National Literacy and Numeracy Week

Critical Numeracy in Context

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Three factors merge to influence the comments that I'm going to make today about Critical Numeracy in our schools. One is the significance of National Literacy and Numeracy Week. It draws our attention to the importance of these two significant parts of the school curriculum.

For some time now it has been accepted that literacy is a responsibility of teachers from all areas across the curriculum. But perhaps because of underlying uncertainties about mathematics in the past, it has been more difficult to convince teachers that numeracy is also their responsibility across the curriculum.

The second factor is the recent release of the *National Numeracy Review Report*. This Report addresses quite forcefully critical numeracy in its first recommendation:

> *That all systems and schools recognise that, while mathematics can be taught in the context of mathematics lessons, the development of numeracy requires experience in the use of mathematics beyond the mathematics classroom, and hence requires an across-the-curriculum commitment.*

It is to be hoped that the politicians who read this Report will support the professional learning needs of teachers in this regard.

The third factor is a reinforcement of the others, in that most of the curriculum statements of Australian state systems include definitions for numeracy that encompass and expand on the National Report's recommendation. Similar to the Australian Association of Mathematics Teachers' definition, New South Wales states:

> *Numeracy is the ability to effectively use the mathematics required to meet the general demands of life at home and at work, and for participation in community and civic life …*
>
> *Numeracy is a fundamental component of learning across all areas of the curriculum …*
>
> *The development and enhancement of students' numeracy skills is the responsibility of teachers across different learning areas that make specific demands on student numeracy.*

Accepting the significance of these factors, I would like to suggest a Framework for Critical Numeracy for the classroom. It can be used for planning and implementation of teaching, as well as for devising assessment.

To meet the demands of education required for citizens of Australia today, all three components of the Framework need to be included in students' learning experiences across all of the years of schooling. The first tier of the Framework is the understanding of basic terminology. This component is fairly easy to assign to the mathematics classroom, for example, we expect students to be taught the meaning of the term "average" in the mathematics class. Learning in relation to "average", however, cannot stop here.

Learning must also take place in what is called the second tier of the Framework for Critical Numeracy and that is the understanding of terminology in context, especially social contexts. What does it mean to say, for example, that the “average shopper is a woman” or that the “average number of children in the family as 2.3”? Without knowing their meaning in context, the various terminologies associated with ‘average’ is useless, as is the ability to perform any calculation.

In educating students today, however, we want to go even further and assist them to reach the third tier of the Framework: the developing of the ability to think critically in context and to question claims that are made without proper justification. This ability is particularly relevant in the light of media claims about sensitive social issues and in the light of advertisements that make claims for products on the market. Is it reasonable to claim an average annual salary for a company of $90 000 if the managing director earns several million, but the vast majority of employees earn less than $50 000? Both mathematical and contextual understanding need to be combined for students to become critical numeracy thinkers.

This Framework for Critical Numeracy has affinities with Luke and Freebody’s claims for Critical Literacy for readers. For them, students need to be code breakers in terms of text, for example, using words like “number, measurement, decimal, fraction”; they also need to be text participants and users. They need to make sense of these words when they appear in text in order for contexts to make sense; and they need to be text analysts, for example, critically reading text and constructing a position in relation to the claims that are made in terms of numeracy.

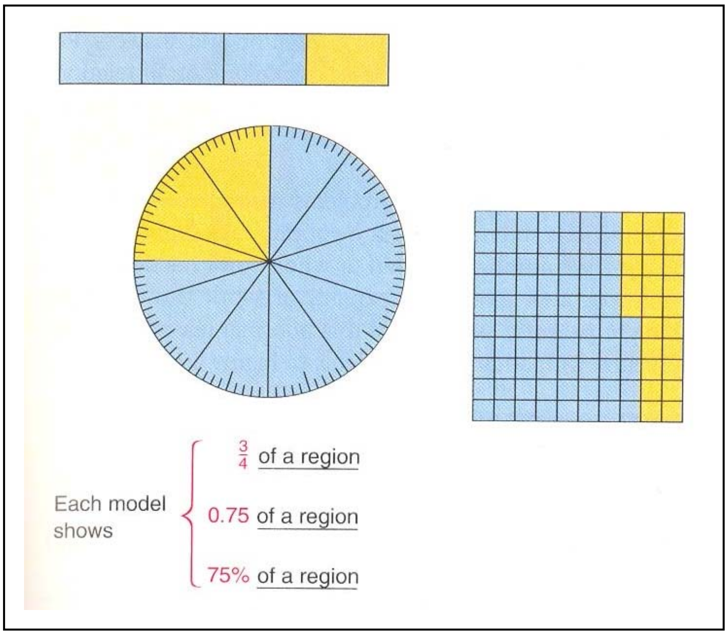
There are also parallels between this Framework and the *Dimensions of the School Curriculum for Numeracy* as outlined in the *National Numeracy Review Report*. The report suggests three dimensions: the first is Mathematical, similar to the learning to terminology of Tier 1 of the Framework; the second is Conceptual, as introduced in Tier 2 of the Framework; and finally, the third dimension is Strategic, including “appreciations and dispositions needed to choose and use mathematics to solve … unfamiliar problems”. These three dimensions are required for students to become critical thinkers and decision-makers in today’s world.

To illustrate these ideas, we will consider the three-tiered Framework as associated with the concept of ‘per cent’. Per cent is a somewhat neglected part of the mathematics curriculum in that it is often taught on its own rather than being taught in conjunction with or via proportional reasoning in relation to fractions and decimals.

Tier 1: Terminology

First, we review Tier 1 of the Framework in looking at the terminology associated with ‘per cent’. The term means “per hundred”, with “cent” being the Latin stem of words like “centenary” and “centennial”. Per cent is linked to fractions, with “1/2 of” and “50% of” both being phrases that act as operators on some whole.

Per cent is also linked to decimals, in that “0.75 of” or “75% of” acting as operators, often in relation to 1. Graphical representations of 75% of various figures show the equivalence of “75% of” to “¾ of” or “0.75 of” in an area format.



The mathematics of actually using per cent shows the link to proportional reasoning. Converting a fraction such as 5/6 to a per cent is equivalent to finding what part of 100 is “equal to” 5 parts out of 6? The steps shown are a reminder to “multiply both sides by 100” and then “divide 500 by 6,” which results in 83.3%.

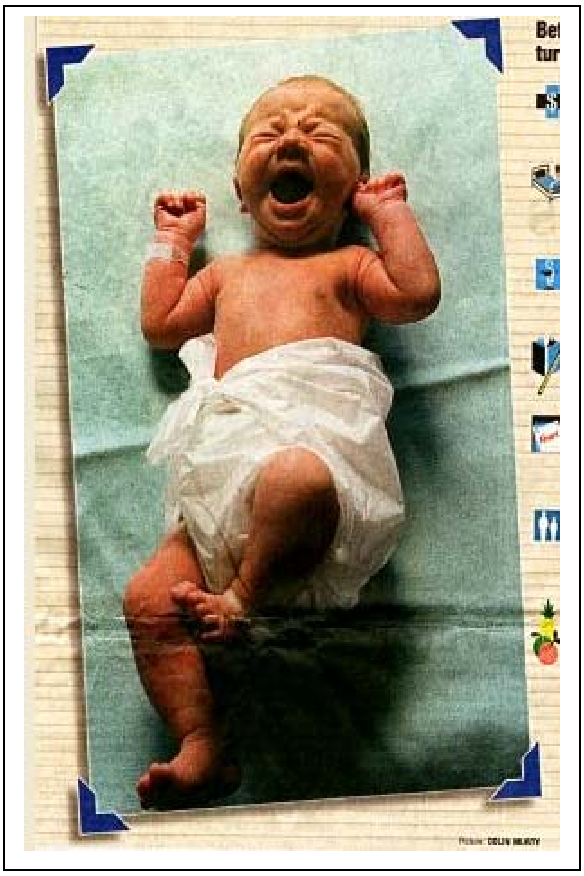
$$\frac{5}{6} = \frac{\square}{100}$$

- $\frac{500}{6} = \square$
- $\square = 83.3$
- $\frac{5}{6} = 83.3\%$

The link to part-whole understanding is also essential, based on the assumption always that 100% is the whole. The figure then shows the relationship of fractions, area and per cent in this context.

Tier 2: Terminology in Context
With this background, we turn to an advertisement from some years ago noting the percentage fat in various foods. It can be an interesting discussion in relation to the health curriculum and, as you watch, it always makes me feel guilty about my love of avocados!

There are many examples of per cent in the media, for example with discounts, and these should be used and discussed across the curriculum. It is important, however, to look at examples more widely than money, and chance and risk provide excellent examples. In the extract from the newspaper shown here, several interesting statements call for interpretation.



Before the baby turns 15, he:

- has a 22 per cent chance of spending some time in the hospital
- has a 40 per cent chance of chronic illness
- has a 70 per cent chance of finishing Year 12
- has an 80 per cent chance of missing some school each year.

Students could discuss how these figures might have been obtained, how reasonable they seem over 15 years, and how they relate to their own experiences. Why might they have been presented in this form? Often in classrooms we consider chance words and we order the phrases along a line from ‘possible’ to ‘certain’.

Recently I read that scientists have a convention that an event that has a 66% chance of occurring is considered “likely”, and then an event with a 95% chance of occurring is determined to be “very likely”. How do these conventions fit with our own expectations and intuitions?

Risk (and risk-taking) is a topic relevant across the curriculum, particularly in relation to behaviours that we would like students either to avoid or to indulge in. When and where should we start talking about and assessing understanding of risk? Should this be considered numeracy or literacy? The following item is one that teachers will immediately know the answer to, but it is interesting to see the progression of student understanding across the years of schooling. The link of ‘per cent’ with ‘chance’ and associated language is very relevant to Tier 2, understanding of per cent in context.

Q2. A bottle of medicine has printed on it:

WARNING: For applications to skin areas there is a 15% chance of getting a rash. If you get a rash, consult your doctor.

What does this mean?

- ☐ (a) Don't use the medicine on your skin - there's a good chance of getting a rash.
- ☐ (b) For application to the skin, apply only 15% of the recommended dose.
- ☐ (c) If you get a rash, it will probably involve only 15% of the skin.
- ☐ (d) About 15 out of every 100 people who use this medicine get a rash.
- ☐ (e) There is hardly any chance of getting a rash using this medicine.

Across the grades, the percentage of correct answers increases monotonically, which is encouraging. The two alternatives with chance words – (e) "hardly any chance" and (a) "a good chance" – illustrate the avoidance of numbers by some students or the intuitive appreciation of per cent as figures. Is 15% a large number or is 15% a small number? The alternatives (b) "apply only 15%" and (c) "involve only 15% of the skin", involving "15%" probably attract the attention of younger students because they repeat what is in the stem of the item.

Grade	5	6	7	8	9	10	11
(d)	37	42	53	63	71	82	90
(e)	19	23	23	19	16	11	10
(a)	25	18	13	11	9	4	0
(b), (c)	19	16	11	7	3	3	0

(Percent of each grade)

Tier 3: Critical Thinking

In moving to Tier 3 of the Framework, critical thinking with per cent involves questioning usage, questioning calculations and questioning claims. In considering the use of per cent to report survey results, as is often done in the media, there may be a link to the way the questions are asked and the use of language to bias people's responses. In the case in the figure, there are, of course, issues of the sampling technique, as well as the way the question is asked. How would you answer the question in a YES/NO fashion? The question says: Do you think tariffs should be reduced to 5% if it costs tens of thousands of jobs.

Think about what is wrong with the questions in terms of its conditional language if it costs tens of thousands of jobs. The use of per cent figures tends to add legitimacy to a context that is really quite meaningless. Students need to be exposed to examples like this to learn the nature of biased voluntary polls. Per cent provides the link to the other issues by attracting attention. For example, 96.5% is quite a significant figure.

Occasionally there are mistakes in the media's use of per cent that can be used to challenge students' critical thinking. Consider the extract from a Tasmanian newspaper that reports on the increase in the number of flies allowed on fishing lines. The limit for the number of flies allowed is being lifted from 2 to 3, which the article claims is a 33% increase. A big problem with this claim is that most readers don't recognise that it is wrong! It provides an excellent opportunity for students to work in groups or complete an assessment task that asks for a critical analysis of the article.

> **Extra fly a boost for Tasmanian anglers**
>
> **By STEVEN DALLY**
> **Chief Political Reporter**
>
> TASMANIAN flyfishers could have a 33% better chance of hooking a trout under new rules allowing the use of three flies for the new season.
>
> Or anglers could just have a 33% higher chance of hooking themselves in the back of the head.
>
> The new rules lifting the fly limit from two to three were unveiled yesterday by Primary Industries, Water and Environment Minister David Llewellyn for the opening of the new trout season from midnight on Friday.
>
> The Mercury's freshwater fishing writer Harvey Taylor said the three-fly limit followed a rise in the popularity of British "loch-style" fishing from a drifting boat.
>
> "It is another discipline of the sport that is coming into vogue," he said. Mr Taylor said he was not an advocate of three-fly rigs although the method had its followers.
>
> "It is a difficult way to fish and most people can get into enough trouble with one fly," he said.

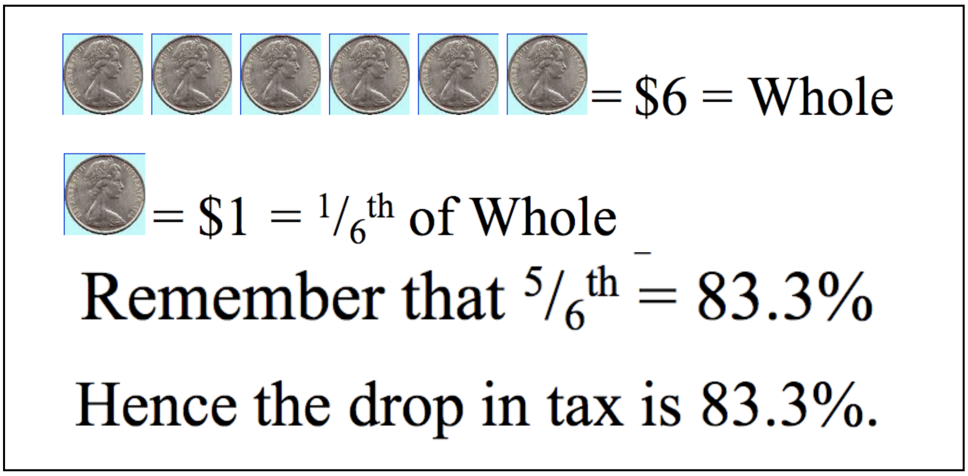
Students can be asked to provide a model to show why the increase from 2 to 3 flies is a 50% increase, rather than a 33% increase. The use of pictures may be helpful. Students might also be asked to explain why they think the reporter's error might have occurred or they might even be asked to write a letter to the editor of the newspaper.

Per cent change can happen in two ways. In the fly fishing article, it was an increase, but decreases are also common, as in the case of sale items (e.g., a 20% discount). The presentation of a per cent decrease may be fairly easy to visualise but when given the numbers only are given, working out the per cent change can be even trickier than the previous example.

Consider for example the case of an opposition member of the Tasmanian parliament who was outraged by the supposed drop of 500% in the tax paid by the local casino on its poker machine profits. When the "whole" tax is 100%, a claim of a per cent drop of more than 100% should produce howls of laughter from critically numerate students. The actual drop in tax was to be from 6% to 1%. Students should be able to discuss why they think the politician might have made this mistake.

There are obvious language issues here in this context because we are talking about a per cent drop in a per cent. Why might the politician have claimed a 500% drop? What if the politician had discussed a 5% drop, a fact resulting from a subtraction rather than a part-whole calculation? Since 5% is a "small" per cent compared to 500%, he would be unlikely to seek publicity for such a claim.

How can students envisage the "whole" as the 6% tax and then ask what would 100% drop to, to be equivalent to a drop from 6% tax to 1% tax? One way might be to imagine an income of $100, with $6 in tax dropping to $1 in tax. Using the coins as shown, the drop in tax is $5 or 5/6th of the whole, which as we saw earlier is 83.3%. This is still a "large" per cent drop when 100% is the maximum possible and should be enough to gain media headlines.



Having students find their own examples from the media is a very useful activity – some quite humorous outcomes are possible. Finding their own examples means students will choose topics relevant to them and hopefully be challenged to consider their own issues, biases and beliefs.

This very attractive photo of Jane Fonda is accompanied by claims for AGE RE-PER*FECT* Pro-Calcium, a product to "recharge your skin with calcium". Notice how the print gets smaller and smaller. Finally we see that 78% of women report "fuller, more resilient looking skin". And who and how many women is this? In even smaller print we see it was a dermo-clinic trial – what is that? – with self-evaluation of 51 women. What about a placebo? Not very impressive, with many sampling issues for students to consider. But the use of a number like 78% again lends credibility to a nonsensical claim.

Many of the examples students find will provide partial information that does not allow a complete understanding of the strength or seriousness of the claims made. Sometimes only per cent increases are given but it is impossible to work out the absolute number of outcomes involved.

Males from 17-22 are 21.9% more likely to have multi-vehicle crashes than females of the same age.

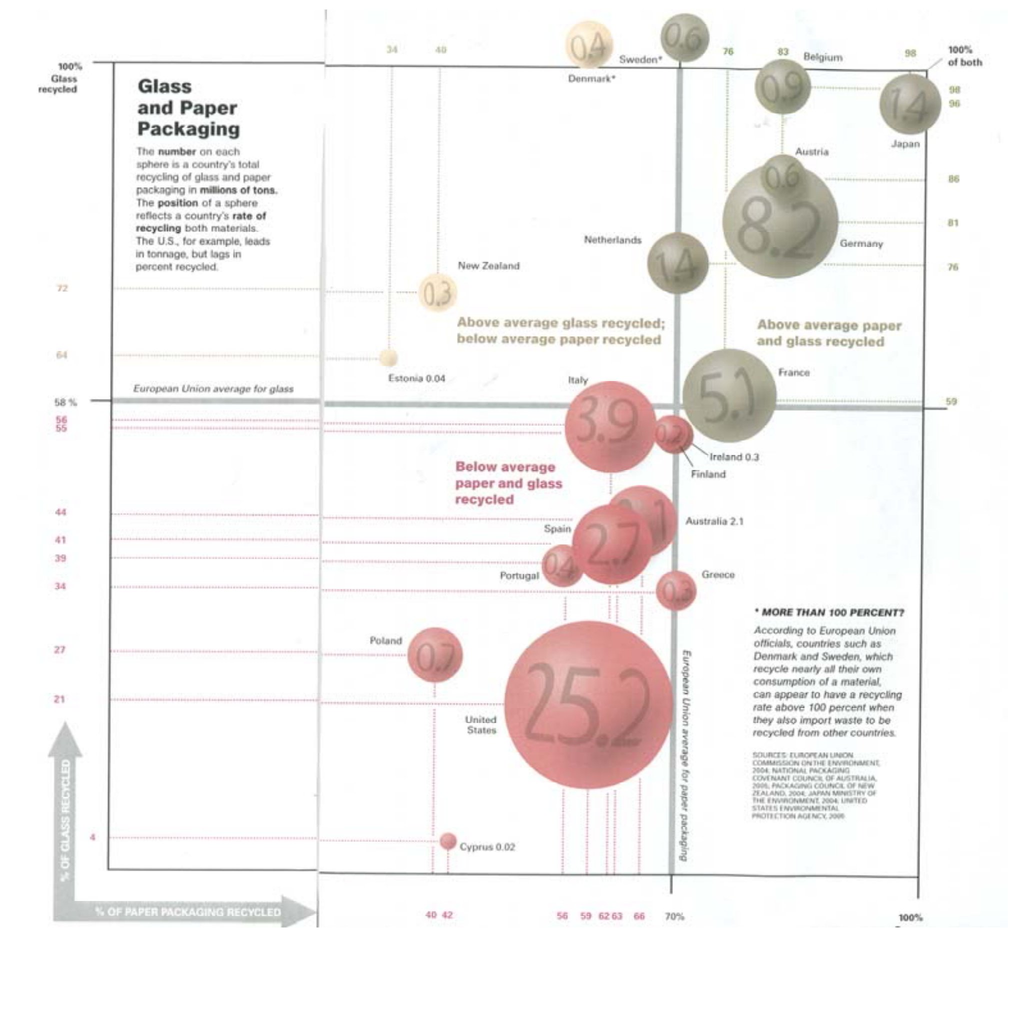
How many males does this represent? How concerned should we be? Sometimes only raw numbers are given and it is impossible to judge the relative size of events. The following is one of my favourites:

Only 21 bands who released debut albums in the US last year made a profit. By comparison, 25 people were struck by lightning.

What per cent of all bands does 21 represent? What per cent of the population (and of what state/country) does 25 represent? Is this a reasonable comparison if we were to use per cents rather than actual numbers?

Not all examples that we use in the classroom should be poor ones. We end with a wonderful but challenging graph from *National Geographic* magazine. It reports on the recycling of paper packaging and glass. On each axis per cents are reported, whereas the relative sizes of the circles indicate the absolute values in tons of recycled glass and paper. The graph is a great way to stress the importance of the relationship of absolute numbers and per cents.

Some challenging questions are possible based on this graph. How is it possible to have a value of more than 100% on an axis? Which is "better"? To have the most tons recycled or the highest per cent recycled? There is an impressive website called "Gapminder" that expands on this type of graph in a dynamic fashion. It can be very powerful in the classroom.



Critical Numeracy in the classroom links understanding of mathematical terminology with context in meaningful, not artificial ways. It is essential to build understanding through context. Assessment of understanding should also take place in context. Teachers should also expect students to display critical thinking in context and where possible investigations should search for further evidence to support or refute claims found in context.

These are the keys to satisfying the curriculum goals for our students in term of Numeracy.