Cracking the NAPLAN code

Numeracy in action

Thelma Perso
Department of Education, NT
<thelma.perso@nt.gov.au>

Background

In May 2008 the first National Assessment Program for Literacy and Numeracy (NAPLAN) tests were administered across Australia to determine the standard of literacy and numeracy achievement of Australia's students in Years 3, 5, 7 and 9.

The purpose of the tests is to provide information on student performance across four levels of achievement in language conventions and writing, reading and numeracy. Information gained from tests will support schools and teachers to plan for whole school and individual student improvement. Comparisons of student achievement levels in literacy and numeracy may also be used to inform policy-making and resourcing for schools at both the national and state/territory levels.

Students in years 3, 5, 7 and 9 sit a number of tests:

For students in Years 3 and 5 NAPLAN testing comprises:

- Literacy — a reading test, a language conventions test and a writing test.
- Numeracy — a single test.

For students in Years 7 and 9 NAPLAN testing comprises:

- Literacy — a reading test, a language conventions test and a writing test.
- Numeracy — two tests, one which requires students to use a calculator and the other that does not.

All Australian students take the tests under the same conditions. The tests vary in length but range from 40 to 65 minutes.

At the time of writing this paper, the second round of testing had just been completed.

The purpose of this paper is to alert teachers and school leaders to the nature of the NAPLAN numeracy tests and the implications for their teaching. It is not to suggest that teachers "teach to the test" but rather that they consider what is being tested as indicated by the test construction. Teacher reflection on student results then becomes a powerful tool to guide the teaching of mathematics for numeracy attainment by students.

Mathematics or numeracy?

In order to determine whether the NAPLAN Numeracy tests actually assess mathematics or numeracy or both, we need a clear definition of numeracy. A plethora of definitions exist, many of them at odds with others. The MCEETYA definition is: "Numeracy is the effective use of mathematics to meet the general demands of life at school and at home, in paid work, and for participation in community and civic life" (MCEETYA 1997, p. 30).

At a recent meeting of national "experts" in this field, convened to inform the National Curriculum development, a draft revised definition was written: "Numeracy is the capacity, disposition and confidence to use mathematics to meet the general demands of school, home, work, community participation and civic life" (2 March 2009).

Willis (1992, p. 5) defined being numerate as "being able to use mathematics—at work, at home and for participation in community or civic life". In 1998 she further stated that people are considered more or less numerate based on "how well they choose and use the mathematical skills they have in the service of things other than mathematics" (Willis, 1998, p. 37).

In a paper by The Australian Association of Mathematics Teachers (AAMT, 1997, pp. 11–12) the following distinction is made:

> Numeracy is not a synonym for mathematics, but the two are clearly related. All numeracy is underpinned by some mathematics; hence school mathematics has an important role in the development of people's numeracy… Further, while knowledge of mathematics is necessary for numeracy, having that knowledge is not in itself sufficient to ensure that learners become numerate.

For the purpose of this paper, I use the AAMT definitions that derive fundamentally from Willis' work, making a distinction between mathematics as it is often perceived by classroom teachers and the community—and delivered in many schools—as a set of de-contextualised mathematical facts and procedures, and the ability to choose and use from these to suit the purpose and audience.

The dimensions of numeracy that need to be explicitly taught through relevant experiences (National Numeracy Review, 2008, p. 9) in schools are three-fold: mathematical, strategic and contextual.

Mathematical numeracy is about mathematical content; having number, measurement and spatial sense that derives from deeply understanding the mathematical ideas and concepts and knowing procedures and skills needed to apply these. For example, students know that the average (mean) of 16,18 and 24 cannot possibly be 17 because they deeply understand that average is a measure of the 'centredness' of a set of numbers; they know that 36 ÷ 0.3 can't possibly be a number less than 36 but must be approximately 3 lots of 36; they know that a whole number minus 1/2 and then 1/3 will leave a small fraction remaining because they can visualise the amounts involved.

Strategic numeracy and contextual numeracy are about using mathematical sense to decide whether mathematics will assist in a situation and whether results obtained through subsequently applying the mathematics make sense in a particular context. It includes having a disposition and attitude of confidence, to choose and use mathematics when and where it is helpful to do so and to reason about those choices.

Mathematical numeracy clearly dominates the NAPLAN Numeracy tests on two counts: firstly because it is seen to be the most important of the

three numeracy dimensions, and secondly because the nature of the test is not conducive to students writing and justifying choices of strategy or approach determined by context.

Implications for testing

It is difficult to assess or determine numerate capabilities through a pen and paper test, especially one titled "Numeracy Test." The writers of the NAPLAN numeracy tests attempt to do this for some questions by describing hypothetical contexts. These contexts however, whilst demanding some higher-order skills and a certain level of literacy, are limited in their capacity to assess the reasoning that is part of strategic and contextual numeracy, since students are required primarily to "tick the box" containing the correct answer. They are, at no time required to indicate the reasoning they use in obtaining a solution.

A pen and paper test, particularly a multi-choice test, is unable to test reliably students' confidence and disposition to use mathematics. Limitations of multi-choice questions include their inability to ascertain the meta-cognitive analysis underpinning student choices of distracters. This is essential if we are to test reliably the dimensions of numeracy listed above. Even if students get the correct answers, it is impossible to know whether they have used the reasoning strategies that we want students who are numerate to have, or if they have merely guessed. Hence the tests are also limited in their validity as we can only assume they have reasoned and that their choices are underpinned by numerate dispositions.

It is my contention that if students are being taught deep understandings of concepts—as distinct from methods, procedures and algorithms that tend to dominate many mathematics lessons—they will have the confidence and ability to apply their mathematical understandings, resulting in numerate behaviours. Moreover, this will result in their being able to complete NAPLAN numeracy questions successfully.

Implications for teaching

The depth of knowledge needed for mathematical numeracy, as described above, is based on informed reasoning that enables students to select correct responses for NAPLAN questions without undertaking specific computation in most cases.

It is my opinion that students are best prepared to be successful with the NAPLAN numeracy test by being taught to draw on the numeracy skills that best serve them in meeting the numeracy demands of life: estimation (based on deep understandings of mathematical concepts), visualisation of context, and common sense. Some might argue that computational skills and routines are just as appropriate. However, for this particular test genre and under these test conditions, students will be more efficient if they utilise estimation skills since many question do not demand, or indeed require, computational skill.

This has profound implications for the teaching and learning of mathematics in our schools. Our primary aim is to teach the deep understandings that result in numerate behaviours; the direct spin-off from this is improvement in NAPLAN numeracy results. Consider the following question from the 2008 NAPLAN numeracy test:

This table summarises the time Mick spent walking his dog over five days.

TIME SPENT WALKING THE DOG	
Day	Time
Monday	45 minutes
Tuesday	50 minutes
Wednesday	1 hour
Thursday	62 minutes
Friday	43 minutes

What was the average (mean) time for these walks?

(a) 40 minutes (b) 52 minutes (c) 65 minutes (d) 260 minutes

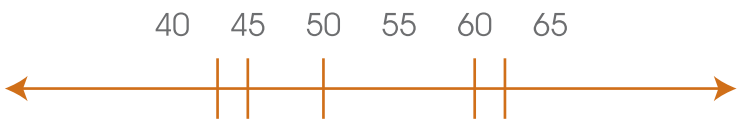
The percentage of the total student cohort from the sample state who selected each of these responses was:

(a) 11%
(b) 59%
(c) 10%
(d) 19%.

These results reveal a great deal about the degree of student understanding of the concept of average. Clearly, the students who selected the first, third and last responses (i.e., 40 minutes, 65 minutes and 260 minutes) do not understand the concept of average or they would have known at a glace that these three responses could not possibly be correct.

Students who selected these three responses are likely to have attempted to calculate the correct solution using an algorithm rather than using some visualisation of the five daily times and their position on a number line with respect to each other—the method that I believe is most appropriate if mathematical numeracy is being used.

By visualising these numbers on an unmarked number line as follows:



and knowing that the correct response must be a number that can be representative of the five numbers, students would be able to estimate the correct response as being between 50 and 55. Since there is only one distracter in this range, it must be correct.

Significantly, because the students are given four numbers to choose from, an estimation is all that is required to be successful, and this estimation strategy is arguably the most efficient in this context.

Unfortunately we are unable to determine whether the 59% of students in this state (and no doubt similar proportions in all states) who selected the correct response did so as a result of this deep understanding and visualisation or by using an algorithm. For the purpose of this test, an estimation is all that is required. Given the time available to complete the test paper, students should be taught to use the most efficient method, which is clearly estimation based on deep understanding.

Being able to determine the purpose and audience from the context is part of critical numeracy, as is being able to determine the degree of error that can be tolerated. From my knowledge of our students nationally and of teaching practices in many classrooms, I suspect that most of the 59% who got this correct answer did so using a standard algorithm. Whilst not being

wrong, this would likely take students longer which would be inefficient in this context. Certainty of this would reveal and confirm the limitations of NAPLAN numeracy tests in determining the numerate capabilities of Australia's students regarding their choices of method and the appropriateness of the choices for the context. Using the definition I have chosen for this paper, I believe that a student using a standard algorithm in this context is less numerate.

So as not to be accused of basing an argument on one example, I share another from the same test paper:

> A garden centre sells a potting mix made up of soil, compost and sand. Sand makes up $\frac{2}{3}$ of the mix and compost makes up $\frac{1}{4}$ of the mix. What fraction of the potting mix is sand?
>
> (a) $\frac{1}{12}$ (b) $\frac{3}{7}$ (c) $\frac{5}{12}$ (d) $\frac{4}{7}$

The percentage of the total student cohort from the sample state who selected each of these responses was:

(a) 19.1%
(b) 48.7%
(c) 13.4%
(d) 17.2%.

On examining these responses it becomes clear that large proportions of Year 7 students across the country do not understand the concept of fraction, or at the very least, are unable to visualise fractional amounts. Putting aside the literacy levels needed in order to understand the context and syntax of this question (see Newman, 1977), it is apparent that many students have at best partially understood these by the way they have responded.

Students who selected 3/7 are those that decided to add the two fractions to get the total amount of soil and compost in the mix. Whether or not they understood that they needed to subtract their answer from 1 is unknown. The fact that 48% of students merely added the two numerators and the two denominators is of greater a concern. Similarly, those who did know to subsequently subtract their result from 1—despite correctly determining that two steps were needed—simply subtracted 3/7 from 1 and obtained 4/7.

All these students (i.e., the 48.7% and the 17.2%) have indicated in their response that they do not understand the relationship between the numerator and denominator of a fraction. Neither do they, I would argue, understand the concept of fraction since they were unable to visualise the quantities they were dealing with. If they had they would have known that if they added 2/3 and 1/4 of the same total quantity they would be left with a very small quantity from the whole amount. In other words, if they deeply understood that fraction is about quantities of a whole and used that information to visualise the situation, they would know that of the four choices presented, the solution could only possibly be a small fraction and since only one of the four possible distracters, 1/12, is small, then this must be the correct response.

It is clear from these results that fractions are still being taught in many classrooms as algorithms and procedures only with little discussion or visualisation and rarely embedded in real world contexts that support the development of deep understandings of mathematical concepts. For students to get these questions correct on NAPLAN tests these approaches are essential.

Conclusions

I recommend that every teacher of mathematics should undertake an analysis similar to that described here using their own data. I further recommend that they reflect on the outcomes of their analysis and share it with colleagues. Teachers can look at an individual student's results, variations in results between student sub-groups in their classes (e.g., gender, culture), and student responses to questions from different strands. Following this, some reflection—individually and collectively—on current teaching of mathematics for numeracy attainment should be considered. A key focus of this reflection and discussion is to question whether students are being taught the deep understandings of mathematics concepts and the capacity, confidence and disposition to use them, or are they merely taught mathematics as a system of methods and procedures set in a relatively neutral context. If the latter, teachers and school leaders need to be aware that they are seriously at risk of not giving their students access to numeracy attainment. We cannot assume that students will make the connections between methods and procedures and the conceptual understandings needed for deep learning based on the fact that they've been taught the methods and procedures for finding answers.

References

Australian Association of Mathematics Teachers (1997). *Numeracy = everyone's business. The report of the Numeracy Education Strategy Development Conference, May 1997*. Adelaide: Author.

Brown, G. & Quinn, R. J. (2006). Algebra students difficulty with fractions: An error analysis. *The Australian Mathematics Teacher, 62* (4), 28–40.

Council of Australian Governments (COAG) (2008). *National Numeracy Review Report*. Canberra: Commonwealth of Australia.

Newman, N. A. (1977). *An analysis of sixth-grade pupils' errors on written mathematical tasks*. Paper presented at the 1st conference of the Mathematics Education Research Group of Australia, Melbourne.

Ministerial Council on Education, Employment, Training and Youth Affairs (MCEETYA) (2008). *National assessment program literacy and numeracy (NAPLAN)*. Accessed 24 February 2008 from http://www.naplan.edu.au/naplan_2008_tests/naplan_2008_tests.html

Willis, S. (1992). Being numerate: Who's right, who's left? Keynote address, Conference of Australian Council of Adult Literacy, Sydney, 9–11 October.

Willis, S. (1998). Which numeracy? *Unicorn, 24* (2), 32–41.

From Helen Prochazka's

Scrapbook

Mathematics is a sophisticated toy you can play around with until reaching total intellectual satisfaction. It is unbelievably perfect and that is why I feel it is not the universal language. The world is an interesting but imperfect place and needs something to balance it. So let's dream in mathematics and wake up in the real world.

Gergana Bounova, senior high school student (1999)