…Where did I lose you? Accessing the Literacy Demands of Assessment

Colleen Kaesehagen, Val Klenowski, Robert Funnell and Steve Tobias

Abstract

In this study we sought to find out how teachers could make assessment fairer for Indigenous students in learning mathematics, given the context of the high stakes of the National Assessment Program Literacy and Numeracy (NAPLAN). Today, teachers are experiencing the full range of demands from their own students who require individual attention, through to system level expectations of improved performances for all students. Many staff experience reform fatigue with limited time for critical reflection and a reduction in support for the use and the analysis of the overwhelming amount of data that has become available in recent years. Over the past three years we worked with teachers in seven schools to gradually refine our research focus to centre on how we might best support teachers in this demanding context with the important outcome of improved teaching and learning of mathematics with particular consideration of how to respond to the cultural needs of Indigenous (Aboriginal and Torres Strait Islander) students.

The methodological approach of a design experiment coupled with a sociocultural theoretical lens for data analysis challenged our thinking and our observations of teachers' assessment practice and pedagogy. Most recently, we worked closely with the teachers of the four schools in the final phase of the study, to support them to modify their practice to engage their Indigenous students' in effortful learning. The main actions we employed included: modelling problem-solving activities; strategic thinking; collaborative learning and employing Indigenous contexts to explicate mathematical terminology and to decode written assessment tasks in order to facilitate Indigenous students' access to the literacy demands of these tasks.

In this article we focus on the role of the teacher in promoting effortful learning in mathematics with Indigenous students. We explore how teachers can promote student mastery and work to improve results in high stakes testing through actively diagnosing and scaffolding student learning. Our research aim required us to critically examine the role of the teacher in effortful teaching to enhance the knowledge and understanding of the Indigenous students when learning mathematics in the specific concept area of problem-solving.

Introduction

This federally funded Australian Research Council Linkage project centred on teachers' pedagogical practices and capacity to promote effortful learning pedagogies with Indigenous students in mathematics education. The aims were to provide greater understanding about how to build teachers' pedagogical repertoires to address the issue of underperforming Indigenous (Aboriginal and Torres Strait Islander) students in regional and remote Australia. These intentions included an analysis of the roles of the teacher in effortful learning within the context of mathematical problem-solving. We aspired too, to identify ways forward by attending to effortful teaching and learning.

Currently Indigenous students underachieve in mathematics in schools where the conditions are unsupportive given the inexperience of some teachers in their teaching of mathematics and the limited family capital and resources in some of the remote and regional locations. These conditions do not exist where sustained, above average performance in national standardised tests is achieved. If teachers are supported to understand the importance of cultural awareness, intercultural relationships, code-switching to access mathematical language and real life examples of mathematical concepts, this combination of understandings can help to promote energy generating factors that contribute to effortful teaching and improved learning outcomes. We argue that effortful teaching occurs when teachers actively design supportive classroom environments and are more culture responsive in their assessment and pedagogic practices, which helps to develop supportive and productive relationships with their students.

In this paper we consider the questions of: why, how and what now? In answer to the why question we explain that the driving forces that underpin the chosen topic relate to the equity issue of the underperformance of Indigenous students as reported in NAPLAN tests. In considering the fundamental question of how, we explain effortful teaching of mathematical problem-solving, which is unpacked in relation to the research design. We complete the article with a consideration of what now or the implications for classroom practice, and recommendations for future policy, and further research.

High Stakes Assessment

Patterns of under-achievement by Indigenous students, are reflected in national benchmark data bases such as: the NAPLAN and international testing programs like the Trends in International Mathematics and Science Study (TIMSS) and the Program for International Student Assessment (PISA). A trend of underperformance in terms of equity has continued over the past six years as evident from the comparative analyses of PISA results, administered in 2000, 2003, and in 2006. However little attention is given to better performances by Indigenous students and to the similarity of spread across percentiles for both Indigenous and non-Indigenous students. On this, De Bortoli and Thomson (2009, p. 26) state:

> Although many Indigenous students performed at very low levels (in PISA), there were also some Indigenous students who performed very well… there was a spread of 304 score points between the 5th and 95th percentile for Indigenous students. The spread of scores for non-Indigenous students between the 5th and 95th percentile was similar, at 310 score points… On the mathematical literacy proficiency scale in PISA 2003, only a small proportion of Indigenous students achieved Level 5 or 6, while around one in five non-Indigenous students were performing at these levels. At the lower end of the mathematical literacy scale, 43 per cent of Indigenous students did not achieve a proficiency of Level 2 compared to 14 per cent of non-Indigenous students.

The data indicate Indigenous children score significantly lower than non-Indigenous children (Sullivan, Tobias and McDonough, 2006) and that the performance of Indigenous students declines in numeracy relative to that of the rest of the school population as the period of time spent at school increases (DEST, 2007). We suggest implementing effortful teaching and culturally responsive practices could improve Indigenous students' test scores.

Sociocultural Issues of Values, Language and Context

We are mindful of the work of Mahuika, Berryman and Bishop, (2011) who have studied issues of culture and assessment in New Zealand. These researchers advocate the use of culture responsive pedagogies and assessment that meet the specific needs of students. They emphasise that an important shift has taken place in their context from a deficit view of the learner to a more considered view of the role of the school or the system and the establishment of culturally responsive models and quality teaching programmes that incorporate formative assessment. Our findings align with those of Mahuika, Berryman and Bishop (2011, p 185) in that we support Indigenous students "to be targeted by teachers through the implementation of culturally responsive pedagogies that include assessment practices." We would also agree in that we are not suggesting Indigenous students "are so different that they need some different, and as yet undiscovered, 'recipe' for addressing these differences." Rather we argue from a sociocultural view that some teachers are unaware of how the education system supports the dominant group's cultural values and beliefs and that although teachers want the best for all of their students they continue to use teaching and assessment strategies that do not respond to the cultural needs of their Indigenous students.

Recent NAPLAN data reveal that there is a significant drop in average numeracy scores when metropolitan to regional schools are compared similar to the difference between regional schools and rural/remote schools. Clearly, there is a lack of parity in mathematics achievement between rural and remote students, including Indigenous students, and their capital city peers. Contextually, this research project has focused on the factors for success of Indigenous students in learning mathematics in regional to remote areas. A fundamental factor is the difference between home and school (McTaggart and Curro, 2009). These researchers identified the many complex and interacting causes of the underachievement of Indigenous students. For example:

> … a vast number of Indigenous Australian students are speaking at least one Indigenous language and no English when they are not in classrooms…The languages used, orally only, by students in schoolyards, at home and in recreation may range from traditional languages, through clearly identifiable creoles, to several dialects, sometimes termed 'Aboriginal Englishes' which are similar to each other but locally specific. Students may use any or all of these, together, or separately, or intermittently with subconscious code-switching. Standard Australian English is almost never used. So, in schools, students are usually learning English as a second or third language (McTaggart & Curro, 2009, p. 6).

Facility with Standard Australian English (SAE) is assumed in the Australian Curriculum Assessment and Reporting Authority (ACARA) Australian Curriculum: Mathematics, NAPLAN and state-based curricula. It follows that students whose first language is not SAE require sensitive teaching and learning strategies to gain an understanding of how to communicate mathematically in classrooms. The *Language of Maths* study conducted in north Queensland explained the "imperative need to explicitly focus on language" and "that students demonstrated that they may have the requisite knowledge and skills, but language can be a barrier to communicating knowledge" (Davidson, 2005, p. 8). Teachers are expected to meet curriculum outcomes and national testing expectations with the diverse range of students who make up their classes. However, as evident in this study they are often unaware or uninformed as how to address culture and language related issues.

Methodology

In this study we adopted a 'design experiment' (Brown, 1992, Kelly, 2003) methodology, which uses an iterative approach to classroom intervention in that Indigenous students, school staff and researchers provide practical theorised views on mathematics learning and insights into how pedagogy and assessment can be improved and made more challenging. We collected a range of data from a number of sources including:

1) a detailed analysis of the NAPLAN data of the Year 4 and 6 Indigenous students' responses (completed when they were in Year 3 and 5 of the previous year) from the four focus schools of the final phase of the study;

2) an analysis of socio-cultural factors which might influence Indigenous students' scores (such as cultural specificity of how the item or question was framed, the linguistic codes and conventions of the test, cultural-specificity of content knowledge, possible misinterpretation of questions);

3) a disposition survey of the individual Indigenous students completed by teachers and

4) interview data about the teaching and learning of mathematics of Year 4 and 6 teachers.

The factors that affect teachers' ability to scaffold and extend Indigenous students' mathematical understandings were identified through an analysis of the corpus of data. Each school principal and each Year 4 and 6 teacher involved in the project received detailed summaries of each Indigenous student's responses to the NAPLAN tests taken the previous year. Each question was analysed such that teachers could check each student's answers to the different mathematical strands. The descriptive analyses of each answer aimed to support a more comprehensive and diagnostic understanding of the underlying concept and to suggest the next steps to be taken to support the student's development in the identified mathematical conception or misconception.

Group interviews were conducted with Year 4 and 6 teachers, to gain a broad view of cultural influences and values that affect the dispositions of Indigenous students' learning, particularly in relation to mathematics. The background information from these interviews was analysed further to augment data from the individual NAPLAN test results. As would be expected Indigenous and non-Indigenous students scored across a continuum of band levels. Further data analyses and reconsideration of interview data resulted in a shift of focus to culture-responsive assessment and pedagogy, particularly centred on effortful teaching.

Effortful Teaching and Learning

In relating effortful teaching to mathematics learning at university Pradip, Uhlig, Amin, Datta, Romney, Gatton, Mudasser, Wyne, and Cruz (2009) say that guessing an answer is a barrier to success because students "frequently and excessively" rely on intuition as a "mode of thought". They argue that better skills to judge one answer over another can be built "through systematic, slow, deliberate, effortful teaching." But, while a capacity for problem-solving can be cultivated and developed in this process, students "are amazed that focused work is required and that it does not come immediately." (Pradip, et. al. 2009, p 289). National tests, such as NAPLAN, most likely produce conditions in primary schools where answers are guesses due to limits in an overall student capacity to perceive what is expected and due to aspects of their language development. The core of effortful teaching in education begins with the teacher and involves putting in place strategies to teach, reinforce and encourage individuals to learn. In this project we extend the definition of the phrase effortful teaching to include collaborative problem-solving, diagnosis, high expectations and supportive environments where it is safe to "have a go" and try again.

Effortful teaching as we apply it, stems from teachers, but extends to others who influence student learning. It is not about reducing explanations of poor outcomes to questions of what is lacking in individuals or to cultural deficit. Rather, effortful teaching gives explicit recognition to Indigenous students' cultural identities and communities in order to build on their contextual understandings engaging with explicit mathematical terminology in challenging situations. In effect, effortful teaching involves learning about Indigenous students, diagnosing and supporting them by finding better strategies to address the emergent access issues across learning situations. Stobart (2008, p. 112) has raised important access questions such as: "What is incorporated from the cultures of those attending?" Many school staff and students we talked with described a conundrum: we, or they "know how to do it", that is how to get the right answers in NAPLAN tests, but they "get confused" and "give up" or "lose the plot" and pick the wrong answer when in fact they knew the right answer from the outset. The following instances of intuitive grasping for answers in a NAPLAN test are examples.

In a section on a Year 5 NAPLAN test of language conventions, children were asked to identify and rectify spelling mistakes made in twenty-five sentences. They were given these directions: "Each sentence has one word that is incorrect. Write the correct spelling of the word in the box." The first of two of the sentences we analysed said, "My aunt was nitting a scarf" Eight Indigenous student answers were as follows – "*nitting", aunty, was, scarf, scarf, (no answer), scarf, anty*." The answers are interesting as correctness depends on the way the directive words "each sentence has one word that is incorrect" are taken. The word "nitting" is incorrect. The word "scarf", mentioned three times, if not incorrect, is out of place in the humid areas of North Queensland where the students live. In our second example the prompt sentence to read was, "The scientist was an expert in the feild of dinosaurs." The answers were: "*Dinosaurs, dindsor, The, was, siententes, (no answer), felld, Scitit*." Briefly, attempts seem to be made to make phonetic sense of the word scientist (siententes, Scitit). The respelling of Dinosaurs with a capital D might imply that names are spelt this way for this student. The word "feild" is seen as incorrect, but the respelling is also wrong. In essence, these Year 5 students have been presented with a two-part problem. But when we consider how they have put their efforts and their thinking only into the first part, it is possible to understand how they "get confused" and more practically, where "the plot" is "lost".

The importance of literacy can thus be gleaned from these seemingly trite examples of two-part questions. However, we are reminded of McNaughton's contention that, (2011, p. 17) "… what is needed for reading comprehension and for writing effectively for school tasks become even more heavily dependent on language-related knowledge and skills as children move through the grades." The literacy demands of assessment tasks present a major challenge again apparent from these examples. These challenges are not uncommon in tests where problems are phrased to assess practical uses of causation. In the instances above the two causal parts were of the type, "if" a word is incorrect "then" can you correct it? What then are the implications of these literacy examples for our learning about mathematics problems?

Mathematical Understanding

In the lead up to our first visit to a school teachers were given a detailed analysis of the previous year's NAPLAN results for each Indigenous student in their classes. The reports, prepared by a mathematician, related to students' conceptual understanding. A child, for example, was said to have been "unable to differentiate part from whole in a probability context"; the qualifier being the child had "probably guessed the answer." Similar instances of intuitive grasping for answers were mentioned, with "probably just a guess", being the most frequent. Students who had missed the full extent of what was being asked, for instance, "only did one step of the problem, two step problems may be beyond his ambit"; "indicates difficulty in keeping a few chunks of information in mind and/or lack of strategy for breaking a problem into a series of smaller easier problems." Finally, "many of the items he got correct seem to be ones where he could have successfully used his intuitive knowledge. I suspect that reading comprehension problems may have been the cause of some of his incorrect responses."

From these comments, it seems that the Indigenous students, and some of their peers, drew on intuitive knowledge in the early parts of the test. A common struggle was moving from the first stage of a problem to the second where a solution could be found. This mathematical explanation of the Indigenous student's difficulties with two-part problems mirrors the explanations of the ambiguity and access issues as discussed to explain the task of correcting the spelling words in NAPLAN tests. The two are linked in similar ways. How this happens in literacy probably needs further explanation. Literacy is an obstacle to performance in NAPLAN tests for Indigenous students. As one teacher explained,

> I had one student last year... loves maths work. If there's no literacy in it he'll get it done and he'll be quick… but… the moment there is text to read and he's got to answer the question, that's when he'll just go, "Oh no!"

Clearly, for many students interpreting what the question is asking and identifying an appropriate response is a literacy issue rather than a mathematical issue.

From Effortful Teaching to Mastery Learning

When students read to make sense of two-part questions they often feel an extraneous or excessive load on the working memory available to make sense of the problem within the written question. Guessing, being stuck on one part of a problem, and giving up on having the right answer are all said to be a result of the "cognitive load" pressing down on students (Gog and Paas, 2008). Cognitive psychologists recommend that the extraneous cognitive load be replaced with one that is more germane or more apt for their working memory and just as challenging. We investigated three paths for demonstrating how to reduce cognitive load using two interventions. The first was diagnostic and involved the use of the Newman's error analysis scale to determine the processes that presented students with most challenge when reading and working through mathematical problems. The second intervention involved scaffolding of learning that required the creation of classroom conditions for germane problem-solving in the manner recommended by Vygotsky (1978). Finally, where possible we emphasised the importance of context and linking Indigenous contexts with explicit mathematical assessment tasks and language.

Newman's Error Analysis

Poor NAPLAN results for Indigenous students are compounded by errors in reading test questions or if students are unable to access the literacy demands of the assessment question (Hipwell & Klenowski, 2011). We found how students can misinterpret or miss what it is that they are expected to do when reading two part questions. To explore this phenomenon further and to gauge where teachers can "lose" students we conducted an intervention using Newman's (2005) analysis of error strategy. This is a diagnostic tool for identifying where and why students make mistakes in mathematical word problems. The approach has its roots in supporting learners to take risks and persist when attempting maths tasks in situations such as those that involve problem-solving and written open-ended mathematical questions. Newman's scale can assist teachers and students to identify five instances where errors most often happen. The dimensions where a student can lose the sense of a problem are in: (i) reading and decoding a question, (ii) comprehension of the overall meaning of a question, (iii) conceptual and mathematical skill or background, (iv) a lack of procedural knowledge, and (v) ability to explain the solution in written or diagrammatic form. In this way Newman's analysis of errors provides teachers with a diagnostic strategy for identifying and recording student errors, with a particular focus on conceptual and procedural knowledge. We used this approach in our study to practically incorporate Newman¹s strategy within a teaching framework.

Following a professional learning session using the method, teachers then applied their understanding and skills with the assistance of the Indigenous teacher aides and the researchers. Colleen Kaesehagen, a teacher, lecturer and researcher, developed the teacher checklist based closely on Newman's error analysis process (see Table 1). This set of questions was used in the capacity building session with the teachers and proved to be a valuable resource for them.

Table 1 about here

It was observed that some students made gradual independent assessments of their problem-solving strategies as they were encouraged to engage in a way that developed their motivation and promoted self-efficacy. The most enjoyable outcome appeared when students devised and set problems for peers and teachers in situations of friendly testing and competition. This activity incorporated a directed approach to teaching for understanding and developing independent problem-solving strategies. This was in sharp contrast to a sense of failure; some shame and avoidance that can prevail when students are faced with a problem they cannot access and lose their way as effective learners.

Reciprocal Teaching and Learning

Students can easily lose their way in NAPLAN tests. In the main, they do not have the words to explain why this is so in clear terms. In Vygotsky's words, present day NAPLAN tests are limited because they stop at recording how children "…can independently deal with tasks up to the degree of difficulty that has been standardized for (their)… age level" (Vygotsky, 1978, pp. 85-86). In themselves the tests are an imprecise foundation for gauging a child's potential to extend their grasp of a problem. Vygotsky said that to do this, was to show children "…various ways of dealing with the problem" to induce an approximation of "the level of potential development as determined through problem-solving under adult guidance or in collaboration with more capable peers." A second intervention was developed along these lines to create classroom conditions where students could talk amongst themselves about the mathematical problems in their own words with a teacher close by. The process was one of reciprocal teaching and learning.

In this intervention we aimed to reverse the conditions of NAPLAN testing where students have to repeatedly frame a question within their short-term working memory. Short-term memory is said to be "the ready state of the conscious mind." Its function is to "compose all the parts… of a virtual scenario" (Wilson, 1998, p. 121), which in NAPLAN test conditions could be the wording, a diagram or a simple equation. Two problems arise. First, the short-term memory only handles limited information for a matter of seconds. Second, chances of making a correct response depend on information from the long-term memory. To extend the time in which long- and short-term memory could be engaged students were organised into groups with others with whom they would not normally be grouped. Their classroom teachers, Indigenous teaching aides and the researchers acted as advisors within these groups. Activities were posed in terms of questions to be solved with the emphasis on testing a group or individual hypothesis. Correct answers were tested as were the positive aspects of any other hypotheses that fell short. Groups were then asked to formulate similar kinds of problems for others to solve. Each session began with an icebreaker, which took the form of number game. Other problem-solving activities were then completed in groups. The sessions were approximately eighty minutes and concluded with an all-group probability game.

As researchers we tried to reverse the classroom conditions to reduce cognitive load and to extend time to discuss a number of solutions to problems. Such changed conditions helped to promote engagement in problem-solving, which had been seen as unattainable by the teachers given the students' NAPLAN scores. With more time, assessment focused on learning and more culturally responsive pedagogy, encouragement, and experience of success, the students could be seen by themselves, their teachers and other students as able to actively participate. For some teachers when removed from their role of managing class behaviour and taking on the role of observer, they were pleasantly surprised to see, as if "for the first time", how their students worked on problems together, and with others. As a result of having the time and the support from adults and other classmates, students were able to develop and trial, response-methods that may or may not lead to a correct answer. They were however able to 'have a go' and to know with some certainty why they had done so.

It was in setting up these conditions and working with the teachers that we were able to locate the mathematical problems in contexts that were more relevant and responsive to the students' own background and cultural circumstance. It was through getting to know the students, their teachers and the school that provided us with the opportunity to ensure that the mathematical problems we presented were context enriched. We were promoting an approach to learning that is responsive to the ways with which Indigenous students are familiar. This may also be the case for all students but we understand and agree with McNaughton (2011, p. 7) in that "students knowledge and skills develop through socialisation processes provided by communities and families." We are also aware that some of this learning is recognised and reflected in schools because they are valued and promoted however teachers need to know their students and be aware of the knowledges and the learning that they bring from their cultural and community backgrounds.

Conclusion

Too often in our research we have heard how the students' low achievement at school was attributable to factors beyond the school, to parents, families and/or communities and therefore there was very little that could be done. In this research we have suggested some factors to help understand situations where teachers "lose" students and students become lost in the wording of problems. If they achieved nothing more, the classroom activities described provided teachers, teacher aides and the researchers with the opportunity to watch and learn from Indigenous students who were afforded the time to learn from each other and their peers. These are conditions where questions of "where did I lose you?" can be understood in some depth. In the process we encouraged teachers to rethink and reflect on their teaching and to work with students and to explicitly acknowledge their cultural identities by providing opportunities to learn as a community of learning with which they felt they belonged. It is here that the teachers can work closely with the Aboriginal teachers aide to help students access the very high literacy demands of current testing regimes. The study that has been described here continues to focus on improving learning through strategic and effortful teaching that encompasses a diagnostic and holistic view of the student's background, culture, language and demeanour for developing mathematical thinking skills.

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Table 1: **Teacher Checklist based on Newman's Error Analysis**

Student:		**Date:**	
Newman	Teacher Prompts	Student	Student Comment
Decode (D)	1. Please read the question.	☐ Can read the problem aloud ☐ Cannot read the problem aloud	
Comprehend (C)	2. What do you think the question is asking you to do?	☐ Can restate the question ☐ Cannot restate the question	
Transform (T)	3. What are you going to do to solve the problem?	☐ Can orally describe the strategy/ process they will use to solve the problem ☐ Cannot orally describe the strategy/ process they will use to solve the problem	
Process (P)	4. Show me how you are going to solve the problem?	☐ Can complete the activity using oral, written or symbolic representations ☐ Cannot complete the activity using oral, written or symbolic representations	
Encode (E)	5. Do you think your answer is reasonable?	☐ Can provide the solution to the problem (synthesis) ☐ Cannot provide the solution to the problem (synthesis)	
Application (A)	Please write a similar question?	☐ Can transfer knowledge to a similar context/process ☐ Cannot transfer knowledge to a similar context/process	