

Developing Mathematical Resilience among Aboriginal Students

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The processes of mathematisation, the use of mathematical models and representations of real world contexts, and contextualisation, the embedding of mathematical ideas into a meaningful context, are key aspects of students' mathematical learning. We present a conceptual framework for thinking about mathematising and contextualising developed as part of the *Make it Count*, a national project that seeks to develop an evidence base of practices that improve Indigenous students' learning in mathematics. We suggest that an intentional focus on mathematisation and contextualisation helps to make mathematics meaningful, particularly for Indigenous students. In particular we suggest that such a focus has the potential to enhance the mathematical resilience of Aboriginal students.

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 a national project, conducted by the Australian Association of Mathematics Teachers (AAMT) Inc., that seeks to develop an evidence base of practices to improve the learning outcomes of Indigenous students in mathematics. It is part of the Australian Government's 'Closing the gap – expansion of intensive literacy and numeracy programs initiative'. This initiative seeks to halve the gap in reading, writing and numeracy achievements for children within a decade (Commonwealth of Australia, 2009). The project has established eight clusters of schools across Australia, supported by AAMT, critical friends and consultants, to develop culturally responsive mathematics pedagogy that will both engage Indigenous students and contribute to improved outcomes.

Specifically *Make it Count* aims to:

- document and share effective models of teacher professional development, whole school change and community engagement in relation to mathematics and numeracy;
- develop whole school approaches to mathematics and numeracy that result in markedly improved achievement by Indigenous students;
- build and participate in networks and professional learning communities; and
- act as catalyst and support for action by others.

In the Alberton cluster of schools in SA teachers have attempted to develop culturally responsive mathematics pedagogy by focusing on the value of context in the learning of mathematics. In this paper we discuss the theoretical framework that has been developed by teachers in the schools, and particularly on the role of mathematisation and contextualisation in planning effective mathematics learning for Indigenous students. We report on the project as it has unfolded at the schools in the cluster. Rather than presenting this as a traditional report structured as literature, research question, methodology and results, we allow the narrative to unfold. This reflects the emergent and ongoing nature of the project. We use Sophie's reflections as a stimulus to show the emergence of a research question that focuses

on the potential of mathematisation and contextualisation for enhancing the mathematical resilience of Indigenous students.

The Alberton Cluster of Schools

The Alberton cluster of schools consists of three schools, Alberton Primary School, Northfield Primary School and Ocean View Birth to 12 College, each of which has a significant proportion of Aboriginal¹ students. The cluster is located to the North and West of Adelaide in suburbs that were typically populated by blue-collar workers with a high proportion of migrants and Indigenous people. Like many dockyard and near-city suburbs they are undergoing rejuvenation, with a growing sense of community pride and identity. This sense of pride is reflected in the schools, where students and teachers are generally engaged and enthusiastic.

It is important to note that the majority of the Aboriginal students at these schools speak English as a first language and live in an urban environment. While these students belong to families that are deeply embedded in the everyday social and economic fabric of second order Australia (Watson, 1988), they nonetheless face significant challenges. They are caught between two cultures, on the one hand maintaining the strong sense of group and family identity and associated practices such as communal sharing and collaborative success, and on the other hand being immersed in a culture that values individual achievement through material success (Malin, 1994). As Watson (1988) says “the particular experience of biculturality that this group knows is the most important characteristic of the form of life of this category of Aboriginal people to consider, when we come to mathematics education” (p.260). Yet there is little research related to the mathematics education of urban Aboriginal children, and almost none that deals with non-cognitive aspects of mathematics learning.

A Purposeful Approach to Mathematisation and Contextualisation

There is a considerable body of literature that suggests that the use of meaningful and relevant contexts may be important for Aboriginal students learning mathematics. Frigo (1999) suggests that “(c)ontextualising mathematics ... means finding ways of providing experiences and strategies in which students can gain meaning and develop the appropriate language that enables them to extend their skills in Western mathematics” (p.13). Although recognising that contextualising mathematics for Indigenous students is not straightforward and involves the overturning of power relations and tacitly held beliefs about Indigenous students, Matthews, Watego, Cooper and Baturo (2005) suggest that it “has the potential to change the educational environment so that Indigenous cultures and their way of knowing are valued rather than devalued and that Indigenous students have pride in their culture and believe that they can perform well in the education system” (p.519).

However Brown (2008) suggests that context alone may not be enough.

Further research is required that specifically targets three things: Indigenous students’ perceived value of mathematics, their conceptualisations of the usefulness of their school mathematics beyond the classroom, and the ways in which their underachievement can be improved. Insufficient research has been performed to reveal new or alternative mathematics teaching strategies that can contextualise mathematics for Indigenous students. Contextualising the mathematics curriculum

¹ We use the term Aboriginal when discussing the students attending these schools, as they identify as Aboriginal rather than more generically as Indigenous.

would be an effective means to significantly improve both Indigenous and non-Indigenous students' understandings of mathematics. (Brown, 2008, p.93)

This caution is echoed by Sullivan, Zevenbergen and Mousley (2003) who suggest that contexts, both mathematical and pedagogical, may exclude some children. They argue that the mathematical context is often artificial, alienating, or excluding and always requires recontextualisation to draw out the mathematics, and that the pedagogical context must be made explicit to enable children to understand the purpose and make sense of the mathematics. It seems that elements such as social justice, empowerment, engagement, reconciliation, self-determination, connectedness and relevance (Matthews, Howard & Perry, 2003) need to work together to ensure that learning mathematics is meaningful for Indigenous students.

The Alberton cluster approach seeks to link mathematics and context through the deliberate acts of mathematisation and contextualisation. We developed a model of teaching and learning (Figure 1) that would be more nuanced and powerful than merely suggesting that teachers should use real-life examples to teach mathematics. In making use of this model we described contextualisation as the shift from mathematics to context, a process in which mathematical ideas are deliberately embedded in everyday contexts. These contexts then provide a springboard for the learning of mathematical ideas. Contextualisation thus provides a strong sense of purpose, in that it has a meaningful learning outcome for students in terms of the mathematical understanding developed (Ainley, Pratt & Hansen, 2006). Mathematisation is then the reverse process in which everyday contexts are expressed mathematically, and mathematics becomes the vehicle for solving real problems. This process shows the utility of mathematics, in that it is used to make sense of and solve a meaningful task (Ainley, Pratt & Hansen, 2006).

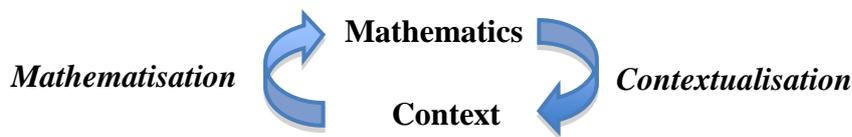


Figure 1. The Alberton cluster model of mathematisation and contextualisation

The deliberate acts of mathematisation and contextualisation described above also address the oft-criticised use of pseudo-contexts in mathematics (Olive, Makar, Hoyos, Kor, Kosheleva, & Str  ber, 2010). Rather than presenting students with artificial and contrived problems typically found in school textbooks, the deliberate acts of contextualisation and mathematisation enable teachers to ensure that students solve rich mathematical problems with an authentic purpose. In this way they closely align with the principles espoused by the Dutch Realistic Mathematics Education program, in which students are guided through the process of constructing mathematical tools and principles in meaningful contexts (Van den Heuvel-Panhuizen, 2003).

The model illustrated in Figure 1 evolved after almost two years of discussion and reflection on teaching practices among the teachers at the Cluster schools. The project was stimulated by the question asked by one Aboriginal student of her teacher, Sophie, "Why can't we draw all day?" Teachers were then 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. Students in years 3, 4 and 5 were then offered the choice of learning contexts, providing, at a school level, empowerment, engagement, self-determination, connectedness and relevance (Matthews, Howard & Perry, 2003). The *Make it Count* project then provided the means and stimulus to

develop a model of teaching that connects mathematics and context in a purposeful and meaningful way. For Sophie, who is also studying architecture outside the school environment, this led to the establishment of the “Deadly Design” studio.

Sophie and Debra²: An Indicative Case Study³

The Deadly Design studio has been a place of incredible change in the last three years. It is a shared space, in which I team-teach with Danielle. Powerful changes in attitude and learning have been experienced both by students and by me. To illustrate this I would like to share my educational journey with an Aboriginal student called Debra from whom I learnt a great deal about my own teaching practices.

Debra is a smart and precocious year four student who came to the Deadly Design studio learning environment with a range of behaviours and attitudes that were productive and some that were clearly counterproductive to acquiring the mathematical knowledge skills needed to perform well in a range of mathematical situations. Debra has had significant support in both English and mathematics, however has continued to underperform, especially in mathematics. To Debra’s credit with all of the difficulties she has experienced she has continued to attend and participate in the curriculum on offer.

At the start of the year, prior to the commencement of the Deadly Design studio, she seemed disconnected from learning. She reacted 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 became loud and often created conflict with other students. She would respond to learning tasks by stating “I’m not doing this!” and would sit in her seat distracting the students around her. When asked to complete her task she would often call out “I can’t do it!” and chat about unrelated matters. Even when she tried to start a task Debra would quickly say “I need help!” Debra rarely took responsibility for her learning. Aside from calling out for help Debra rarely put her hand up during group discussions. She spent a great deal of the time either sitting quietly or distracting others.

On one occasion Debra was working with a relief teacher in Danielle’s space. She had an argument with another student and spent a great deal of the lesson crying. Mid way through the lesson she gave up being responsible and she was about to be sent to buddy class. I decided to intervene and asked her to come and work on my side of the design space. She obliged quite happily as I have a strong connection with her, having taught three generations of aunties and uncles and brothers and sisters within her family. All of their “Sophie” stories are positive. I believe that coupled with the contextual learning this relational connection had a profound impact on Debra, and created a place where she had the space and confidence to learn. We were connected on a personal level, and also connected to our environment through the use of context as an entry point to learning. This connection is in contrast to the usual separation of teacher and student and the imposition of performance based criteria which would have only fuelled Debra’s resistance by reinforcing what she did not know.

In the ensuing lesson on measurement I asked her if like Aunty Alicia she had used a tape measure. She replied that she had and proceeded to share an occasion when this had occurred. I also knew that Alicia was studying to gain a horticultural certificate, giving me a direct hook into the ANZAC garden project we were doing. I asked Debra if she would like to investigate how our garden could include Aboriginal plants and which ones were the

² Names of students are pseudonyms.

³ This section is written by Sophie in the first person as her reflections of the program.

most appropriate. She got very excited by this and was extremely keen to get home and start the conversation with her family. She returned with a list of names and is in the process of inquiring about prices and quantities needed to plant out the garden.

I believe that the conscious mathematisation and contextualisation used in planning has led me to deliberately break with the content-based approach I used previously. A linear, hierarchical curriculum tends to impose a teaching methodology that always starts with the mathematics and seldom makes connections with children’s lived realities. On the other hand the Alberton cluster *Make it Count* model encourages both relational and contextual connections. Along with the other teachers in the project I have developed an increasingly complex planning approach that sustains mathematical skills for the long term and allows for multiple entry points into the mathematics curriculum, particularly for Debra and the other Aboriginal students in my group. Figure 2 shows how planning the ANZAC garden provided the context for learning about concepts of measurement and place value.

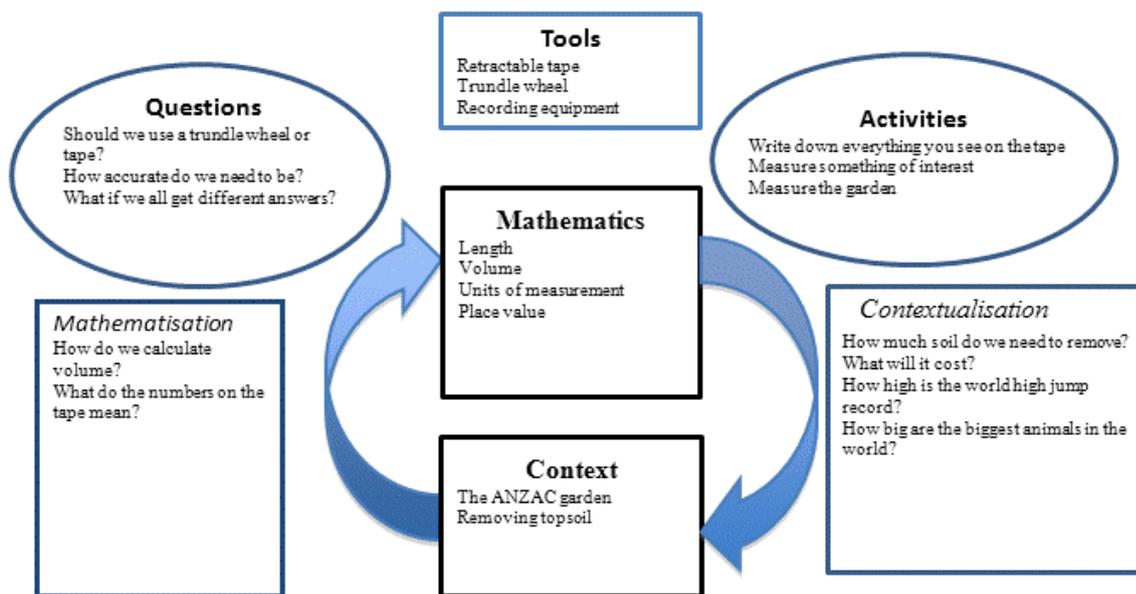


Figure 2. Mathematising, contextualising and the ANZAC garden.

Six weeks down the track my observations and reflections are showing that Debra has made great shifts in her approach to mathematics. As illustrated below in the graphic of the lesson plan, we used the tape measure as a way into looking at hundreds, tens and units. This mathematisation was an entry into a lesson on place value, during which Debra was paired up with a student with whom she had never worked before. At the start of the year this would have upset Debra significantly as she sought only friends or family to work with. Instead, Debra quickly asked her learning partner where she wanted to work and together they collected popsticks and other materials. She independently set out her book with the required tally table, asked her partner who should go first and started the game. She trusted her partner to help her and even asked other students for assistance. While playing the game she made mistakes but she did not get shamed and try to hide her lack of understanding by becoming withdrawn or angry. Instead she tried to solve the problem of how many bundles were allowed in the tens column by checking the procedure as she understood it, then with peers and finally with an adult.

At the end of the game the class reflected on the learning they had done. I asked the group why the pop stick game might be important to their mathematical learning. Immediately Debra's hand was up to participate in the conversation.

Sophie: Why do you think the pop stick game might be important to our maths learning?

Because we need to use the tape measure correctly (A).

Because we need to learn our units, tens, hundreds and thousands (D).

For carrying numbers (A).

Helps maths and you learn more about thousands (N).

Learning more about different numbers (N).

Teamwork (A).

Sophie: How did teamwork help you?

It's better having a go with someone (A).

Taking a risk (N).

Encouraged other (D).

Researched with my partner (D).

Solved the problem together (N).

Collaborated to work out the problem (D).

D = Debra's response

A = Another Aboriginal student's response

N = non-Aboriginal student's response

Articulating the Research Focus and Methodology

Like Sophie, the project teachers have maintained reflective journals that focus on the responses of Aboriginal students to approach to learning described above. We shared and discussed these reflections to draw out common themes. Almost universally the teachers highlighted students' increased engagement, and their enhanced understanding of the nature of mathematics. One teacher related how an Aboriginal student who had previously been negative about mathematics had become much more confident, actively looking forward to learning mathematics. On entering the classroom he now asked questions about what he might be learning, rather than expressing his dislike for learning. Another reported that an Aboriginal student was able to articulate what she saw as the distinction between mathematics and numeracy in terms of using mathematical ideas to solve everyday problems. All teachers reported on the sense of pride students took in their work and on their capacity to articulate the concepts they had learnt. They considered this increased engagement particularly important for Aboriginal students, who are often quick to opt out of learning when they see it as lacking in meaning or purpose (Purdie and Buckley, 2010).

However the teachers' reflections encompassed more than just engagement. They suggested that the Aboriginal students' orientation to learning may have been positively impacted by the approach. Like Debra, rather than being performance-driven the students were more learning-driven, which in turn led to a greater sense of purpose and a willingness to ask questions or embrace mistakes (Dweck, 1999; Sullivan, Tobias & McDonough, 2006). The project team adopted the concept of mathematical resilience (Johnstone-Wilder & Lee, 2010a) to describe this orientation to learning, and considered it crucial to improved outcomes in mathematics.

All learning requires resilience; however we contend that the resilience required for learning mathematics ('mathematical resilience') is a particular construct as a consequence of various factors including: the type of teaching often used ..., the nature of mathematics itself ... and pervasive beliefs about mathematical ability being 'fixed'. Helping learners to develop mathematical resilience enables them to adapt positively to the difficulties presented by mathematics and to be in a position to consider continuing to develop their mathematics beyond compulsory age. (Johnstone-Wilder and Lee, 2010b, p. 4, in-text references omitted)

Like Sophie, the other teachers in the team felt that the approach to teaching and learning in the *Make it Count* project was, in fact, changing the type of teaching and addressing students' perceptions of the nature of mathematics as a fixed and disconnected body of knowledge. Hence it had the potential to engage disinclined learners, particularly Aboriginal students, and to encourage them to maintain positive attitudes to mathematics beyond primary school. We identified five key aspects of mathematical resilience: 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.

Sophie's reflections on Debra's learning powerfully illustrate each of these aspects of mathematical resilience. She was prepared to make mistakes; she took responsibility for her learning; she checked procedures and started again when she was unsure; she willingly worked with and asked questions of other students; and she gave insightful responses to Sophie's questions about the purpose of the game. Throughout the project the team has gathered data relating to the mathematical resilience of their Aboriginal students through structured observations of indicative behaviours and fortnightly reflections. As Johnstone-Wilder and Lee (2010a) state "if [mathematical resilience] is important, why are we not measuring it?" (p.41)⁴.

Conclusions

The project is ongoing. We are conscious that, at this point, we are not in a position to report on the impact of the Alberton model on students' cognitive outcomes. However, as Sophie's story vividly shows, we are confident that teachers have developed an approach to teaching that is both complex and purposeful. It requires deep thinking about mathematics, context and the relationships between them. We have developed a conceptual framework that values the inherent unpredictability of learning and the emergence of new knowledge, and that explicitly builds connections between mathematics and the real world of Aboriginal learners. Debra's response to Sophie's challenge to find native plants for the ANZAC garden shows the power of such a framework in creating authentic and meaningful learning.

We are confident that this approach is impacting positively on those aspects of students' learning behaviour that we have described as mathematical resilience. Debra's story is but one example of how Aboriginal students in particular have benefitted from the approach. It has been repeated across classes and across the three schools involved in the project. We believe that paying attention to the development of productive dispositions to learning such as mathematical resilience is a key to better learning outcomes for Aboriginal students.

⁴ The project team also identified the capacity to transfer knowledge as an important cognitive outcome of the project. This will be the subject of future publications.

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