

# NUMERACY, MATHEMATICS AND ABORIGINAL<sup>i</sup> LEARNERS: DEVELOPING RESPONSIVE MATHEMATICS PEDAGOGY

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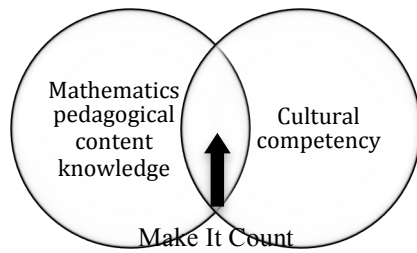
*Aboriginal students' mathematics outcomes in Australia's schools continue to remain substantially behind those of their non-Aboriginal counterpartsii. Developing responsive mathematics pedagogy that will improve these outcomes is the goal of the national project Make It Count. This theoretical paper derives from the work of the project's Clusters and presents a model for Responsive Mathematics Pedagogy (RMP) based on the different pedagogies being developed by the Clusters. These pedagogies are responses to the cultural, social and academic needs of Aboriginal learners. Three case studies, drawn from the project, illustrate how RMP can cater for the differing and varied needs of Aboriginal students.*

## INTRODUCTION

At the heart of quality teaching of students in mathematics are the professional judgments about teaching and learning - judgments based on teachers' knowledge, experience and evidence in relation to pedagogy, their students, and mathematics. If teachers are to provide quality experiences in mathematics they will need deep content knowledge and deep pedagogical knowledge in mathematics (such as those outlined in the Standards for Excellence in Teaching Mathematics in Australian Schools (AAMT, 2006)). However, for many Aboriginal students, this is not enough and mathematics remains a gatekeeper, or a gate that is kept locked, to future prospects. According to Perso (2003) a teacher's approach to teaching Aboriginal students mathematics needs to respond explicitly to Aboriginal people and their culture, Aboriginal children's mathematics understandings, and explicit mathematics teaching. Perso's research provided a foundation for the work of Make It Count and the subsequent development of the model presented in this paper. Make It Count is a project of the Australian Association of Mathematics Teachers (AAMT) Inc., funded by the Australian Government as part of the Closing the Gap initiative.

The work of Make It Count includes consideration of what constitutes a highly effective teacher of mathematics in the context of Australia's Aboriginal learners. We know that teachers need to have high levels of mathematical pedagogical content knowledge but, beyond this, are able to teach in ways that are "relevant and responsive to social realities and the cultural and racial identities" (Martin, 2007, p. 18) and academic identities of their Aboriginal students. Make It Count brings together two "fringe dwellers" in the educational landscape – Aboriginal education and mathematics education (the major focus of funding has been literacy rather than numeracy) - and through their intersection, is developing cultural competency in its

teachers and their mathematical pedagogical content knowledge in an endeavour to improve learning outcomes of Aboriginal students (Figure 1).



**Figure 1. Make It Count focus: Developing responsive mathematics pedagogy**

## **THE MAKE IT COUNT: NUMERACY, MATHEMATICS AND INDIGENOUS LEARNERS PROJECT**

Much of the present teaching of mathematics, particularly in the primary years, has Aboriginal students doing mathematics that is not related to their world and their everyday experiences. As a result, by the time many Aboriginal students have reached the latter years of primary school they have been alienated from mathematics. (Matthews, Howard & Perry, 2003, pp. 12-13)

Make It Count is an Australian-wide project striving to improve the learning outcomes of Aboriginal and Torres Strait Islander students in mathematics through whole-school, sustainable, evidence-based practice. It is part of the Australian Government's 'Closing the gap - expansion of intensive literacy and numeracy programs initiative'. The project has established eight Clusters of schools across Australia to find something new, or adapt something old, which will make a difference through the development of RMP. It needs to be made clear that RMP does not mean mathematics worksheets with boomerangs around the border or "counting the number of beats from a clapstick"; Aboriginal content that 'is tokenistic, separated from the core content and treated as an interesting or fun activity. These approaches only marginalise Aboriginal learners further from mainstream education' (Yunkaporta, 2012). Rather, RMP means valuing what Aboriginal learners bring to the classroom and responding to it in ways that develop deep mathematical knowledge.

The eight Clusters are engaging with RMP in different ways, with a different focus, but generally their approach can be described in Figure 1. Cluster teachers are increasing their mathematical pedagogical content knowledge – they need to know the mathematics well and the different ways it can be taught - and they are developing cultural competency so they are responsive to the learning needs of Aboriginal students. In other words, teachers need to know the mathematics, know how to teach the mathematics well, and know how to teach Aboriginal students.

Clusters are developing cultural competency in educators with the view that this might improve pedagogy. McAllister and Irvine (2000) describe cultural competency as:

...one who has achieved an advanced level in the process of becoming intercultural and whose cognitive, affective, and behavioural characteristics are not limited but are open to growth beyond the psychological parameters of only one culture.

Clusters' approaches to this, and ways for teaching mathematics, includes learning that: is investigative and problem solving; is explicit, scaffolded and sequenced; provides one to one tutoring that 'front-ends' Aboriginal learners in the mathematics in preparation for the classroom learning; contextualising, mathematising and transferring learning; builds resilience in Aboriginal students; and uses Aboriginal pedagogies and processes. Whatever their approach, the Clusters are designing learning that entails being intentional (being very clear and articulate about what mathematics Aboriginal students are to learn), being responsive (the pedagogies and practices teachers draw on to teach the mathematics), and being effective (how the teacher will know if their students get it)<sup>iii</sup>.

It is clear that there are different ways to teach mathematics suggesting that a repertoire of practices based on deep understandings of pedagogy is necessary. Teachers need to be able to understand how mathematics and pedagogy (and the practices within pedagogy) connect to Aboriginal students and their cultural and social realities. One Cluster has a focus that is strongly focused on academic inclusion through the use of scaffolded, sequenced learning; another has a focus on cultural inclusion through the infusion of Aboriginal pedagogies and processes; a third has a focus on social inclusion through the use of contexts that are authentic and meaningful to Aboriginal students. In the next section we describe the work of these three Clusters and use it to propose a new model that describes the elements of responsive mathematics pedagogy.

To develop RMP teachers and students need to engage in reciprocal learning - a mediation between home and school. This two-way learning is integral in the development of repertoires for participating in practices (Gutierrez & Rogoff, 2003) that are culturally, socially and academically responsive. Through the development of responsive mathematics pedagogy teachers are able to 'develop dexterity in determining which approach from their repertoire is appropriate under which circumstances' (Rogoff, 2003).

## **RESPONSIVE MATHEMATICS PEDAGOGY**

Make It Count is a work in progress and the following illustrates the project's progress so far in developing mathematics pedagogy that is responsive to, and inclusive of, the cultural, social and academic needs of Aboriginal learners. It reflects the pedagogical frameworks devised by various education systems around Australia but, at the same time, raises questions about the polarity in mathematical practices around the country.

The project is developing a series of messages from the Clusters about responsive mathematics pedagogy. They are based on what has worked for schools involved in the project and are supported by evidence that they have worked in improving

outcomes for students. Some of these are illustrated in the following three case studies. These consist of an outline of the relevant Cluster's focus, data collected and what the data have told those involved. These are followed by relevant Cluster findings drawn from all eight of the Clusters.

### **Cluster A: Academically responsive mathematics pedagogy**

Cluster A is applying principles of Gray's Accelerated Literacy (AL) pedagogy to the teaching of mathematics that is scaffolded and explicit in Reception to Year 7 classes. AL has been shown to be highly effective in enhancing literacy for Aboriginal students and this is why it is being adapted for the teaching of mathematics. Gray, (2007) describes this approach to teaching and learning as an organised teaching sequence that provides careful development of an explicit and supportive classroom interaction process, a teaching/learning context that is systematic and inclusive (Gray 2007, p. 4). He outlines four central concepts behind what is now called the National Accelerated Literacy Program (NALP) in Australia. They are:

- The notion of discourse as a primary goal for teaching
- The application of the Zone of Proximal Development (Vygotsky, 1978) as a strategy for achieving access to high-level performance within academic/literate discourses
- The staging of a teaching sequence structured around the two concepts above
- The integration of scaffolding (Wood, Bruner & Ross, 1976) as the framework for teaching /learning processes within the Zone of Proximal Development and the NALP teaching sequence in particular (Gray, 2007, pp. 4-5).

When the Cluster first became involved with the Make It Count project it became apparent to the teachers that they lacked adequate mathematical content knowledge. AL is underpinned by detailed knowledge of literacy and its development – they were short of the mathematics equivalent of this knowledge base. To address this they embraced the Big Ideas in Number program developed by the Department of Education and Children's Services in South Australia in consultation with its developer, Professor Di Siemon from the RMIT University in Victoria, Australia. When designing learning, they were able to be explicit about the learning goal and intention, which is articulated clearly in the first step of the learning sequence the Cluster has developed. Basically, the learning sequence begins with low order orientation which includes welcoming students into mathematical discourse. It moves to a clear articulation of the learning goal for the whole lesson followed by high order orientation which includes drawing on knowledge from other lessons. Finally, at the end of the sequence, handover is reached through joint conceptualisation and meaning making.

Student transformation - Andrew switches on to mathematics: Ruby is a middle primary teacher in an urban school in Cluster A. She is very experienced in using the AL pedagogy and explicitly teaching the cultural orientation necessary to engage in

school learning. Ruby discusses the change in Andrew, one of her Aboriginal students:

At the beginning of the year and throughout most of term one Andrew presented as a quiet, under achiever who was lacking in confidence particularly in the area of mathematics... Towards the middle of term 1, I changed my pedagogy in this subject area and brought it into line with how I taught Accelerated Literacy...Andrew in particular, began to shine in the lessons. He gradually became more confident to offer answers. He now asks questions when he doesn't understand. He shows that he enjoys mathematics and is eager to share his knowledge with others. He goes home and shares what he knows with his parents who have been delighted with this transformation. They have written notes in his diary.

The diary entries by Andrew's mother provided Ruby with rich data that reinforced the pedagogy. Ruby continues with an analysis of Andrew's diary:

This was not set as homework. He just went home and did it himself every night for the week. (I always say to the children that they can practise Maths at home. Until this, hardly any children ever did extra Maths at home.)

Andrew's mum commented on his enthusiasm in his diary. "He conquered his frustration of the Maths", wrote Mum.

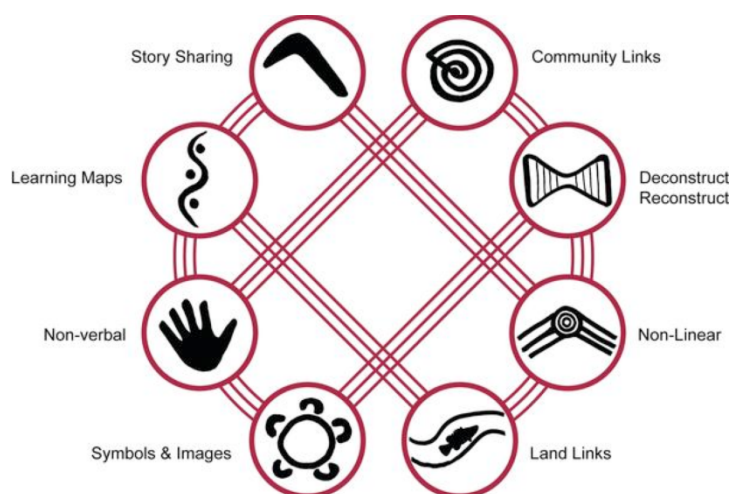
Cluster findings relating to academic responsiveness include:

- Practice explicit teaching with a defined and planned learning goal for each lesson.
- Remember that strong mathematics skills build learners' confidence and enthusiasm for mathematics, and this encourages risk taking which is an integral part of mathematics learning.

### **Cluster B: Culturally responsive mathematics pedagogy – Centring Aboriginal values and processes for cultural inclusion**

Orange Public School (OPS) began working with the 8ways pedagogy of learning (Figure 2) as part of their participation in the Make It Count project.

This Aboriginal pedagogy framework is expressed as eight interconnected pedagogies involving narrative-driven learning, visualised learning processes, hands-on/reflective techniques, use of symbols/metaphors, land-based learning, indirect/synergistic logic, modelled/scaffolded genre mastery, and connectedness to community. But these can change in different settings. (Yunkaporta, 2012)



**Figure 2: 8 Aboriginal Ways of Learning - Tell a story. Make a plan. Think and do. Draw it. Take it outside. Try a new way. Watch first, then do. Share it with others.**

The school localised the framework to become: Yarn up. Learning map. Model work. Hands on. Different ways. Symbols and images. Assessment item. Community links. A Yarn up could be about times when mathematics has been used to solve real problems in everyday life. Teachers highlight the importance of yarning as a way of creating and passing on knowledge in Aboriginal culture. Symbols and images could be about using visuals and creating symbols to help students understand and remember content. Teachers at OPS promote this as an Aboriginal form of communication (Yunkaporta, 2012).

The project findings to date have highlighted the importance of explicitly modelling assessment items and tasks, including the provision of key ideas, indicators and criteria for students at the beginning of the learning sequences. All mathematics units are now designed according to the school-community's Aboriginal learning cycle.

Community connectedness has proved to be the key factor for success in Aboriginal student engagement, and is the most clearly demonstrable outcome of the program to date. There are 15-20 Aboriginal community members regularly attending meetings, as opposed to negligible community involvement prior to the project. Additionally, pride in Aboriginal identity has measurably increased, with more students being willing and proud to self-identify and assert their Indigeneity. There has been a 15% increase in the number of students officially identifying as Aboriginal since the beginning of the project. This indicates a significant shift in school values and attitudes towards Aboriginal culture and community.

This all began with the establishment of a community advisory group for Aboriginal pedagogy, with a particular mathematics focus. The advisory group continues to have direct input into unit planning and curriculum design. They also put out a quarterly newsletter. In addition, they have established an ongoing project whereby community members are leading the planning and construction of an Aboriginal space in the school, including an ethno-garden and a roundhouse. The garden symbolically

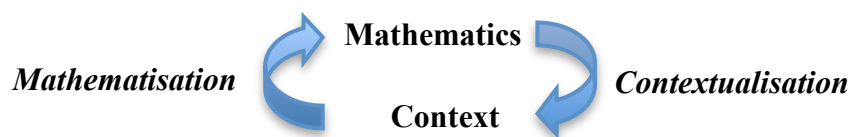
represents the Aboriginal learning cycle used in teaching and learning across the school, incorporating sacred sites, songlines, dreaming stories and local histories.

Cluster findings relating to cultural responsiveness include:

- Know that for Aboriginal students the sense of community and belonging is very important to learning
- Design mathematical learning experiences that have family and community significance.

### **Cluster C: Socially Responsive Mathematics Pedagogy**

From an initial focus on learning through context, the Alberton Cluster of schools sought to link mathematics and context through the deliberate acts of mathematisation and contextualisation (Thornton, Statton & Mountzouris, 2012). The model illustrated in Figure 3 evolved after almost two years of discussion and reflection on teaching practices among the teachers at the Cluster schools. Teachers were challenged to think about how they might make the teaching and learning of literacy and numeracy more meaningful by embedding it in contexts such as art, design, technology, sport or enterprise. They then spent some time exploring and evaluating this approach in practice.



**Figure 3: The Alberton Cluster model of mathematisation and contextualisation (Thornton, Statton & Mountzouris, 2012).**

The teachers in the team felt that the approach to teaching and learning in the Make It Count project was not only making their teaching more connected and purposeful, but that it was also engaging disinclined learners, particularly Aboriginal students, and encouraging them to maintain positive attitudes to mathematics beyond primary school. The teachers described this as increased mathematical resilience (Johnstone-Wilder & Lee, 2010), and identified five key aspects: having a growth mindset shown through behaviours such as learning from mistakes; meta-cognition shown through a willingness to reflect on answers and problem solving processes; adaptability shown through a willingness to try new strategies or start again; inter-personal aspects of learning such as seeing asking questions as clever rather than an admission of lack of knowledge; and a sense of purpose shown by a student's desire to seek meaning in his or her learning.

Debra is a year 4 student at Alberton school. She is a smart and precocious student who, like all young learners, had a range of behaviours and attitudes that were productive and some others that were clearly counterproductive to learning mathematics well. Prior to the Make It Count, she seemed disconnected from learning, reacting negatively to the shock of a new set of circumstances, such as a new space or a relief teacher, often challenging staff or failing to follow

organisational structures. She would respond to learning tasks by stating “I’m not doing this!” or “I need help” and would sit in her seat distracting the students around her.

Through the explicit focus on connecting mathematics and context through the processes of mathematisation and contextualisation, Debra has made great shifts in her approach to mathematics. In a lesson on measurement she was asked if, like Auntie Alicia a prominent Aboriginal leader in the community who was studying horticulture, she had used a tape measure. She replied that she had and became very excited about the prospect including Aboriginal plants in the native garden project the class was undertaking. In an ensuing lesson on place value, arising from an investigation of hundreds, tens and units from the tape measure, Debra worked with a partner, asked for assistance and did not become withdrawn or angry when she made mistakes. Debra’s teacher attributed this to the greater mathematical resilience developed as a direct result of the connection between mathematics and context.

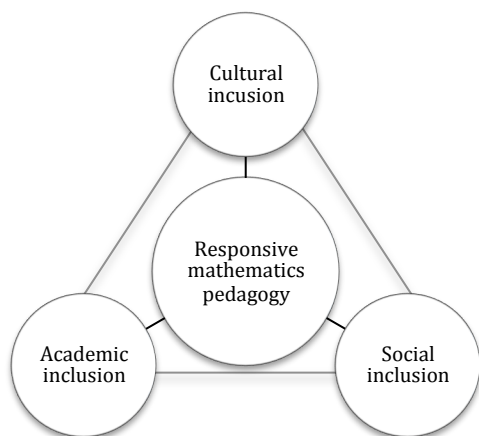
Cluster findings relating to social responsiveness include:

- Know mathematics that is beyond the classroom so you can teach mathematics through rich contexts.
- Help learners develop and maintain positive attitudes to mathematics. Develop positive dispositions, resilience, and skills of effective mathematical learning and thinking that equip learners to solve problems then transfer and apply their understandings, whatever the context.

## **SUMMARY**

The diversity of approaches highlights the three critical dimensions of responsive mathematics pedagogy: academic inclusion, cultural inclusion and social inclusion. No one of these is enough in its own right. The three elements interact in a dynamic and generative way. Cluster A has focused strongly on academic inclusion through explicit teaching and scaffolding, and has noticed greater engagement and sense of pride among students in their mathematics learning. The challenge now is to create stronger cultural links and to look at how meaningful contexts can become embedded throughout their mathematics. Cluster B has focused strongly on cultural inclusion through the 8 ways of learning and noticed that students feel a greater sense of pride and identity as Aboriginal people. The challenge is to infuse this pedagogy throughout mathematics teaching in a way that leads to deeper understanding of mathematical ideas. Cluster C has focused strongly on social inclusion through meaningful contexts and has begun to look at how to draw out the significant mathematics from these contexts. The challenge is to infuse pedagogical approaches that draw on Aboriginal ways of knowing.





**Figure 4: Responsive mathematics pedagogy**

There are also findings that are potentially conflicting. For example Cluster A has adopted an approach that is driven strongly by the mathematics curriculum, emphasising the developmental progression that is necessary for further learning within the Big Ideas in Number framework. On the other hand Cluster C has adopted a dynamic and emergent approach to curriculum, teaching content as it arises from the contexts and projects being undertaken by the students. Perhaps there is no one right answer, but it is critical that the research community investigate further questions concerning curriculum content and pedagogy that promotes academic, cultural and social inclusion for Indigenous students.

It is becoming clear in Make It Count that teachers who successfully engage in responsive mathematics pedagogy possess (a) deep content knowledge, (b) strong pedagogical content knowledge, and (c) strong culturally, socially and academically relevant pedagogies. They have a deep commitment to Indigenous students and these students are empowered as a result of their mathematical experiences (Ernest, 2002) and are able to make second-by-second to lesson-by-lesson to term-by-term judgements about practices and pedagogies that engage and inspire Aboriginal students in mathematics and numeracy. Clusters are realising that perhaps they need to be looking at each other for ways to achieve this. The model we have described summarises these components of responsive mathematics pedagogy, and provides a theoretical framework that can be used to inform further research and practice that enhances the mathematical learning and experiences of Aboriginal students.

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<sup>i</sup> 'Indigenous' is the terminology used by the Australian Government for Aboriginal and Torres Strait Islander people. In this paper the term 'Aboriginal' is used for Australian Aboriginal people.

<sup>ii</sup> Thomson, De Bortoli, Nicholas, Hillman, & Buckley 2011.

<sup>iii</sup> Adapted from the Department of Education & Children's Services, South Australia Teaching for Effective Learning Review Tools