
TEACHERS' USE OF NATIONAL TEST DATA TO FOCUS NUMERACY INSTRUCTION



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With increased accountability attached to students' results on national testing in Australia, teachers feel under pressure to prepare students for the tests. One approach is to use evidence from school and student results to identify areas for targeted teaching strategies to improve students' understanding. Using NAPLAN results lower secondary mathematics teachers in one school implemented mental computation and estimation approaches as well as a strategy to address the literacy demands of typical test items to support student learning before and after the NAPLAN test. An analysis of the professional learning identified approaches to enhance both students' learning as well as teaching practice.

Introduction

Prior to 2008, each state and territory in Australia used state-developed tests to collect student achievement data for the Federal Government. To better standardise the monitoring of student achievement the *National Assessment Program in Literacy and Numeracy* (NAPLAN) was introduced in 2008 (DETYA, 2000). The same tests in literacy and numeracy are now administered to all students in Years 3, 5, 7, and 9. Testing early in the school year potentially provides diagnostic information to teachers about their students' performance in mathematics topics common to all states and territories (Curriculum Corporation, 2006).

Whether we approve of a national testing regime or not, this level of accountability is in place for the foreseeable future with pressure on school principals and teachers to improve results. While the information may be useful after the results are released, teachers of Years 3, 5, 7, and 9 are experiencing increased pressure early in the school year to prepare students for the test. Principals, school systems personnel, and parents are scrutinising the results to determine whether schools and their teachers are 'measuring up'. Public comparisons between 'statistically similar' schools are now possible with the recent release of the *My School* website by the Federal Government which presents statistical and contextual information about schools.

The results from the assessments are reported in individual student reports to parents, as well as school and aggregate reports with substantial information including results for each item and for each student. The school reports enable teachers to analyse the results for each year group to determine which items appear to be understood and which are problematic. In addition, school data can be compared to the Australian student data.

The information is useful to address common errors and misconceptions as well as to aid planning and programming of future learning (Perso, 2009). Rather than abandon good pedagogical practices and have students individually practise test items, NAPLAN items can be used as one source to address key issues in students' mathematical understanding and develop appropriate quality-teaching approaches (Anderson, 2009).

The purpose of the project reported here was to engage teachers in using evidence from their own NAPLAN results to identify their students' needs and collaboratively develop pedagogical practices which research has shown to be beneficial in building understanding. In particular, this paper describes and analyses the outcomes of a program conducted in one school by addressing the following research questions.

1. What strategies did teachers choose to use to support student preparation for NAPLAN and how was this different to previous practice?
2. Did the professional learning support have an impact on student learning and on teaching practice?

Literature review

Teaching to the test

High-stakes testing has been criticised for encouraging teachers to limit the curriculum to what is assessed (Abrams, Pedulla & Madaus, 2003) and resulting in the “corruption of indicators and educators” (Nichols & Berliner, 2005, p. 1). While the types of testing being conducted in some states in the United States of America in recent years could be considered higher stakes than the NAPLAN testing in Australia, systems, principals and teachers feel under pressure to prepare students for the tests and achieve good results, particularly given the publishing of the *My School* website. The pressure to raise scores has the potential to distort teaching and learning but there are ways teachers can support students' preparation for high-stakes tests without detracting from real learning (Gulek, 2003). Miyasaka (2000) identified five types of test preparation practices that support student learning and improve achievement—teaching the mathematics content, using a variety of assessment approaches, teaching time management skills with practise in test-taking, reviewing and assessing content throughout the year, as well as fostering student motivation and reducing test anxiety. In addition, Marzano, Kendall and Gaddy (1999) found knowledge of test vocabulary and terminology improves student performance.

Compulsory testing of students in Years 3, 5, 7 and 9 in Australia has the potential to focus teachers' efforts on preparing students for the test by using past papers for practise and limiting learning to technical support such as how to fill in answers (Nisbet, 2004). However, balancing this is the potential benefit of identifying students' strengths and weaknesses with data informing planning and teaching. In a survey of 56 primary schools, Nisbet (2004) reported about two thirds of the schools used the data to identify topics causing difficulties but only 40% of teachers used the results to identify individual students who were having difficulty, and only 22% used the results to plan their teaching. The low proportion of primary school teachers using the data to inform teaching and learning represents a missed opportunity and there is little evidence that secondary mathematics teachers are analysing NAPLAN data in meaningful ways.

An alternative approach

There is an alternative approach to ‘teaching to the test’ but the evidence above suggests teachers require support to analyse and interpret the data and consider alternative practices, to address common student misconceptions and difficulties (Anderson, 2009). Gulek (2003, p. 42) refers to the need for “school practitioners to become assessment literate in order to make the maximum use of test results” and Thomson and Buckley (2009) describe the potential of test item analysis to inform pedagogy. It should be noted the test preparation practices that we are advocating are aimed at improving students’ knowledge, skills and understanding of mathematics and **not** at artificially increasing students’ test scores.

Research has advocated several teaching practices that have the potential to target particular aspects of students’ difficulties in mathematics and numeracy. While many strategies could be considered, in this project, to be based on students’ errors, the following strategies were chosen from research which has shown them to be helpful in increasing mathematical understanding: mental computation, estimation and number sense, and the literacy demands of context-based mathematics questions.

Sources of students’ errors

Common student misconceptions have been identified as a major source of errors. For example, Ryan and Williams (2007, p. 23) use the term “intelligent overgeneralization” to refer to students’ predisposition to create inappropriate rules based on experiences. Some common generalisations include: multiplication makes bigger; division makes smaller; division is necessarily of a bigger number by a smaller number; and longer numbers are always greater in value. The following is an example of a NAPLAN Numeracy item where this type of over-generalisation occurs with few students selecting the correct answer of 22.

What is the answer to $6.6 \div 0.3$?

A) 0.022

B) 0.22

C) 2.2

D) 22

A common fraction misconception occurs when area is not the feature students identify in regional models of fractions (Gould, Outhred, & Mitchelmore, 2006). The “number of pieces” interpretation is a common response. This research explains the responses to the 2008 Year 7 NAPLAN item shown in Figure 1 where only 28% correctly selected the last option.

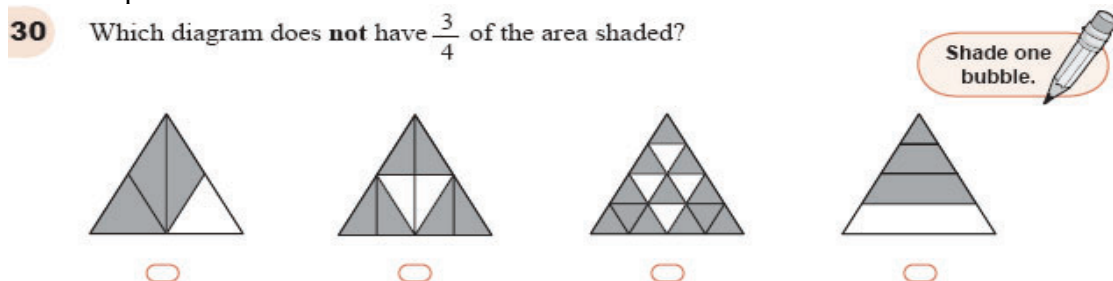


Figure 1. A fraction item from the 2008 Year 7 non-calculator numeracy NAPLAN test.

1. *Mental computation, estimation and number sense*

In dealing with misconceptions like these, Anderson (2009) points out those encouraging students to apply reasoning about numbers to evaluate answers can be a challenge. She argues that one way to support the development of students' thinking strategies is to use test items that focus on mental computation, estimation and number sense (McIntosh, Reys & Reys, 1997). Options in multiple-choice items may often be eliminated after considering whether the solutions are reasonable. Anderson proposes that after students have estimated the answer, teachers can pose questions such as:

- What strategies could you use to check the solution?
- What would the question need to be to obtain each of the alternative answers?

An estimation focus allows test items to be a source of meaningful mathematical discussion.

2. *Literacy demands of context-based mathematics questions*

The contextual nature of many NAPLAN items and the associated language implications often leads to claims that these tests are more comprehension than mathematics. However, interpreting mathematical situations in context is what numeracy is all about. Hence, we claim the contextual nature of the items is at the heart of numeracy and deserving of special attention. It seems pointless to pursue repetitive symbolic manipulation exercises to address poor responses to contextual items.

Newman (1983) developed an error analysis protocol to analyse student responses to contextual items. She identified five levels of difficulty (Table 1). Most errors occurred in the second and third levels of 'comprehending' and 'transforming' the text into an appropriate mathematical strategy, not applying the symbolic procedure. By translating each of the levels from Table 1 into a question for students, teachers are able to determine their first level of difficulty (White, 2005).

Table 1. Levels in Newman's error analysis.

Reading the question	Reading
Comprehending what is read	Comprehending
Transforming the words into an appropriate mathematical strategy	Transforming
Applying the mathematical process skills	Processing
Encoding the answer into an acceptable form	Encoding

Engaging teachers in professional learning

Planning professional learning opportunities for teachers in relation to promoting a change in practice requires consideration of several factors such as teachers' knowledge, beliefs and attitudes (Wilson & Cooney, 2002). Rather than change in beliefs and attitudes preceding change in practice, Guskey's (2002) model proposes professional learning precedes the implementation of new ideas in classrooms, which when implemented can lead to a positive change in student learning outcomes, and subsequently, a change in teachers' beliefs and attitudes. This model suggests that teachers need to try new ideas and witness positive student outcomes before they fully embrace such approaches.

Building on Guskey's model, this project aimed to change secondary mathematics teachers' attitudes towards NAPLAN and its usefulness. The approach taken with the teachers encouraged them to use evidence from the previous NAPLAN Numeracy test for their students, to identify topic areas and mathematical concepts of concern, and to develop strategies addressing the particular learning needs of their students

Methodology

One school which had a high NESB enrolment and low NAPLAN results volunteered to participate in the project. Ten teachers of Years 7 and 9 (12 classes in total) were involved. In May each year, Years 7 and 9 students complete two 32-item test papers for Numeracy, one with and one without the use of a calculator. The authors used the school's 2008 NAPLAN numeracy test results to identify specific areas of the curriculum requiring consolidation. Items from NAPLAN 2008 in these areas were used by the authors to compile a short diagnostic pre-test for each of Years 7 and 9 consisting of 5 non-calculator and 5 calculator items. Though the results from 2008 were those of the current Year 8 and 10, not the cohorts involved in the project, they were still considered reflective of teaching approaches in the school because the teachers were the same. Teachers administered the tests in early March, slightly more than two months before the NAPLAN tests in May, 2009. Each teacher corrected their class responses. In the six Year 7 classes, only one class had more than 50% of total responses correct in the calculator and non-calculator pre-tests (same class). In the six Year 9 classes, two had more than 50% of total responses correct in the non-calculator pre-test and no class had more than 50% of total responses correct in the calculator pre-test. These data support the items chosen as being areas of difficulty for the students.

A one day meeting two months before the NAPLAN tests was held between the teachers and the authors. The day consisted of reviewing the students' pre-test responses, considering the key mathematical ideas and misconceptions in the tasks, and exploring a range of possible teaching approaches identified by the authors. Teachers also contributed suggestions about the mathematical issues they saw as relevant and strategies they believed could be used to address student difficulties. As a result, a list of possible strategies was jointly constructed. Each teacher then nominated one or more to implement in their general teaching as well as with targeted NAPLAN items.

Data collected from teachers included teacher questionnaires and interviews plus eight teachers were observed for one lesson by a trained research assistant who was a qualified mathematics teacher. Pre-tests were collected from students in each of the eleven classes. In addition, comparative NAPLAN results for the Year 7 and 9 students in 2009 with their Year 5 and Year 7 results respectively in 2007 aligned with the corresponding New South Wales data have been used.

Results and discussion

The results mainly report the preferred teaching strategies identified and used by the teachers. These data inform on pedagogical practices and potential teacher change during the project. A second section reports on student learning. Given there was only two months of teacher implementation before the NAPLAN test and the length restrictions of the paper, these data are only briefly reported. They are seen as some

indicator of the success of the professional learning but not in any way conclusive on their own.

Teaching strategies

During the one day meeting, the teachers reported giving their students practise on NAPLAN type items before the tests. However, there was no use of school data to inform their planning and practice, or approaches to build desired understanding in their general teaching. When each pre-test item was discussed, teachers were asked to estimate the proportion of the school cohort correctly answering each item. They tended to overestimate and were frequently surprised by the low number of correct responses.

From looking at the mathematics involved in the identified areas and the incorrect answers chosen by students, the teachers and authors chose eight strategies as potentially useful for improving students' mathematics proficiency. These strategies contained a mix of general teaching strategies and some for class discussions based around NAPLAN style items. The teachers indicated that they intended to focus on the areas of concern and use strategies from the day not only in their general teaching, but also with NAPLAN items as stimuli for constructive class discussion.

After implementation, teachers completed a short questionnaire where they ranked the strategies in their preferred order of usefulness. Table 2 shows the results from the eight teachers who responded to the questionnaire. Scores were calculated by assigning 1 to the first choice, 2 to the second choice and so on, hence the lowest score indicates the most preferred strategy and the highest score indicates the least preferred (scores could range from 8 to 64).

Table 2. Preferred strategies as reported by the teachers to address students' difficulties.

Strategy	Score
1. Promoting interpretation of context-based mathematics questions using Newman's error analysis questions	20
2. Developing efficient mental computation strategies	29
3. Using estimation strategies with all calculations	36
4. Eliminating possibilities in multiple choice questions	41
5. Checking reasonableness of answers	43
6. Developing visualisation strategies in geometry (2D to 3D and 3D to 2D representations)	47
7. Identifying irrelevant information in mathematics questions	52
8. Developing strategies for answering open-ended questions	58

Their ranking must be interpreted realising they may not have tried some at all and only chose from the specific ones they did implement. None the less, the attractiveness of the ones they did choose to try is a factor in determining effective strategies that promote good pedagogy and are seen as comfortable for use by teachers.

Newman's questions and mental computation emerged as the most popular choices with 7 teachers ranking Newman's in the top 3. Some teachers' comments revealed some believed they were already using such strategies. For example:

The majority of the strategies I already used prior to the PD except for the Newman's method.

Others found the opportunity to consider new approaches was beneficial to both their teaching and student learning as shown by the comments below from three different teachers.

Identified their need for mental computation and to read all of the question.
 I found the Newman's questions are very useful. I went through that with all my classes.
 Newman's strategies—worked—ensuring read all of question.

Three teachers' comments suggest their knowledge and understanding of the potential of NAPLAN items and data have improved:

It gives me an idea of which kind of questions students found hard so I would focus more on those areas.
 Next year I intend to show students a variety of strategies for approaching the numeracy tests. I will also target some specific areas of knowledge that students in the past have had difficulties with.
 The pre-test identified common areas of weakness in my class. Common misconceptions were easily identified by the alternate choice students made when choosing the answer.

Professional dialogue between teachers and the researchers enabled the identification of a range of strategies for implementation in classrooms, an approach acknowledged as successful by the following three teachers' comments:

It was good to gather with colleagues and to discuss alternate teaching strategies.
 It was especially good to get the chance to do practical maths questions and be the "student" ourselves.
 Focusing on mental computation, visualisation, Newman's as part of each unit, from beginning of the year—encouraging this as a normal part of doing Maths.

Even though teachers indicated they already used some of the teaching strategies in regular lessons, their awareness of the strategies and ability to identify when they were using them increased. Further, they had not used them as a focus for supporting NAPLAN preparation nor in taking items and through these strategies making them a source of constructive class discussion rather than right/ wrong drill and practice. The data here show they were still using some of the learning three months after the NAPLAN tests.

Table 3 shows the strategies which were planned for and actually used by the teachers in the observed lesson. Some teachers used more than one strategy.

Table 3. Observed strategies.

Strategy	Planned	Observed
1. Promoting interpretation of context-based mathematics questions using Newman's error analysis questions	3	3
2. Developing efficient mental computation strategies	2	2
3. Using estimation strategies with all calculations	0	0
4. Eliminating possibilities in multiple choice questions	3	1
5. Checking reasonableness of answers	1	2
6. Developing visualisation strategies in geometry (2D to 3D and 3D to 2D representations)	3	3
7. Identifying irrelevant information in mathematics questions	1	0
8. Developing strategies for answering open-ended questions	0	0

The data set here is not big but still allows for some inference about the classroom practices of the participating teachers.

The top two (Newman's analysis and mental computation) figured prominently but a specific focus on estimation did not. All three who used Newman's analysis actually went through the steps with the class. Visualisation, though not an original popular choice, was used as the basis for three of the lessons. The specific test strategy of eliminating possibilities in multiple choice questions was planned but not widely used indicating lessons became more involved with the mathematics and appropriate procedures rather than test based strategies. As one teacher said to her class, "Does the answer actually fit the question? Have confidence in your ability."

Four of the lessons involved NAPLAN items as a source of class discussion and group work. In all these lessons, teaching went beyond right/wrong answers and looked at procedures. Three involved group work, while one was more teacher centred. The visualisation lessons were three of the four that did not use NAPLAN items. The teachers chose other activities that involved students in groups building objects given specific properties (for example, can you build the shape which looks like this from the front and has the most cubes). The level of student engagement was commented on positively in six of the eight lessons.

Student learning

Student data from 2007 to 2009 for each student were compared to the total NSW data. The groups used in the comparisons were the same in both 2007 and 2009. The mean gain for each group was calculated by averaging the individual gains. The results comparing the mean gains using a one tailed *t*-test showed that the gains by the sample school compared with the state are significant at the 1% level for Year 7 and at the 2% level for Year 9. These comparative data are encouraging and do support a positive impact of the project on student learning but, especially given that only two months of intervention occurred and all the other influences on the students and teachers, the approaches implemented can only to be viewed as one factor impacting on the gains.

Conclusions

There is evidence that engagement in the project by teachers and students coincided with some positive student learning outcomes and new teaching practices. The use of Newman's analysis in particular seems to have provided a better way of dealing with contextual mathematics. Thus the project was seen as successful by the school. The mix of using clearly identified strategies in general class teaching with NAPLAN items as a stimulus for discussion appear to be an effective pedagogical combination. The results here are consistent with Martin's (2003) observation that showing students test items and discussing strategies for thinking about questions and responses promotes student confidence and resilience, and enables a greater sense of student control over their learning. In addition, the assessment literacy (Gulek, 2003) of teachers by using data to inform teaching certainly became apparent as part of teaching practice where no indication of doing so previously was evident. However, there is no conclusive evidence about the way the data were used.

The results presented here are not advocating ‘teaching to the test’, rather they support the notion that there is much to learn from using a school’s NAPLAN data to develop pedagogical content knowledge about important mathematical concepts. Nor is national testing being promoted as the most desirable approach to assessing students’ knowledge, skills, and understanding. Teachers best carry out assessment as they talk to and observe their students (AAMT, 2008). However, given the reality we face and the fact that many teachers do feel pressure to actively prepare their students for the tests, the approach presented here offers some ideas for a constructive way to do so. Future iterations therefore are supported and, in particular, the results suggest looking for ways to increase long term positive beliefs and ownership by teachers.

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