
- present numerical data in a range of forms appropriate to different purposes and audiences;
- select and apply numerical methods to problem solving.

Students should be able to use numerical information, tackle quantitative problems and use statistical analysis and presentation.' Core Skills 16-19: A response to the Secretary of State, page 10).

The National Curriculum Council (1990) explains:

'Definitions of core skills must be flexible to accommodate changing needs.'

Building on the above we need to remember that the word 'numeracy' was introduced to partner the word 'literacy'. Conceptually both literacy and numeracy are subject to change over time. Further, both words have social definitions which will be based on people's perceptions of the numeracy they think they use and what they think people should know.

There is significant research data to show that people are not always aware of the numeracy concepts and skills that they employ daily (eg the Cockcroft Report, 1982). Consequently views on what numeracy concepts and skills should be known are likely to exclude some things which are probably essential.

Investigations have been carried out on the mathematical requirements of employment since the mid-seventies using a number of different techniques such as job, skill and task analysis; observation of what employees do at work; and employers' training programmes. Clearly different aspects of numeracy underpin performance in different areas of work. Further, the NCC (1990) in its analysis of post 16 requirements for A and AS levels points out:

'Numeracy, ... cannot be fully developed in every subject ... ' Core Skills 16-19: A response to the Secretary of State, page 11).

This is why the NCC put it in the second group of core skills, rather than the first. Jessup (1990) develops the NCC argument further and goes on to explain:

'These (numeracy is included) are considered to be of a different order in that they do not underpin performance almost universally, ... This set of core skills could be described as highly valuable techniques or methods that have wide application and which it is desirable that all people should achieve a certain level of competence.' (Common Learning Outcomes: Core Skills in A/AS levels and NVQs, page 20).

So it becomes clear that is it not a simple task to create a precise definition of numeracy acceptable to everybody. At the extreme there are two schools of thought. One school of thought focuses on the basic skills of adult life, whilst the other focuses on the perceived needs of industry.

The NCVQ (1992) has created the core skill area 'Numeracy – applications of number' as part of the core skills for National Vocational Qualifications (NVQs) and General Vocational Qualifications (GNVQs and defined it by identifying the key themes of:

- gathering and processing data
- representing and tackling problems
- interpreting and presenting data.

They have then defined five levels around the three themes and say that progression through the levels is marked by increasing complexity in the nature of the mathematical operations performed.

In this brief overview of definitions it is possible to see that some are focused on daily activities (eg ALBSU), whereas others are more process oriented (eg NCVQ).

From these definitions assessable levels of performance have been specified.

Specifications of Numeracy standards

There is a wide variety of models that can be use for describing and specifying numeracy skills. The FEU (1979) adopted the following model:

'We have decided to describe the curriculum of the common core we recommend in terms of a checklist of:

a those **experiences** from which we think students should have had the opportunity to learn

b the nature and level of **performance** we think students should be expected to achieve. A Basis for Choice, para 51).

They went on to suggests:

'In some areas of learning, mathematics for example, it will doubtless be desirable to specify an assessable level of performance which it is intended the student should reach and the existence of such a specification will help towards purposeful course planning and the currency of the qualification.' (A Basis for Choice, para 55).

However, this still begs the question: how do you specify an assessable level? Research at Brunel University in the late seventies and eighties looked at the mathematical requirements of people aged 14+ with a view to creating a hierarchy of concepts and skills based on qualitative and quantitative research into the difficulties students experience in learning mathematics. Such a hierarchy could provide a specification for assessable levels. There are clearly many ways of creating conceptual hierarchies: consequently the Brunel model is one of many. One of the aims of the Brunel research was to provide a model for specifying a structure for the numeracy requirements in employment and life in general.

One of the products of the research at Brunel was a Mathematics Curriculum Framework (see Barr, 1989) which was designed to help curriculum developers appreciate the mathematical demands made on students when certain mathematical concepts and skills were specified in pre-vocational and vocational syllabuses. This framework was used, for example, in the development of the City and Guilds Numeracy scheme from 1978 onwards) and the ALBSU

Numberpower standards in 1989. In presenting Numberpower a competence-based model was adopted and an NVQ style of presentation was used. An example of this presentation taken from a stage one unit is given below:

UNIT 3 PLANNING THE USE OF TIME AND MONEY IN EVERYDAY SITUATIONS

ELEMENT 1 Planning the use of available money

Range

types of money:	pounds and pence (sterling)
planning constraints:	the plan should include at least five but not more than twenty items; the names of the items will be given (eg food, gas, electricity, telephone, rent, ...; total money available will be a fixed amount between £20 and £2000
example contexts:	weekly spending; a party; works' outing; wedding; holiday spending money; petty cash
optional aids:	calculator, ready reckoner

ASSESSMENT SCHEDULE

In at least two real or simulated situations of the type illustrated in the range the candidate must demonstrate that he/she can

PERFORMANCE CRITERIA

1.1 perform all calculations accurately
1.2 include all essential items
1.3 keep within the fixed amount of money.

The NCVQ in developing its five levels for the numeracy units based them around the three themes (see above) and also wanted a close alignment with the National Curriculum. All the numeracy level 1 techniques were extracted from National Curriculum statements of attainment at levels 1-4: level 2 techniques are from National Curriculum level 5 & 6: level 3 techniques are from level 7; level 4 techniques from levels 8 & 9 and level 5 techniques from National Curriculum level 10. The National Curriculum for mathematics is a hierarchical structure of concepts and skills broken down into ten levels. The NCVQ development also built on previous numeracy specifications.

The NCVQ model for a specification of numeracy has been presented in an NVQ style of units, elements, performance criteria and range. It should also be noted that it is a 'criterion-referenced, outcome based' model, that is it presents a statement of a level of competence to be demonstrated, it does not present a teaching or learning programme. An example of the style of presentation is given below.

Application of number level 2

2.1 Gather and process data using group 1 & 2 mathematical techniques

1 techniques appropriate to the task are selected and used by the individual
2 activities required by the techniques are performed to appropriate levels of precision and in the correct sequence
3 data recorded in the required units
4 data are recorded in the required format
5 records are accurate and complete

Range

Group 1 techniques: converting between different units of measurement using tables, graphs and scales; making estimates based on familiar units of measurement, checking results; conducting a survey

Group 2 techniques: drawing and constructing 3D objects; designing and using an observation sheet to collect data; designing and using a questionnaire to survey opinion

Early feedback suggests that there are concerns about the need for specialist tutors for both teaching and assessment purposes. It seems that non-number specialists lack confidence in assessing the skills. It is tempting to ask how these skills can be 'essential to and embedded within performance by an individual' (Oates (1992), page 34) when the assessors lack confidence in assessing these skills? Of course the next question to follow is: Is numeracy a core skill when the assessors do not have the confidence to assess it? Oates (1992) suggests that the problem derives from the 'state of the world' rather than a problem associated exclusively with the units.

The two examples presented show differing views on the presentation and specification of numeracy as a core skill. The first presentation is a 'life skill' model and was based on a 'functional analysis' of the numeracy used in work and non-work activities, whilst the second is a 'generic unit' model anchored to the National Curriculum.

It is interesting to note that ALBSU (1993) has broadly mapped the Numberpower standards with the National Curriculum (NC) and the NCVQ Core Skill Units as:

Numberpower	NC Mathematics	NCVQ Numeracy
Foundation	Levels 3 & 4	Level 1
Stage 1	Levels 3, 4, 5, 6	Levels 1 & 2
Stage 2	Levels 4, 5, 6, 7	Levels 2 & 3

The common aims of these specifications would be to prepare people for work and create opportunities for personal development. Again it would appear that it is possible to identify two schools of thought for the numeracy specifications, one focusing on basic skills and progressing from them (a bottom up strategy), whilst the other appears to focus on a 'generic unit' which attempts to 'bridge the academic/vocational divide' (a top down strategy).

It is anticipated that by providing a clear specification people are able to recognise their own skills and prepare for future learning. However, is learning numeracy so simple?

Difficulties of learning numeracy concepts and skills

There is a substantial body of research on the learning difficulties. Ideally the specification should not include concepts and skills which are overburdensome for the people they are intended for. Further, the progression through the specification should be organised by increasing complexity in the nature of the numeracy concepts and skills through a series of levels. This approach should help build peoples' confidence in their own ability and help prevent conceptual blockages occurring.

Placing numeracy in contexts is frequently seen as a general panacea. The relevance of the numeracy to be learned is important but must not be regarded too superficially. An applicable context will be an appropriate context for some because it appeals to the imagination (such as, how would you invest/spend £1 000 000?), whereas for others it may be a familiar everyday context (such as, working out how much change you should receive from 10). Whatever the context the learners' knowledge of numeracy should be sound in order to be able to solve problems and also to learn further skills and techniques. There is a need to be aware both of the level of difficulty at which the numeracy is 'pitched' and the level of familiarity/relevance that the context presents. This has implications for teaching, learning and the specification of numeracy standards. In some senses this issue concerns transfer.

Transfer

Transfer is seen as the ability to apply concepts and skills learned in one context to another context. Research suggests that making the core skills explicit helps learners both to learn and to transfer their skills more readily. However, Oates (1992) points out that:

> 'Core skills offer the potential for enhancing transfer of learning to new contexts, not least by making people more aware of the skills they possess and of the skills required in different contexts. But there has been difficulty in translating this widely held belief into effective practice' (page 11).

In spite of evidence against it, the viability of the concept of transfer remains largely unquestioned. From an assessment standpoint it is possible to ask what appears to be the same numeracy question in different contexts which generate markedly different performance from candidates. Transfer is something not to be assumed.

Conclusion

Some aspects of numeracy underpin our daily lives and on that basis it is fair to argue that numeracy is a core skill. Further, if the underlying numeracy concepts and skills can be transferred from one context to another then the argument is strengthened.

The main problem with numeracy as a core skill is its specification and perceived relevance. It is easy to argue a case for the Numberpower model since the specification is so clearly life skills related. It is not so easy to argue a case for generic units (especially at the high levels) since they are clearly not relevant to a significant proportion of the population. Further, if it is possible to show that people can satisfy the performance criteria in the NVQ numeracy standards at level 3, say, it is unlikely that if these people do not use these skills and techniques on a regular basis that they will retain them on the future occasion that they do need them – which is clearly one of the desired goals. It is generally accepted that if skills are not used on a regular basis then they deteriorate.

The middle ground in this argument would be that there should be an agreed minimal level of numeracy, which is part of the core, with free-standing generic units for the occupational areas that demand a higher level than the accepted minimum.

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The views expressed in this paper are the views of Dr George Barr and do not necessarily represent the views of City and Guilds.

Sorting out statistics: Confessions of a numeracy tutor

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"Nos numerus sumus et fruges consumere nati."
"We are just statistics born to consume resources." (Horace 65 – 8BC)

Statistics are inextricably associated with tedious tabulations and little grey men telling lies on television. The soullessness of our society in general and our education curricula in particular can be blamed largely on the "stochastization of the world"[1] – a world in which computers and qualifications have been raised to the status of demigods, in which the word 'value' has been denuded of all ethical significance and in which the misconceived notion of 'norms' is the ultimate authority dominating our lives.

I do not intend in this paper to pretend that I find statistics exciting. And that is the crux of my problem. If I were on the wavelength of Marilyn Frankenstein, if I were a radical mathematician, I wouldn't have a problem. I would realise that although "statistics are often mystifying, they can be empowering and critical tools."[2] But I neither feel empowered by nor endowed with greater critical faculties as a result of my reading and interpretation of statistics. On the contrary, the more information that I assimilate, the more I am overwhelmed by the enormity of information to be assimilated. How, then, do I set about teaching this subject with the enthusiasm and integrity that is the essence of all successful communication?

This paper is written in an attempt to grapple with the problem of how a teacher can approach a subject for which she initially feels little affinity but which is an obligatory part of the syllabus. And rightly so; for however much I might wish it were otherwise, an understanding of statistics is rapidly becoming the lynchpin upon which so-called 'numeracy' rests.

Changing numeracy needs in the age of information

Although I have been teaching numeracy for a decade, I have to admit that I have never been very certain as to what exactly I was teaching, I am even less clear today than I was ten years ago. A blindingly obvious fact has only recently dawned on me: I don't know what I'm teaching because what I'm supposed to be teaching changes.

It is inevitable that numeracy will always be an impossible subject to define for the simple reason that definitions of numeracy vary according to the degree of stochastization of society. In the sixteenth century arithmetic was a university degree subject. Today we judge a person to be seriously impaired on the numeracy front if he cannot perform the four rules. Perhaps we have got cleverer in the intervening five hundred years? Given the condition of today's society this is hardly a convincing explanation; more informed certainly, but information is not at all the same thing as cleverness. It seems far more likely that numeracy needs fluctuate and that, in an age in which the rate of change appears to have exploded exponentially, blitzing us with the future before we have assimilated the past or breathed in the present, the basic maths curriculum (and its exponent) suffers accordingly. Tomorrow's numeracy is not today's and yesterday's worksheets had better be binned because they won't be any use next week.

We live in 'The Age of Information, a Golden Age of Digits'. Our information is force-fed to us via computers. And computers, being less bright than commonly supposed, can only handle digitalised data. It is hardly surprising that the information resulting from that data should have a distinctly numeric flavour. Our brains are continuously bombarded with a "statistical blizzard that numbs the attention."[3] Society, we are reliably informed by the pundits, is better informed than at any time in human history. These same pundits also inform us that education standards are sadly low and that we must all become even better informed if we are to keep pace with the march of mankind. Hence we cannot open a newspaper without being regaled by column inches of figures, we cannot select a school for our child without first studying the latest league table of exam results and we cannot have a peculiar thought in our head without wondering whether we are more than a standard deviation from the norm in urgent need of psychiatric help.

Statistical thinking pervades our society leaving us individually isolated and impotent. The ever-increasing flow of information communicates less and less on a personal level. Even the statisticians have drowned in their own mania for data collection. The deterioration of the ozone layer could have been detected ten years earlier from existing data if anybody had bothered to analyse it. But nobody did. They were too busy collecting more data. The overload of data has replaced ideas as the foundations upon which our thinking rests and information masquerades as knowledge.

The tutor's problem

The numeracy tutor, along with rest of society, has inevitably been swept along in the wake of performance indicators and market forces. Statistics dominate her professional life: her students are statistics, her exam results are statistics, her very existence in adult education is a statistic. And, as if that weren't enough statistics for anyone, she must be a purveyor of tabulations and pie charts to consumers who have long since been "bludgeon(ed) into a dumb acquiescence"[4] by the overwhelming authority invested in numbers.

I have with some difficulty come to accept that we live in a digitalised world and that we need to be numerate to cope with it. I am also aware that it is my job to communicate to my students that, far from being baffling rows of figures and slices of cake with percentage signs in them, statistics are vital and empowering sources of information. I have therefore dutifully followed the rules of good practice as laid out in every tutor's basic education guidebook. Surely, despite my negative feelings, if I follow the rules I can't go wrong?

All I have to do is help the students pick a topic of interest to them: local authority spending plans, say, or the relative earnings of men and women. I can provide relevant worksheets, instigate a healthy class discussion, dissect the figures with the aid of a pie chart and enable the students to draw another pie chart more to their liking. Hey presto, I have introduced my students to critical thinking, empowered them and ensured that they have completed one more element of their City & Guilds Numberpower unit all in one blow.

This is where my problem starts. Have the students really achieved any of the intended goals? Or have I, rather, presented them with an inherently boring task, given them the illusion of empowerment by permitting them to air their views in a protected space and a tick in their Numberpower book with no more guarantee that they will remember how to draw a pie chart in six months time than they were able to recall how to do fractions after they had left school? Have I not sent them out onto the street to face the unpalatable truth that they are just as impotent against local authority spending cuts or inequitable pay scales as they were two hours previously? I cannot help feeling that the student is no more empowered, no more educated, and more likely than not reduced to a state of paralysed helplessness in the face of the overwhelming odds against obtaining a job even with a Numberpower certificate pinned to the wall. The only conceivable result of those two hours in the classroom is that a student's awareness of an unalterable reality has been raised. It is not always sensible to ram reality down people's throats unless you can also equip them with the necessary tools for handling that reality.

The root of my problem lies in the nature of statistics. Statistics are like electricity bills. They may be frightfully relevant but they are also intrinsically boring and frighteningly unalterable. The truth about both statistics and electricity bills is that the numerate individual does not bother unduly about them. She does what everyone else does – pays her electricity if she can and complained if she can't. She does not read the latest trade figures nor write to the local authority because she disapproves of their pie chart breakdowns. Her empowerment comes from the knowledge that she could interpret the figures if she so wished not from the information provided by the figures. And she did not get that sense of empowerment by studying statistics or reading electricity bills. She got it from entirely different sources: from learning a way of thinking, from connecting with ideas not data, from being educated in maths not informed by numbers.

The solution to the problem

Whenever I have a problem I invariably turn to George Polya's 'Mathematical Discovery' in the firm belief that any problem, mathematical or otherwise, can either be solved with his guidance or will have evaporated by the time I put the book down. Polya lists 'Ten Commandments For Teachers'. His first commandment is: Be Interested In Your Subject. "There is just one infallible teaching method; if the teacher is bored by his subject, his class will be infallibly bored by it. If a subject has no interest for you do not teach it, because you will not be able to teach it acceptably."[5] In other words, since I have got to teach statistics, I have got to get interested in statistics. This is no easy task for me. I have a serious attitude problem towards statistics. I find them either too dull or too frightening to spend much time contemplating them. But I did once read an interesting statistic: "Homosapiens took around 3.8 billion years to evolve. A further 700 million years was enough to invent radio and 57 years later came nuclear weapons and potential annihilation" (Independent Sep. 1990).

These figures made a deep impression on me, although I'm not sure why. For some reason they appeared to impress my students as well. It's a beginning. At least it has sparked my interest in statistics.

Polya's second commandment is: Know Your Subject. "No amount of interest or teaching methods, or whatever else will enable you to explain clearly a point to your students that you do not understand clearly yourself."[6] This commandment seems at first sight easy enough to obey. I am numerate: of course I understand basic statistics. It's true that I get a little lost when it comes to chi squares, distributions and standard deviations but, fortunately, these are not on my syllabus. However, when I examine my understanding more closely, I realise that, although on one level I understand basic statistics in that I know how to 'do' them, on a deeper level I have no real understanding of the underlying ideas. I do not know my subject. I have the requisite information but I don't have a firm grasp of the ideas that are the bedrock of that information.

I must make it clear at this point that I am not propounding an argument for teaching these ideas to students. Ideas do not get taught; they get caught. And they only get caught by connecting with pre-existing ideas in the learner's head. But if the teacher does not have any ideas about her subject then the students have nothing to catch. They may well leave the classroom a veritable mineful of information, an apparently desirable attribute nowadays, but they will not leave any better equipped to think. Surely, even in the Information Age, the primary purpose of all education must still be to teach people to think?

The solution to my problem is becoming clear. My interest in statistics has been stimulated. Now I must delve into some statistical ideas in the hope that they will connect with what is already in my head and enable me to get to know my subject.

Big numbers

"That which everywhere oppresses the practical man is the greater number of things and events which pass ceaselessly before him and the flow of which he cannot arrest. What he requires is the grasp of large numbers" (Theodore Merz).

My only interesting piece of data immediately strikes the reader with the enormity of number. However, if the student has no grasp of numbers larger than thousands and the tutor has no real understanding if the relative sizes of millions and billions, the full implication of the figures is lost.

All of us, presumably, have taught big numbers – that is to say, we have enabled our students to read and write numbers of more than four figures. But how many of us have thought about why we are teaching big numbers, other than the obvious fact that they are on the syllabus and they are useful? And when have we wasted any time wondering whether he has a feel for them?

I have been able to read and write big numbers for most of my life. I have only recently (thanks to J.A Paulos) learnt to get a feel for the relative size of a million and a billion. (A million seconds is approximately 11½ days; a billion seconds is 32 years). If I don't have any idea of the relationship between numbers, how can I expect my students to?

An understanding of big numbers is not merely useful, they have a relevance for us far beyond the fact that international debt, currency dealing and trade figures are counted in billions. A grasp of big numbers is essential to our psychological wellbeing. In a world in which we are surrounded by billions of beings very similar to ourselves, we need to be able to visualise ourselves in relation to a large number. Just as a grasp of the relationship between 57,700 million and 3.8 billion is essential to the understanding of my statistic, so a grasp of the relationship with the world. If a number is outside our concept of number then it has no meaning for us. Only when we have the concept of number can we make the necessary adaptation to it: although we are very small (one actually), we are part of the whole. Rather than being squashed by size, we can be aware of our own small but significant part. We can flit comfortably back and forth between the idea of one and the idea of a billion, relating to both with sense of connectedness instead of alienation.

Exponentiality and rates of change

"The rate at which the taste of Juicy Fruit gum diminishes is exponential" (Paulos).

A second idea implicit in my statistic is that of exponential growth or, in this case, shrinkage. Exponential notation is not included in the basic maths syllabus. It should be. It is not difficult to teach index notation and once students have got to grips with the chessboard problem (Q: if you put two 2mm coins in a pile on the first square, four on the second, eight on the third etc., how tall will your pile be on the sixty fourth square? A: reaching beyond the sun and almost to the nearest star). It puts social issues such as Aids and population growth into perspective. We're right to be a bit concerned. And if statisticians were to find that the ozone hole was growing exponentially, it would be time to stop getting informed and start to do some thinking. People automatically tend to think of growth and shrinkage happening at a constant or linear rate. I have no idea whether or not the banner of progress encourages mankind to march to an exponential tune, but my statistic looks as though it may well be.

Averages

"As I was going up the stair
I met a man who wasn't there
He wasn't there again today
I wish, I wish he'd stay away" (Hugh Mearns).

Far too much of the statistical information presented to us is based on averages. Social scientists, in their eagerness to achieve scientific respectability and reduce human behaviour to quantities, seized on averages as a suitable mathematical device for their purposes. They then leapt from the maths of averaging to the idea of norms. The 'normal person' has become an archetype towards which we are all meant to aspire. This archetype is a myth conjured up by statistics. It is a dangerous myth. It encourages us to deny our individuality in a vain attempt to find security by fitting into a data-designed mould.

Averages are very useful for governments and breakfast cereal manufacturers. Neither of these parties is remotely interested in the individual. In the one case they are interested in crowd control and in the other in how they can get that crowd to consume as much as possible. I do not deny the usefulness of averages. "When many events are averaged, one arrives at stability, order and lawful behaviour"[7]. I do dispute the relevance of the way they are presented on the basic maths syllabus. I find it hard to believe that average citizens sit around working out their average annual petrol consumption or their average household expenditure.

The interesting thing about averages is that the resulting figure is illusory. This is what makes them dangerous and it might be helpful for all of us if we were a little more able to distinguish between an average and reality. There is no such thing as the normal person therefore there is no point wishing to be normal. A norm is defined as an 'authoritative standard'. But whose authority? "The Criterion Makers tell us that society should move so that such and such a norm is optimised and they base policy on this, but no one can say why the criterion itself is appropriate"[8]. Our twentieth century idea of adjustment to the norm is governed only by numbers. Numbers are neutral symbols thus, at rock bottom, the idea of a norm is a sterile absurdity.

Probability

"Probability is not just for mathematicians anymore it permeates our lives" (Paulos).

Probability crops up everywhere. There is an advertisement around at the moment which states: "There's a 1 in 5 chance it could be you". I presume this advert is designed to scare us into donating money to cancer research in the hope that a cure will be found before we become that 1 in 5. It is objectionable on both ethical and mathematical grounds. Firstly, because it plays on our anxieties rather than our compassion, our motive for donating would be fear not charity. Secondly, in statistical terms, it is nonsense: quite apart from the fact that it should give us grounds for rejoicing that we have an 80% chance of not dying of cancer – good odds against. The figure has been arrived at by blanket averaging without any allowance for age, smoking habits, hereditary factors etc. It is a meaningless statistic and is a classic example of the abuse of figures in the manipulation of the innumerate.

A realistic understanding of probability can help us in our everyday lives. It can help us to rationalise our irrational fears and take proper precautions when we are at high risk. If we examine the statistics we can see that women's fear of being raped by a stranger, is out of all proportion to the actual risk of being raped by a stranger, and their sense of false security when travelling by car is astoundingly foolhardy. The innumerate person will take umbrage at the fact that their fear of rape is statistically uncalled for. They will say, "Yes, but what if it does happen to me? What about the Yorkshire Ripper?" One cannot help suspecting that many people satisfy their need to feel fear in such a way that it does not interfere with their convenience. Cars are much too convenient to be overly concerned by accident statistics whereas walking on a cold windy night is distinctly uncomfortable. A trivial but true consequence of this attitude is that it substantially increases the chances of dying of circulatory disease through lack of exercise.

Every day of our lives we are confronted by uncertainty and governed by the laws of chance. Yet all too often, as a result of information overload, we can be made unnecessarily fearful because of our inability to determine rationally the risk of what we do. It is almost unbelievable that something so central to our lives should be missing from the basic maths syllabus, that the arbiters of numeracy should have decided that pie charts take precedence over probability. Even at GCSE level problems of probability are confined to absurd questions about coloured balls in bags. There has been a lot of fine talk over the past decade about relevant and meaningful mathematical activity. It is time for the talk to be reflected in the curriculum. What could be more relevant than the maths of risk?

Generality

"A single death is a tragedy; a million is a statistic" (Stalin).

The ability to generalise while retaining meaning is at the heart of mathematical thinking. When we generalise we are either looking for connecting patterns in apparently shapeless heaps of facts or we are attempting to create a pattern out of very few facts. It is through the process of generalisation that data can be used to illuminate an idea or can help us predict an outcome.

Innumerate people tend to feel ill at ease with generalisation. They fear that their individual tree will be suffocated by the wood. Numerate people, on the other hand, either innately or through sound mathematical education, learn to leap from a particular tree. These mental gymnastics, the art of specialising and generalising, are involved in all mathematical activity. The more consciousness of this that there is in the classroom the better. Statistical information is an ideal tool for discussing ideas of generality in a real context, since statistics, by their nature, lead to generalisations.

The art of differentiating between personalisation and generalisation is not only an essential mathematical skill, it is psychologically important in a mass culture. "Innumerate people have a strong tendency to personalise – to be misled by their own experiences, or by the media's focus on individuals or drama"[9] with the concomitant danger that they can take a tragic view of their own life while maintaining a Stalinist indifference towards mass disaster. An education in generality is essential if we are to maintain any vestige of humanity on our over-populated planet. In a world in which, increasingly, any of us could be anybody, a grasp of the generality of statistics in connection with the particularity of individual behaviour is vital to our self understanding.

Ideas not information

In the process of writing this paper I have become aware that I have a lot to learn about statistics. I need a deeper feel for the difference between arithmetical and geometric progressions in order to understand exponential growth; I need to understand distribution curves in order to clarify the process of averaging; I need to be aware of variables and false correlations and the difference between practical and statistical significance. I need all this in order to teach students how to interpret a pie chart. Only when I have empowered myself with ideas will I be able to empower my students. The information that I have at my disposal is only meaningful if it backs up an idea. Students are not sausages to be stuffed with a syllabus and turned out as a satisfactory product. They can only learn successfully if the information they receive is based on ideas that make connections. And now I begin to feel in tune with Marilyn Frankenstein: "There are many levels on which we have to fight to make our individual and collective lives meaningful....... knowledge of basic numerical and statistical concepts is important in these struggles."[10]

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Learning Contracts in Higher Education: Towards confidence in developing numeracy skills

Ian Beveridge & Gordon Weller

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Introduction and Background

In this report we intend to explain how new developments in numeracy-related teaching support at Luton College of Higher Education can break down traditional barriers to developing numeracy skills. This study is currently in its preliminary stages, and base line data that has been used in this paper, will form the basis for more in depth research using data accumulated throughout the first full year of operation.

Over the past decade, higher education has slowly opened its doors to those who have traditionally been disadvantaged through lack of G.C.E. qualifications. Today, many Higher Education Institutions are encouraging adult learners to prepare for entry to various degree level courses. It is possible for anyone with little or no formal qualification, but who has past experience which can be taken into consideration, to be enrolled on to a one year Access course, or indeed, directly on to a degree course (Handy 1985).

Luton College of Higher Education has, over the years, developed a reputation for being a good 'access college'. A large proportion of 'mature' students are enrolled on to 'access' courses, and are encouraged to pursue higher education to degree level. The assessment for enrolment is dependent upon the past academic and work experience background of the student. The student has the opportunity to question a course manager on the content and level of the course which is of interest to them. In many cases 'mature' students, particularly women, retain unpleasant memories of their last period of formal education – at school, up to the age of 15 or 16 (Stanworth 1984).

Enterprise in Higher Education

The needs of adults returning to education may be very different from students who enter higher education straight from school or college. However, there is a common need for ongoing motivation and self development. In this respect Luton has recognised the vocational nature of most of the courses offered within the college, and has sought the help of the Employment Department and support from local and national employers. This aid came in the form of the Employment Department funded Enterprise in Higher Education (EHE) programme, which Luton was awarded in July 1991.

From the start of the programme employers have contributed in cash and kind to add to Employment Department funding to achieve the EHE objectives of Luton College of Higher Education, which are briefly outlined below:

1. To give students the opportunity to participate in a module to develop job seeking skills. This covers self awareness, sources of information and the employer market, CV's and application forms, interviews and methods of selection.
2. Changes in the curriculum to foster self-managed and student centred learning, for example through the use of case studies or projects.
3. Closer involvement with employers in course design and development.
4. A commitment to providing some real world experience for all students while at Luton College of Higher Education. This may be through work placement, work shadowing, work based projects or structured company visits.
5. A commitment to staff development through employer led workshops and seminars, staff work placement for updating and practical experience and consultancy.
6. A Personal Development Portfolio for students, in which they record and assess their skills development with a view to promoting continuous self development. This portfolio will also form the basis for a comprehensive CV which can be

supported by evidence of skills if necessary.

7. A Student Enterprise Committee, organised in collaboration with the Student Union in order to promote an awareness of skills development both within and outside college based activities.
8. Students are encouraged to undertake an Enterprise Learning Contract for skills development. They assess their own skills and negotiate with tutors on how they will develop and improve in target areas. Where students participate in a work placement the negotiation is three way; tutor, employer and student.

(Crystal 1992)

A Learning Contract for Numeracy Confidence

It is this last objective of Enterprise in Higher Education that is being used as a change agent for Luton students to develop transferable skills. One of the most important transferable skills recommended by employers, as necessary in virtually all aspects of employment, is competence in numeracy. Indeed a recent survey of 220 new graduates by employers found that "a sizable minority have difficulties with and are nervous about numeracy tests set by recruiters" (Cornelius 1992).

With this in mind every effort is now being made to encourage all students to target numeracy skills using the Enterprise Learning Contract (see Appendix 1). This contract is owned by the student and is personal to them. It is not marked or graded. and is intended to be a genuine opportunity for active participation in skills development. The student works with a tutor in negotiating how s/he will achieve a certain skill. and how evidence of this will be provided. The timescale is also negotiated and, where skills development involves contact with an outside organisation. the student is encouraged to discuss their skill targets with the employer.

Learning Contracts can be understood as the efficient and effective use of tutor and student time, which results in clear student objectives being set. thus giving a framework for discussion. Earwaker (1992 a) notes the importance of effective tutoring in education institutions with ever increasing student numbers.

> "Our students need our help and in future they are going to need it even more. We can respond by increasing the quality if not the quantity of tutorial time. The mark of that quality will be in the businesslike way we establish the kind of productive. working relationships they are entitled to expect" (p.18 Earwaker 1992 b).

There are many books and manuals available to tutors suggesting ways in which students can develop transferable skills doing useful and practical tasks. Paul Kearney's *Training Through Enterprise* (*1991*) is a good example. Further supporting information for students, tutors. and employers, on developing transferable skills using the Enterprise Learning Contract, has also been produced by the Enterprise Unit at Luton College of Higher Education (Crystal et al 1992). The concept of the Learning Contract is not new, although when initially conceived in the U.S.A, it was intended to help research students in negotiating research objectives with their supervisor (Knowles 1978). Currently many Higher Education institutions, and some U.K. employers are promoting the benefits of Learning Contracts in skills development (Higher Education Developments 1991).

The Enterprise Learning Contract (ELC), as developed at Luton College of Higher Education. is particularly useful for numeracy skills development. The student can use the ELC for targeting any number of transferable skills, although it is recommended that between 3 – 5 skills are worked on for each year at college. This program is open to all Luton students in full or part-time education and was first introduced in January 1992, involving some three hundred students across the college. All students who complete one or more skill objectives are eligible for the Enterprise in Higher Education Certificate of Achievement which is endorsed by employer partners of EHE at Luton.

Support for students who wish to target any numeracy related skill as part of their ELC will be provided by a new Maths Learning Centre, which will initially be staffed by tutors. The eventual aim is to train and develop student tutors who will be able to work in the Maths Learning Centre with client students and negotiate numeracy skills achievement using the ELC. A similar system has been developed at the University of Minnesota. General College, where more advanced students were trained as numeracy instructors (Beveridge 1992, unpublished).

The Job of a Maths Tutor (student tutor)

A maths tutor is someone with respectively good listening, counselling and, eventually, numeracy skills. The customers of the Maths Learning Centre (MLC) will include students with considerable anxiety about mathematics and statistics. It is not the job of maths tutors to do the work for students who come to the MLC for help. It is their job to listen and understand the problem of the students at its most particular level and then to advance the student forward in his or her task .... and then return to find out how much progress has been made. There will be peak load situations around exam times which will require tutors to increase their pace and make decisions to service all the extra students. Tutors will also ensure all users of the MLC are signed in and assign exams and other work the MLC is keeping for particular maths classes. Where arranged, they will grade and give feedback immediately after testing.

The skills cited in the Enterprise Learning Contract that are exercised in the job of Maths tutor include skills in all six areas: presentation skills include self-presentation. self-management skills include time-management. study skills, assertiveness. awareness of resources around the college and prioritising. Communication skills will be of great importance as development of good oral communication skills can increase effectiveness. and put the client student at ease with the student tutor. Computer Aided Learning mathematics study packages are being introduced and will entail computer literacy skills on the part of the student tutor, and the client student. Interpersonal skills development is a high priority and weekly review sessions for student tutors will focus on this vital aspect of the work. Numeracy skills will sharpen both as students think about mathematical problems in their tutoring time and as they realise the patterns of errors do not change from semester to semester. The general skills we are most concerned about as we satisfy many Access students is a sensitivity to Equal Opportunities. Customer care, graphics, assertiveness and interviewing skills will be worked on continuously and in weekly review sessions with the MLC manager.

Maths Learning Centres – Catalysts for more Equal Opportunities?

Maths Anxiety was a term coined by Sheila Tobias in her workshops for women students during the early 1970's in the New York area (Tobias 1978). It refers to the stress-induced behaviours which result from years of feeling inadequate during maths at school. In particular it affected women and the various ethnic groups that live in the inner cities where the most oppressive teaching of maths occurred. The performance of the same groups were increasingly divergent from that of the white male population. For the U.K. we need only look at the absence of women engineering students to know the same situation applies here. When examining the causes of this situation, we enter the debate of "nature versus nurture" lying behind our revealed abilities. Elizabeth Fennema, among others, has documented the worsening relative performance of women after the age of 15. She suggests there is more acceptance of women dropping maths as they are not expected to need it much in later life (Fennema 1976).

The Access programme attracts a lot of single parent mothers, housewives with older children and non-mainstream groups. Dealing with maths is often a key issue in surviving higher education for many students. There is a need for a fresh approach in learning mathematics, one which does not restimulate old fears and insecurities. Maths courses must make sense, allow students to work more at their own pace, and pursue personal interests and needs. However, students cannot be expected to become independent learners of maths overnight since the skills involved are not widely known.

The Maths Learning Centre – Renaissance in student numeracy support

A Mathematics Learning Centre is a place where students can go and get help in learning maths in a supportive environment and where students are dealt with on a one-to-one basis. Its primary resources are tutors who are non-judgmental and expert problem solvers. The training for such tutors focuses mainly on the counselling techniques that make it safe for students to reveal more of their own good thinking. Students' ideas are never "wrong" and all ideas are developmental. Any idea has the possibility of being developed. Naive ideas can be tested against situations where they must be redefined rather than taken away and replaced by someone else's ideas. The adage, "From what to what", is the developmental goal of the tutors. They must find out how students think about the problem as the starting point of any dialogue. Handling feelings is basic in problem-solving and tutors have to give students room to allow their feelings to surface. The maths learning centre is not like a regular classroom, nor should it be.

Higher education will have expanded from 7% of the 18 year old population in 1980 to 30% of the population by the year 2000, if official targets are met. Currently, over 20% of the 18 year old population is in higher education and we are likely to meet the target before the year 2000. Past assumptions of homogeneous groups taught in similar ways at "O" and "A" Level are now irrelevant. More students need maths than before and the standards are increasingly diverse as are the students. The learning style of lecture and tutorial is both expensive and inefficient. It is time to make radical changes in the way maths is taught and we must effect these changes with existing teachers excited about them.

Maths learning centres can catalyse such changes. They support the work of existing teachers by their remedial work. They offer students the chance of independent but supported study to complete maths requirements. They offer good lecturers a resource to support students through more interesting open-ended questions to continue the discovery maths of the GCSE's best aspect, its project work.

The central quality of this agent for change is that all tutors are charged with listening to students and understanding their thinking on a one-to-one basis. Emotional needs are recognised. Tutors work hard at learning how a student thinks about a problem in order to advance the situation in the direction determined by the student. This is respectful, student centred, independent learning but students are supported. Many problems will not get "solved" this way, but students are more likely to develop their thinking when not "told the answer".

Learning to think Mathematically: some examples

Promotion of the Maths Learning Centre (MLC) has involved short presentations to various groups of students on courses throughout the college. The objective of these presentations was to encourage students to discuss mathematical problems, and offer the opportunity to further their interest at the MLC. The following is an account of one such presentation:

Take 1 minute with a pencil and paper and consider this question: what concentration of an acid solution results when you mix a 40% with a 10% solution? After you have *written down what you consider to be a believable answer, take 5 minutes to tell each person sitting next to you what it is that makes your answer reasonable. We are anxious that you and your neighbour can agree on an answer or, failing that, that you are able to explain your neighbour's reasoning to the rest of us here.*

About one-half of all students decided to agree that a 50% solution resulted with the mixture, one third thought a 30% solution was produced while the remaining one-sixth mostly agreed on a 25% solution.

Take another minute with another piece of paper and consider what temperature results in your bath when you mix 40°C hot water with 10°C cold water? Once again we want you to agree on a reasonable answer with your neighbours in the following 5 minutes. Alternatively you may choose to show respect for your neighbour by learning this other explanation well enough to explain it clearly to the rest of us.

A resilient few students thought a 50°C bath resulted and one-half decided the bath temperature would be 30°C. Another third chose 25°C as their answer. The remaining sixth were perplexed and tentatively wondered how we could know the temperature, not knowing if more hot or more cold water was used in the bath.

Each group who were asked this pair of questions were equally divided as to whether they were the same or different questions. There was also division as to whether the bath temperature or the acid mixing was easier to think about.

They were asked what was similar between them. The numbers were the same and there were two quantities in each problem. Both problems involved the same process of mixing similar things. Both asked to find a result. What was different about these two problems? They involved different things, acid and bath-water, percents and temperatures. Bath-water is less than 100°C and acid can be 100% (and some thought more than 100%). One problem is unfamiliar and another is quite familiar.

A large ice-cube of 0°C is dropped into a cup of strong hot coffee of 40°C. What is the likely temperature and what is the strength of the coffee by the time the ice-cube is finally melted? Take one minute and write down your thoughts as to the consequences of the ice-cube for the coffee. Once again get an agreement with your neighbour if you can. Alternatively make sure you understand a different answer and get the neighbour to understand your answer well enough to explain it sensibly to the rest of us. Practice summarising your neighbour's thinking until it is agreed that it is accurate.

Just a few students held on to the strategy of subtracting the numbers to get a result. The discussions began to get longer. Demands to know "the answers" to the questions began to grow. A considerable amount of irritability was expressed at the back of the auditorium at the vagueness of the questions and the lack of "answers" as feedback. Those students who decided the questions lacked sufficient information, in particular about the quantities of the ingredients of the mixes grew to about one-third in some groups. Along with the irritability, there were animated discussions throughout the adjoining rooms.

Analysis of students visiting the Maths Learning Centre during its first full week

Currently the Maths Learning Centre at Luton College of Higher Education has had an impressive response from students, and wide acceptance of the objectives from college lecturing staff. Statistics from the first week of operation are shown below.

The Maths Learning Centre is open Tuesday, Wednesday and Thursday from 12:00 noon to 7:00 pm. Students were asked to sign in as they entered the Study Centre. They wrote down their names, their course and year, the time they entered the room and the help they needed. They were asked to sign out too but most forgot to do this. The data on the year of the students was also incomplete.

Student Visits	**Once**	**Twice**	**3 times**	**4 times**
No. Students	61	10	2	1

Student Backgrounds	**Year 0 (Access)**	**Year 1+ (HND)**	**Year 1+ (BA,BSc)**
No. Students	31	19	26

Courses Serviced	**Health/ Soc.**	**Design/ Tech**	**App Sci.**	**Business**	**Access (various)**
No. Students	11	31	3	11	31

Time of Entry	**10-12**	**12-1**	**1-2**	**2-3**	**3-4**	**4-5**	**5-7**
No. Students	5	17	20	0	13	9	11

Type of Help Required	**General Study Skills**	**Specific Maths Skills**
No. Students	8	67

The future of this study

The above figures give some credence to the need for such student support in the general area of numeracy and, with increased promotion of this facility, it will be possible to monitor the type and frequency of typical numeracy problems. This information can then be made available to tutors, and may result in changes of teaching material or style. Only through ongoing evaluation can a combination of student Learning Contracts and the Maths Learning Centre be assessed in terms of effectiveness.

Note:
If you would like to know more about EHE or participate in developments, please contact the Enterprise Unit at Luton College of Higher Education, Park Square, Luton (0582) 489246.

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Note:
If you would like a copy of the Enterprise Learning Contract Handbook and the unpublished paper by Ian Beveridge, please contact the Enterprise Unit on (0582) 489246, a charge of £5 will be made to cover printing and postage.

Effective provision of literacy and numeracy instruction for long-term unemployed persons

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Introduction

In Australia, as in many countries around the world, funding for provision of adult literacy and numeracy programs has been considerably increased in the last few years. Much of this increase is due to the success of public awareness campaigns which culminated in International Literacy Year in 1991. However, much of the increase is also due to the economic rationalism and human capital models which have dominated government planning since the 1980's. Funding for programs in adult literacy and numeracy is seen to be desirable not from the perspective of enhancing people's quality of life and empowerment but for the purpose of enhancing the productivity of the nation. The changing nature of employment is believed to place more demand on literacy and numeracy skills of workers and the ability to be multiskilled in work performed. In Australia, the most often quoted figure for the loss of productivity due to poor literacy and numeracy is $3.2 billion yearly, a substantial amount relative to our gross national product.

At the same time, the increase in unemployment levels in Australia, as in many other nations, has meant an increase in expenditure on training programs for the unemployed. In 1989-90, when the following project took place, the Federal Government already expended $100 million dollars on training programs for the unemployed through a scheme known as JobTrain alone. Again, the government perceived that national productivity and employability would be increased by the improvement of literacy and numeracy skills of those who were unemployed, particularly the long-term unemployed.

It is important for all stakeholders in these programs – participants, staff, employers, government and taxpayers – that such programs are as effective as possible. This paper presents the findings of research which has looked at best practices in literacy and numeracy provision within the context of such government commitment and expenditure and within the constraints of the types of programs being funded. The discussion includes a brief analysis of criteria of best practice which emerge from the literature on adult literacy and numeracy provision in general and for unemployed persons in particular.

Best practice in literacy and numeracy provision for unemployed persons: previous research and writing

Most definitions of literacy and numeracy are now complex, involving not only skills of reading, writing, speaking, listening and mathematical computation and space manipulation, but also critical thinking, problem solving, questioning, and the appropriate use of language and mathematics. In conjunction with this, research has shown that there is a multiplicity of needs and contexts in literacy and numeracy (for example, Guthrie & Kirsch, 1985; Levine, 1982; Moss, 1984; Sticht, 1988; Szwed, 1982).

In practice, therefore, this indicates that there is a need for diversity in the provision of programs for adults and for long-term unemployed persons. One type of program is not going to suit all. Literacy training with an overall vocational perspective may take several forms depending on the level of literacy or numeracy of the long-term unemployed person. Provision for people with very little literacy or numeracy may be directed at basic education; people who are moderately literate may develop skills quickly in the general context of job demands; while provision of integrated skills and vocational training in specific jobs may be most suited for people with reasonably well-developed literacy or numeracy skills (Mikulecky, 1990).

Both literacy and numeracy are now seen to represent a range of performance with literacy demands and performance context-based (Kirsch & Jungblut, 1986). Today's models of literacy and numeracy instruction emphasise that learning should be based on meaningful, contextual and purposive practices (Mikulecky, 1989). These models acknowledge that in learning to read or be successful in mathematics, background knowledge, familiarity with a topic and relevant experiences will influence the acquisition, understanding and application of new knowledge.

A critical question therefore for adult literacy and numeracy programs with a vocational expectation, such as those for long-term unemployed persons, is how to choose a context on which to focus the literacy and numeracy instruction. Conversely, relatively little is still known about the literacy and numeracy demands and activities which do take place in many workplaces. Both the duration of literacy and numeracy involvement and the level of literacy and numeracy activities at work are often underestimated by workers and employers (Mikulecky, 1989).

Choice of context is not the only issue in provision of literacy and numeracy instruction for unemployed people. Even when a vocational context is chosen as the focus for the instruction, the degree to which authenticity of the workplace is maintained must be considered (Mikulecky, 1989). Literacy and numeracy tasks within the workplace have been shown to differ from most academic-based learning tasks. Workplace tasks have generally problem-solving orientations, involve communication within social settings and often take place in an informal way (Brinkworth, 1985; Mikulecky & Ehlinger, 1987; Sticht, 1983; Willis, 1984). The development of metacognitive and problem-solving strategies are seen as desirable outcomes of training programs in literacy and numeracy for the workplace (Fingeret, 1984; Mikulecky, 1989).

Choice of a specific vocational context over a generic vocational context or a basic education context is also problematic. Sticht's (1982) research found that general training in literacy did not transfer to job tasks, that the effect of any such training may be lost within eight weeks and that it took between 80 to 120 hours of instruction for adults to improve a grade level in general reading. The complexity of mathematics in different contexts means that such estimates are impossible.

Programs for adults should be designed to meet individual learner's needs and goals. In addition, these programs should emphasise learning rather than teaching (ALBSU, 1987; Heaney, 1983). Staff working in programs for adults should be well-trained (Draper, 1986; Ulmer, 1980). They need to be multiskilled both in teaching strategies and in their content area as well as very confident in order to be able to meet these individualised goals. The ways in which this can be done include flexibility both in program design and availability and use of alternative instructional approaches and sharing of goals of instructors and learners. Teachers should avoid isolation of the adult learner and make use of group work and work settings to support learning development. The teacher becomes the facilitator (Morrison, 1986).

Research has shown again and again that literacy is tied to social context and environment and these must be considered in addressing literacy and numeracy provision. A recent study (Wickert, 1989) demonstrated the need for adult literacy and numeracy provision in Australia for English-speaking background people as well as for those from non-English speaking backgrounds. Results from the study showed that people who were unemployed or in unskilled employment had the poorest performance on the three dimensions of literacy (document, prose and quantitative) assessed.

As most practitioners know, programs for the long-term unemployed in particular may need to address other factors which can coexist with literacy and numeracy problems such as self-concept, work attitudes and life skills. Programs need to emphasise the personal responsibility and empowerment of the learner through negotiation of goals and program content (Adams, 1982).

Previous writers have also alluded to the alienation which adult literacy and numeracy learners can feel in institutional settings (ALBSU, 1984; Simpson, 1988), since many may have had very negative experiences for most of their formal schooling. This, combined with the sensitivity of publicly admitting to problems with literacy and numeracy (although numeracy problems are more socially acceptable) means that it can be difficult attracting those people with greatest needs to courses (Lane, 1983; Munday & Munday, 1983; Reubens, 1986).

Finally assessment is still an area where much work still needs to be undertaken. Assessment here is defined as meaning processes by which judgements can be made about learner's needs and progress, not necessarily traditional or formalised testing. If literacy and numeracy are perceived to be culturally and context specific, the development of assessment strategies which can be applied across a range of programs is problematic. Difficulties therefore arise when literacy and numeracy instructors try to gauge the progress of their students. Common practices in adult literacy and numeracy include using student self-assessment, the setting of small, reachable goals and certificates of completion. The compilation of folios of work over the duration of study is a simple technique through which both students and teachers can realise the progress made.

Effective provision of literacy and numeracy instruction in programs for long-term unemployed persons: observation of programs in Australia

Context

In 1989-90, Bert Morris and I undertook a national research project funded by the Commonwealth Department of Employment, Education and Training (DEET), under the auspices of the National Policy of Languages, to investigate alternative models of vocational literacy and numeracy provision for long-term unemployed persons (Cumming & Morris, 1991).

The two models to be investigated were classified as:

> pre-vocational – programs with main emphasis on the acquisition of literacy and numeracy skills; and
>
> vocational – programs with main emphasis (over 60% of the content) concerned with training in vocational areas and with a literacy and numeracy component.

Although the original brief called for a contrastive evaluation, we saw as our goal the identification of what was good practice in literacy and numeracy provision in both pre-vocational and vocational programs, and in what context were the different types of programs most beneficial.

In order to do this, we examined 32 exemplary programs across all states and territories of Australia, from inner city areas in Sydney to the outskirts of Alice Springs. To be included in the study a program had to be identified as exemplary by at least two people from different sectors who had direct knowledge of the program but were not involved in the teaching of the program. For example, the program might be known favourably to a funder such as a Commonwealth Employment Service (CES) officer and to an administrator in a TAFE college. Not only were these programs usually seen to involve exemplary instruction and structure, they usually had high retention rates, placement in work or training and remarkable learning and affective outcomes considering their duration.

One immediate finding of the study was that in 1989 very few programs which could be classified as pre-vocational, or in other words access basic education, were being funded externally or internally through the adult education sectors in Australia. In fact programs for the unemployed which were funded by CES were required to have at least 60% vocational content. Programs which deviated from this to have a basic education focus did so only because of an individual relationship between a provider and a more visionary CES officer.

A second immediate finding of the project was that most courses which were operating, either vocational or basic education in nature, were of very short duration, usually 3 to 12 weeks. Repeats of courses were always dependent on funding availability and need. A technical reality of doing the study was identifying courses for visiting before they were finished.

A case study approach was used. Because of the requirement to travel large distances, and the usual restrictions on budget, only short visits could be arranged to each site. Data were collected through interviews with funders, administrators, teachers and students, collection of work samples and student records, as well as observation of the literacy and numeracy practices in these programs. We looked for recurrent and idiosyncratic themes emerging from our data which reinforced the criteria of good practice derived from the research literature as well as adding to these.

Characteristics of effective programs

The general finding of the study was that the basic education (pre-vocational) or vocational focus of a project was, of itself, not a limitation on the quality of literacy and numeracy instruction provided. Excellent examples of both types of program were found. What was found to be important was the provision of appropriate instruction oriented towards achievement of the aims of the program and the needs of the individual participants.

From the case studies undertaken in the project, general characteristics of effective provision were identified. For the most part these were congruent with those identified in the research literature, although there were also some characteristics idiosyncratic to programs. The criteria can be loosely considered in three categories: content and teaching strategies within programs; the qualities of the teachers in the programs; and organisational factors associated with the programs. These categories are obviously not discrete but provide a simple framework for consideration of the nature of these effective programs.

Content and teaching strategies

Individualisation of instruction. As identified in the literature, individualisation of curriculum and instruction occurred in the exemplary sites. Teachers made judgments about participants' needs in a number of ways, usually informally. An outstanding and recurrent feature of the teachers in these programs was their ability to respond flexibly to different needs within their group. Students commented that less competent teachers lacked the same insights into individual needs and learning styles and were far more rigid in their teaching. For many students these teachers recalled memories of school days with teachers more concerned with teaching curriculum than the child.

Of course not all teaching observed was as desirable as the above practices. Many teachers, particularly in mathematics, used workbook activities based on primary or secondary school textbooks, 'busy' tasks and whole-class teaching regardless of the individual performance ability of the students. But effective teachers **were** able to individualise their programs and the students were appreciative of their efforts and made noticeable improvements.

Teaching strategies. Teaching of literacy and numeracy in effective programs was always contextualised, whether in vocational context or life skills. Worksheets which had no transferability nor purpose for the students were not used. In addition, staff tended to make use of peer tutoring, group-based approaches and have a problem-solving orientation to any task. Work centred around the development of metacognitive strategies as much as content knowledge.

Another common approach in both literacy and numeracy instruction in the most effective programs was the emphasis on oral communication in the learning process. Most students have strong oral ability and a capacity to verbalise problems and solutions without knowing the formal written forms of literacy or numeracy. Thus the use of an attained strength provides a firm basis for the development of new abilities. Not only did the use of oral skills facilitate group problem-solving activities and participants working together and helping each other, it simultaneously provided an environment more authentically related to the workplace. At the same time this removed students' preconceptions of what an education setting should be. In fact, in many programs providing for people who have obviously had very negative previous learning experiences, staff have to allow students to undergo a form of re-birthing to allow them to divulge themselves of these misconceptions of how learning should take place. This was particularly true in modules based on mathematics, where many students who have failed in mathematics enter with the notion of correctness of answers, that only a correct answer is indicative of success, and that there is only one was to solve a problem.

Two other noticeable features of instruction relate to the numeracy provision in the effective programs. Firstly, because of the predominantly oral approach taken it was often difficult to distinguish between what was actually literacy, numeracy or vocational or basic life skills content. Therefore, the better the program, the more blurred the lines between these areas.

The second feature related to the content of the numeracy in the effective programs. Lacking were the worksheets and emphasis on basic facts and operations worksheets which are often regarded as numeracy. These were still regarded as important needs, particularly for the workplace, but were approached in different ways. Numeracy was much broader and generally included many dimensions of mathematics from the number system through games to spatial awareness. Large physical objects such as tables and chairs were manipulated in the classrooms to deal with problems ranging from percentage and discount to volume and area. Estimation occurred as a physical activity such as standing beside a window and deciding how low it was, rather than the topic approach of estimation in school curricula. Money was used as a valuable tool in aiding understanding of place value. Through the use of varied approaches and content in numeracy, students not only acquired new knowledge and problem-solving strategies, they also enhanced from a different perspective the imperfect mathematical knowledge and concepts they usually brought to a program.

Adult learning principles. The features of adult learning which were mentioned by staff in effective programs were negotiation and responsibility for learning. Students were encouraged to set or help set their own learning goals and how best they might achieve them. The flexibility of the programs and the teachers meant that meeting such individual needs was achievable. In some programs the nature of modules to be studied or the content of individual sessions was negotiated between students and teachers. It is important to note however, that this was not an attitude of *laissez-faire*, for when necessary teachers would help provide a structure and knowledge base within which students could make an informed choice. Often the adult learner with basic literacy and numeracy needs is not in a position to be able to identify their needs.

A theme that emerged constantly within the best programs related to group dynamics. Staff believed that the development of group dynamics was vital to the success of a program, particularly in assisting many long-term unemployed people in regaining or acquiring social skills. Positive encouragement by a group of peers is one of the strongest motivators an individual can have. In several programs deliberate strategies were employed at the beginning to assist in the formation of group dynamics including social outings or the formation of a tea club on the first day with students having to take responsibility for different roles.

Integration of literacy and numeracy across the program. Vocational programs usually incorporated a number of modules including literacy (or communication skills), numeracy (or workplace mathematics), life skills and vocational content. Full-time programs with a basic education orientation usually had a similar format with other modules instead of vocational content. These additional modules ranged from computer skills to study of the community.

In both types of programs, effective programs incorporated and integrated literacy and numeracy instruction across all modules. The orientation of most of these programs was that literacy and numeracy development were the major need and focus of the programs. Therefore, every module had a literacy and/or numeracy focus. This was undertaken in a range of ways such as the u[illegible] of instructional materials, manuals and activities written at appropriate levels and team teaching by vocational and basic education teachers in vocational modules. In actuality, some of the better basic education and vocational programs showed only marginal differences in orientation, but were identified as pre-vocational or vocational by the project brief definition.

Balancing specific and transferable literacy and numeracy skill development. Most of the programs we visited were aimed at low occupational skill levels because generally these are the jobs undertaken by people with much lower literacy/numeracy skills than the general community. If a program focused only on the skills needed to do a job such as factory hand or sewing machinist, the students would have little opportunity of improving their general literacy or numeracy abilities. We found that in effective vocationally-oriented programs staff tried to balance the development of skills which were specific to undertaking a job with the more general literacy and numeracy needs of the participants. Work with money might help in operating a cash register but was also incorporated in applied areas such as personal budgeting and food shopping, while at the same time developing transferable knowledge of mathematics such as place value and basic operations. In this way, staff knew that they were not only meeting the immediate work and life needs of the participants, but were also affecting their capacity for better skilled work or training.

Identifying vocational literacy and numeracy competencies. The effective vocational programs, which usually offered skill development for up to three jobs, had specific curriculum orientations to pursue. In the most effective vocational programs, staff devised their curriculum by undertaking skills or competency audits of those jobs. For example, one program provider had identified that there was a local need for clerical hospital staff to help organise admission information forms. The nature of the work to be undertaken was audited and appropriate curriculum developed. In fact, this provider operated outside the normal guidelines by spending a few months developing appropriate instructional materials for a range of jobs before taking clients, again incorporating basic literacy and numeracy development throughout all content. Needless to say, these materials were then greatly sought after by other providers.

The practice of audits and identification of skills and competencies facilitated individualisation of instruction. The staff were able to examine what incoming participants were able to do against what was necessary in the job. This gave a clearer picture of what areas of literacy and numeracy development needed most focus.

On completion of the program, students were given a certificate on which was listed the skills or competencies which they had either 'achieved' or 'attended for', out of the total required for the job. Thus all students could be shown to have achieved in a positive way. The employment placement of these students was very high because the providers had first identified an employment demand in the region and then developed the students' skills to suit.

Teacher qualities

Teachers' qualifications and expertise. There can be great differences in the backgrounds of staff employed in basic education and vocational programs for the unemployed, according to the location of the program. In general the teaching staff in basic education programs are more likely to be qualified teachers than those in vocational programs. However, the generally poor employment conditions provided for staff in these programs, low pay and poor or nonexistent job security, can make it difficult to employ qualified staff. This was particularly true in rural Australia where such staff would have to leave the region to find employment elsewhere. Should another program suddenly be funded, qualified staff simply would not be available.

Within such programs, however, it is not always the case that formal qualifications make for the better teacher in general. Adults with trade or clerical experience who related positively to long-term unemployed people and who provided the flexible and individualised attention needed in effective provision were also found to be appreciated as staff in these programs. Among the qualified teaching staff, there appeared to be no clear pattern that primary trained teachers were more suited to these programs than secondary trained teachers, or vice versa.

Teachers who had had formal training in adult basic education were found to be among the best teachers in programs. Teaching literacy and numeracy to adults in these types of program involves skills which are extensions of and often different from those used by teachers in mainstream education. In Australia until recently very few training programs for teachers have been offered in this area, and hence the number of qualified adult basic education teachers are very few. Again, more programs are being offered to meet this need but there are not enough qualified people to meet the growing number of literacy and numeracy teaching positions being advertised nationally. This is extremely critical at this point. Literacy and numeracy instruction cannot be left to untrained or inexperienced staff. Should this occur, and the programs are not effective in improving literacy and numeracy and hence deemed unsuccessful, the present emphasis on meeting these needs and associated funding may disappear.

What we often found in programs was that the most effective qualified and non-qualified teachers had 'been around'. While not identifying with the participants in a depressing manner, these teachers had often had a range of occupations from professional to menial, been unemployed, and undergone personal traumas common to our society such as divorce. This is not to paint a picture that the only good staff for programs for long-term unemployed persons have had to undergo all these negative experiences first, but to say that the most effective teachers were those who understood some of the issues confronting their clients, who could maintain respect for people from whom most others would turn, and who could be positive and encouraging throughout.

Team spirit with respect to other staff and students. In the most effective programs, staff worked together as a team and deliberately fostered a cooperative working atmosphere. Communication about the program and participants was very good, with regular, often daily meetings for planning, program organisation and discussion. In one case this occurred with staff who had worked together for ten years. This cohesion is both more important and more difficult to achieve when programs employ a large number of part-time staff.

Team work was also important within the teaching context. With regard to literacy and numeracy emphases, this ranged from the literacy and numeracy staff assisting in the development of materials for all content areas and teaching strategies to the team teaching by vocational and basic education teachers.

In most programs, staff were carefully selected on their ability to work with long-term unemployed people who had many learning and social problems. Staff in the effective programs were always positive about their students, often with humour, but emphasised respect for the students as adults and honesty as important ingredients of successful provision. The staff had the capacity to maintain control of the situation but were never patronising to the participants. In general, the staff enjoyed their work despite its demanding nature.

Organisational factors

Flexibility of programs. Just as the teachers could be flexible, so too the most effective programs were in themselves flexible. Although operating within basic constraints of starting and finishing times and number of contact hours per week, the best programs were continually adjusted to meet the needs of each intake group.

Expected outcomes. Staff were usually realistic about the outcomes they could expect from programs of short duration. They recognised that for participants with major literacy and numeracy needs little could be achieved but to set them on a pathway of instruction and learning. For some students, recognition that they had a literacy and numeracy problem which needed to be addressed was a critical outcome.

While the success of the programs in funding terms was measured in terms of placement of participants in further training or employment, staff saw these as not the only outcomes. Affective areas such as self-esteem were always targeted in effective programs. Modules such as life skills, hygiene, personal development and conflict resolution (explained by one teacher as 'you don't hit the boss') were included in most programs. Often physical activities such as walking or basketball would be included to help students attain a healthy lifestyle. Self esteem and confidence-building were most important in programs where clientele were mature-age women with reasonable literacy and numeracy skills who were returning to the workforce after twenty years' absence.

Selection of participants. Although it may be obvious that a program operates best if the range of student ability is reasonably constrained and appropriate to the level of a program, the opposite did occur in several programs. This was mainly due to inappropriate placement in programs being made by Employment Officers of the government. For example, within one small vocational program we saw an English-speaking background student who was unable to write his name, and a non-English-speaking student with a Ph.D. in a technological area. However, in the better programs, participants were generally matched with an appropriate level basic or vocationally-oriented course.

Often participants had to successfully complete a screening task or tasks set by the provider. In these cases the provider had established working relations with the local Employment Officers which facilitated this process and conveyed the importance of appropriate placement. In Australia today, screening and placement is undertaken by selected consultants outside of the Commonwealth Employment Service and recommendations are made as to the general level of literacy and numeracy needs of the individual as well as to whether they are best suited to a basic education or vocationally-oriented program.

As an outcome of our project we recommended that unemployed people with extreme literacy and numeracy needs should be funded to undertake basic education programs prior to vocational training. This is now happening. We felt that students who had need of intensive instruction in general literacy and numeracy were disadvantaged by being placed in a vocational program. However, at the same time, many such students are either strongly targeted towards getting a job or reluctant to face their literacy and numeracy difficulties. Initial involvement in a hands-on vocational program is often a procedure by which these reluctant literacy and numeracy learners decide that they have a need in this area and for arrangements to be made for further instruction, either individually or in a group class.

Assessment and certification

Effective literacy and numeracy programs were individualised to meet both program goals and individual needs. This places great demand on teachers' skills in identifying those needs. In some programs staff made use of standardised norm-referenced reading and mathematics tests which were theoretically suspect and contextually inappropriate.

However, in the effective programs we saw, teachers had developed expertise in using informal testing, observation, examples of work and interviews for assessment. Either through knowledge of adult literacy literature or naive knowledge of their clients, the teachers were able to gauge how far they could stress students, who were often easily stressed in formal testing situations, to assess their literacy and numeracy performance ability. The most common practice in monitoring progress was for teachers to have ongoing discussions with individual participants about their needs and to observe closely the work which was carried out.

In 1992 and the future, programs are finding themselves facing stronger accountability requirements and the need to demonstrate in tangible ways that students are making progress. Staff across Australia are looking at certification procedures similar to those developed by ALBSU and at the same time a number of research projects for 1992 and 1993 are continuing to investigate the issues and means of assessment in adult literacy and numeracy. This still remains the most problematic area of adult literacy and numeracy provision.

Finally, most effective programs provided some form of certification on completion of the program, usually with a moderately formal ceremony and presentations with family present. This was obviously a very motivating and positive activity and for many the first feeling of success in their lives. With the introduction of standards frameworks and competency modules in Australia as in the United Kingdom, such certification can eventually be made more meaningful and can contribute to further learning pathways.

Structure. Despite the often disparate nature of the participants in these programs and many participants' lack of life skills such as self-management, staff in effective programs provided a strong structure in content as well as daily organisation. There was always an expectation that students would arrive on time, participate fully and attend regularly. In some programs students would complete a personal contract with the staff regarding not only their learning and personal goals but also behaviour on site. In most effective programs, behaviour control was exercised by the student group themselves who would establish rules of conduct and undertake their own 'enforcement'. Staff found that not only were the participants undertaking responsible behaviour but that they would generally be much harder on each other than the teachers would be. In one site, students had decided that latecomers would not be admitted and had themselves once locked out a student.

Program structures. Programs varied considerably in duration and intensity. Some programs were only three weeks long and focused on life skills and self esteem, others in Technical and Further Education Colleges were from six months to twelve months long and intended to raise participants to a Year 9 standard of education.

One successful and different structure was a continuous entry model. The program started at the beginning of the year with between 30 and 45 participants, participants stayed up to 8 weeks, and new participants could enter monthly into vacant places. Advantages of this model included the capacity to employ good staff consistently, small numbers of new students entering for whom instruction could then be tailored and, overall, the atmosphere of success generated when students could see others being successful in getting jobs.

Most vocational programs offered or wanted to offer work experience as part of the program. In some cases this was being hampered by appropriate legislation to cover areas such as liability for worker injury. However, by 1992, work experience had become a part of most vocational training programs. In many cases students are now expected to find their own placement with a contract then being made between the employer and the training provider.

No clear pattern emerged from the project about the desirable length of programs. Short duration programs were clearly limited in the learning they could bring about. At the same time many long-term unemployed people are anxious to obtain work and daunted and disillusioned by the prospect of long instructional programs. Conversely, once immersed in a program they often considered that programs should have been longer, and many arranged to continue further studies themselves. An important outcome of this is that articulation from the short vocational and basic education into other programs is an important consideration for the training of the workforce in general. Participants who have a long time lapse from completion of their program to enrolment in a further training or education program often lose both the skills and motivation just developed.

Location. The programs we visited were arrayed in a variety of habitats from sleekly modern office accommodation to extremely run down houses. While the warmth and quality of the teaching staff was the major contributor to the effectiveness of a program, staff were also concerned about the self-image of participants if their environment was really poor and hence their training appearing to be devalued. Therefore it is desirable that all training programs should be in accommodation of a standard similar to that provided for any other learning environment.

Just as it was not clear from the visits to different programs as to what was the most desirable length of a program, so the effect of location of the program on its effectiveness was ambivalent. It is often stated that adult learners who have had unsuccessful or negative learning experiences at school will find an institutional setting alienating. In fact, many adults feel that their training program is more prestigious and respectable if it is held in an environment such as office space or a Technical and Further Education College. What is more important, it appeared, is for staff and students to be in reasonable proximity with a home room for the students. The more isolated the staff offices from the teaching spaces, the more difficult it was to encourage team work and cohesion amongst the students. The students themselves may not be alienated from a formal training setting but it is less likely that they will engage with regular campus activities and liaise with regular students.

A final comment with regard to the effect of location of the program and alienation due to school experiences is the presumption that all participants have had negative experiences or in fact even attended school. Many participants had quite happy times at school, they just didn't learn. Others even in these times have attended only one to two years, if at all.

Conclusions

The major conclusion drawn from the study was that both basic education and vocational training programs incorporating literacy and numeracy should be available to the unemployed. Since 1989 there has been a dramatic change in the recognition that literacy and numeracy ability can be a major inhibitor to people obtaining work and the provision of funding and programs to address this. However, on conclusion of our project, we recommended a model of provision of training for long-term unemployed people which we felt would meet most needs and be most effective. To some extent the concept of the model has been introduced in the types of programs now being offered, although the fully basic education programs are seen to be the domain of further education providers rather than the Commonwealth Department of Employment, Education and Training.

We suggested that running parallel should be 10 week intensive basic education modules and the same length or longer vocational programs. Following screening, participants should enter either program and movement between programs should be facilitated.

We also suggested that smaller centres which could not support both types of program should offer a continuous entry model. The content of the program could be adjusted to suit vocational vacancies in the district with the advantage of being able to keep qualified and experienced staff employed.

In addition to these programs, we recognised that there would always be a role for community and individual tutoring to assist those with the greatest literacy and numeracy needs.

Finally, we recommended that all such programs should try to address the criteria for effective practice which we had identified from the literature and from our own research, while at the same time they addressed 'the needs of the whole person in a constructive and deliberate manner' (Cumming & Morris, 1991, p.48).

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