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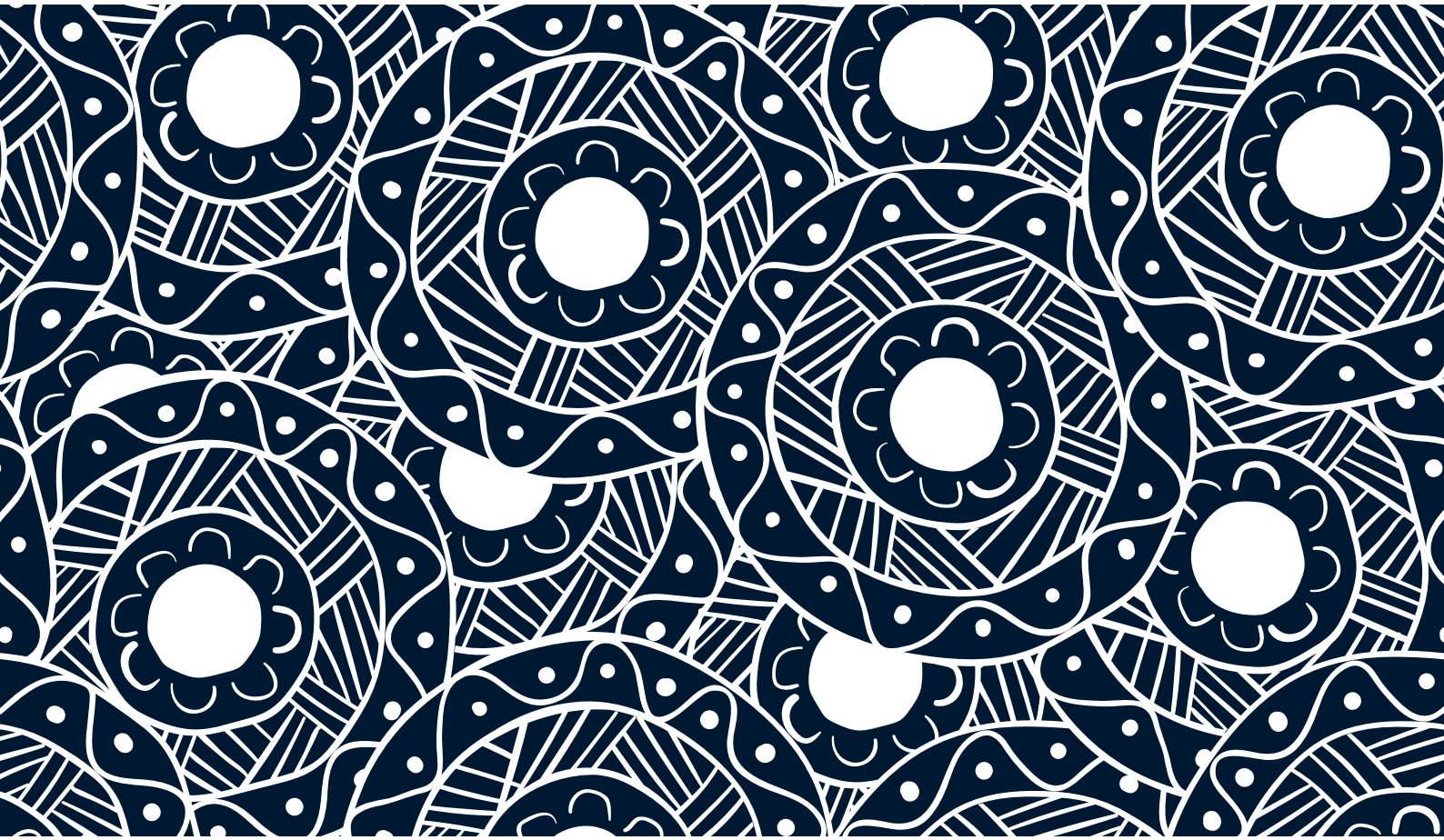
Indigenous STEM Education Project

Purposeful Rich Indigenous Mathematics Education (PRIME) Futures Program | Case Study Report

October 2019



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Growing community through education

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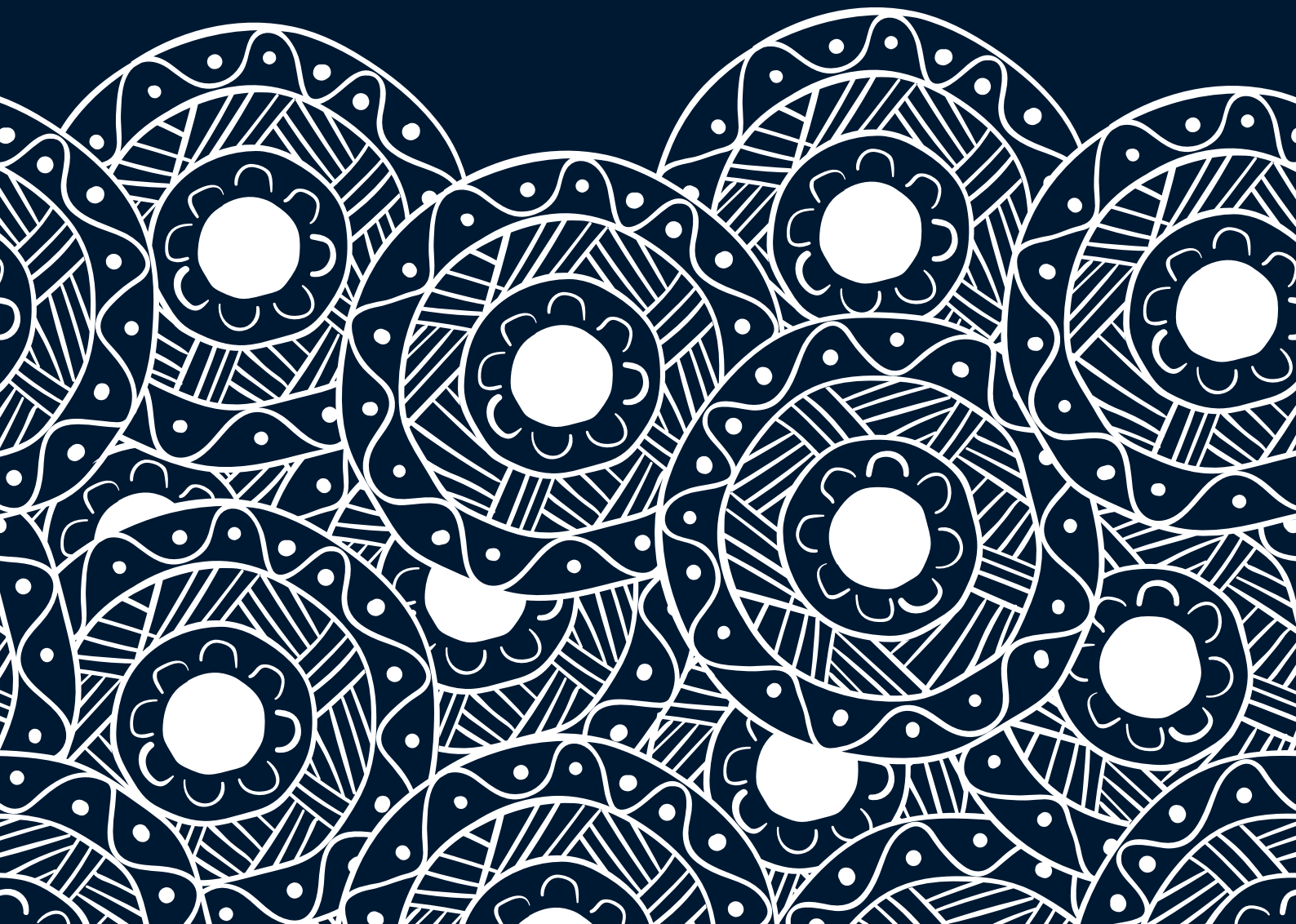

Acknowledgements

Acknowledgement of Country

Aboriginal and Torres Strait Islander peoples have longstanding scientific-knowledge traditions. These traditions have developed knowledge about the world through:

- observation, using all the senses
- prediction and hypothesis
- testing (trial and error)
- making generalisations within specific contexts.

These scientific methods have been practised and transmitted from one generation to the next and contribute to particular ways of knowing the world that are unique, as well as complementary to Western scientific knowledge.

A deep respect for these Aboriginal and Torres Strait Islander cultural practices and knowledge underpin the philosophy and practice of the Indigenous STEM Education Project. Recognition of traditional contexts for technologies and concepts and their application in the past, present, and future—including supporting modern STEM career pathways for Aboriginal and Torres Strait Islander students—reaffirm the ingenuity and creativity of Aboriginal and Torres Strait Islander peoples' knowledge systems.

The Indigenous STEM Education Project team acknowledges the Traditional Owners of the lands with whom this project is collaborating and their vibrant living cultures and knowledge systems. In particular, we acknowledge the Traditional Owners of the lands on which the three summer schools take place: the Kaurna people (Adelaide), the Awabakal and Worimi peoples (Newcastle), and the Bindal and Wulgurukaba peoples (Townsville). We pay our respects to Elders past and present, and we thank all community members who are providing the leadership to ensure meaningful and effective engagement with Aboriginal and Torres Strait Islander communities for the six distinct, but complementary, STEM education programs that make up this project.

QUT and CSIRO acknowledge that Aboriginal and Torres Strait Islander peoples make extraordinary contributions to Australia in cultural, economic and scientific domains; for example, incorporating Indigenous knowledge of ecological and social systems is vital to the achievement of sustainable development.

Other acknowledgements

CSIRO wishes to acknowledge the invaluable contribution of Aboriginal and Torres Strait Islander scientists and educators and program leaders—without their knowledge and leadership the development and implementation of the Indigenous STEM Education Project would not have been possible.

QUT wishes to acknowledge the contributions of the staff of the YuMi Deadly Centre, whose work as practitioners, educators, managers, researchers and assistants has contributed to the success of the program that is the subject of this case study and to the preparation of this report. In addition to the named authors of this report, they include Associate Professor Grace Sarra, Kim Alexander, Jan Cavanagh, Gillian Farrington, Edlyn Grant, Judy Hartnett, Jim Lowe, Anne McIntyre, Chelsea Meyrick, Chelsey Priddle and Lindy Sugars. QUT also appreciates the work of the school principals, teachers, teacher assistants, other staff and students in the many schools that participated in the PRIME Futures program and the officers in the relevant state education authorities that also supported the program. The authors would like to thank the external peer reviewer for their valuable suggestions, which made a significant contribution.

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Glossary of Terms and Abbreviations

ACARA	Australian Curriculum, Assessment and Reporting Authority
AEO	Aboriginal Education Officer
Big ideas of mathematics	Key ideas that link numerous mathematics discipline understandings into coherent wholes (Charles, 2005).
C2C	Curriculum into the Classroom: According to the Queensland Department of Education (2019), 'C2C is a comprehensive set of whole-school and classroom planning materials for single-level and multi-level classes' (para. 2) '... to support Queensland state school teachers deliver the Australian Curriculum' (para. 1).
Conceptual schema	A conceptual schema can be defined as a set of linked mental representations of the world, which we use both to understand and respond to situations (Piaget, 1977).
CRP	Culturally relevant (or responsive) pedagogy that uses the cultural knowledge, prior experiences, frames of reference and performance styles of ethnically diverse students to make learning encounters more relevant to and effective for them (Gay, 2010)
CSIRO	Commonwealth Scientific and Industrial Research Organisation
EDI	Explicit Direct Instruction: A pedagogical framework with behaviour management strategies built in that was initially developed for teaching English language learners and students with special needs. It has a simple and clear structure for teaching procedures to students that is frequently shortened to 'I do, we do it together, you do, plough back and review' (Hollingsworth & Ybarra, 2017).
Engoori	'Engoori is a three-phase strength-based approach which acknowledges that when dealing with complex challenges, having conversations with structure, purpose and process is often the most powerful action one can take. The Engoori story belongs to "Tjimpa" of the Mithaka people of South West Queensland and historically was used as a method of diplomacy between conflicting ideologies and groups. Traditionally, Engoori was used as a set of diplomatic protocols to create and maintain robust challenging cultures that embrace diversity to enable forward movement with the big issues.' (Murri Matters Pty Ltd, 2014a, para. 1)
F (or P or R)	The first year of schooling has different names in different places. The Australian Curriculum describes it as 'Foundation' (F). Queensland schools commonly refer to it as 'Prep' or 'Preschool' (P). South Australian schools use the term 'Reception' (R).
FLC	Flexible Learning Centre
Folding back	When faced with a problem at any layer that is not immediately solvable, students often return to an inner layer of understanding, and this shift is termed folding back. It enables learners to make use of the current outer layer of knowledge to inform inner understanding acts, which in turn facilitate further outer layer understanding (Martin, 2008).
HoC / HoD	Head of Curriculum / Head of Department
Indigenous	Where the term 'Indigenous' is used in this report, it refers to Aboriginal and/or Torres Strait Islander peoples of Australia.

Maths mat	A portable 10 × 6 grid that is laid on the floor for students to walk on to act out mathematical situations. Commonly used in YDM lessons.
NAIDOC	National Aborigines and Islanders Day Observance Committee
NAPLAN	National Assessment Program—Literacy and Numeracy (Australian Curriculum, Assessment and Reporting Authority, 2016); standardised testing of all students in Years 3, 5, 7 and 9, conducted on behalf of the Australian Government.
Out-of-field teacher	A teacher who is teaching a subject that is outside their field of qualifications or expertise.
PD	professional development
PRIME	Purposeful Rich Indigenous Mathematics Education
QCAA	Queensland Curriculum and Assessment Authority
QUT	Queensland University of Technology
RAMR	Reality–Abstraction–Mathematics–Reflection. Often referred to as the RAMR framework or RAMR cycle.
SES	socio-economic status
STEM	science, technology, engineering, mathematics
Teacher-trainers	Given the train-the-trainer focus of the PRIME Futures program, those attending the PD sessions were encouraged to train their colleagues in YDM. Thus, those attending the PD sessions are referred to as teacher-trainers.
TfEL	Teaching for Effective Learning (South Australian Department for Education resource for developing quality teaching and learning; referred to in the teacher reflective journals)
Y chart	A three-part graphic organiser used for describing three aspects of a topic.
YDC	YuMi Deadly Centre
YDM	YuMi Deadly Maths

1 BACKGROUND AND METHODOLOGY

1.1 Introduction

This Case Study Report describes the Purposeful Rich Indigenous Mathematics Education (PRIME) Futures program (the program) that was the mathematics element of a broader Indigenous STEM Education Project (the project) managed by CSIRO in partnership with the BHP Foundation. The overarching goal of the Indigenous STEM Education Project is to provide supported pathways that improve the participation and achievement of Aboriginal and Torres Strait Islander students in science, technology, engineering and mathematics (STEM) fields. The six programs that comprise the project cater to the diversity of Aboriginal and Torres Strait Islander students as they progress through primary, secondary and tertiary education, and into employment. The PRIME Futures program was one of the six programs and was subcontracted to the YuMi Deadly Centre (YDC) at the Queensland University of Technology (QUT). It was delivered across four years from September 2015 to August 2019.

The PRIME Futures program targeted Foundation to Year 9 students in metropolitan and regional schools across Australia. The main aims of the program were:

- to increase the participation of Indigenous students in mathematics
- to increase the achievement of Indigenous students in mathematics
- to improve teacher capacity in the teaching of mathematics to Indigenous students.

PRIME Futures used the YuMi Deadly Maths (YDM) approach developed by YDC to improve student outcomes in mathematics (Cooper & Carter, 2016), described in detail in Section 1.2. This report is presented as a case study (Stake, 1995) of the PRIME Futures program implemented across 10 geographic clusters of between six and nine schools each, in three Australian states. It describes the implementation and outcomes of the PRIME Futures program in the context of the program's aims and intended outcomes.

Chapter 1 of this report provides an overview of the theoretical framework that was used to inform research and development of YDM within the context of the PRIME Futures program and then outlines the case study methodology and rationale that has been applied to the program. Chapter 2 presents results in the form of quantitative and qualitative data collected and used to assess the outcomes of the program. Chapter 3 discusses these results in relation to the program's aims. Chapter 4 concludes the report with a discussion of the key findings and conclusions of the case study. Factors from within and outside the theoretical framework that influenced the implementation of the PRIME Futures program are examined. Recommendations are made for modifications at both the theoretical and practical level to advance theory informing future research and practice in the teaching of mathematics in schools with Aboriginal, Torres Strait Islander and/or low socio-economic status (SES) students.

1.2 The YuMi Deadly Maths approach to school change

YDM is the basis of the PRIME Futures program. It has been developed and refined by researchers and teaching practitioners employed by QUT over a period of 10 years and implemented in more than 250 schools (Spina et al., 2017).

A systematic weakness of Australian mathematics teaching, especially in secondary schools, has been the shortage of teachers with the necessary training and skills to teach mathematics in an effective manner. For example, government reports repeatedly point to the lack of qualified mathematics teachers in Australia and the detrimental effect of out-of-field teachers on the quality of mathematics teaching and learning (e.g., Queensland Audit Office, 2013). The scant data available on out-of-field mathematics teachers suggests that, on average, up to 50% of those teaching mathematics to junior secondary students (Years 7–10) may be out-of-field. In the experience of YDC practitioners, many schools find it difficult to attract and retain qualified mathematics teachers (e.g., schools in 'less attractive' geographical locations and/or those with high numbers of students who are disengaged and/or exhibit challenging behaviours). The proportion of out-of-field mathematics teachers in these schools is often considerably higher than indicated by the averages.

Partly because of limited teacher capacity, Australian mathematics teaching tends to be dominated by passive, imitative textbook teaching where students recite definitions and rules and copy procedures (Hollingsworth, Lokan, & McCrae, 2003). These systemic weaknesses make it difficult for students to acquire the conceptual schema necessary for success in the future study of high school and university STEM subjects or in STEM vocations. Within many schools with a high proportion of Aboriginal, Torres Strait Islander and/or low-SES students, the experience of YDC educators is that the situation is even grimmer—passive imitative textbook teaching tends to be more prevalent than elsewhere.

In this context, the YDM pedagogy was developed using a design-research methodology (Kelly, 2004) to promote school change and directly confront existing pedagogical methods. Two fundamental principles have underlain the implementation of the design-research methodology throughout the course of YDM over the past 10 years:

1. The only acceptable research for Indigenous and low-SES schools is the 'empowering outcomes' decolonising methodology of Tuhiwai Smith (2012), where research is designed to immediately benefit the researched.

2. The role of researchers in school change can be negative in that there is a danger that change agents can become the new oppressors (from the ideas of Gramsci, 1977).

The design-research methodology has two interrelated outcomes: (a) the construction of novel and effective educational practices, and (b) the development of illuminating explanatory theory (Kelly, 2004). Thus, in addition to the generation of culturally relevant/responsive pedagogy (CRP) (Enyedy & Mukhopadhyay, 2007; Gay, 2002, 2010) practices for the teaching/learning of mathematics (with associated teacher guides, in-service teacher education programs and other teaching/learning resources), a major outcome of YDC research and development has been the ongoing development of a theoretical framework to advance research and practice in the teaching of mathematics in Indigenous and low-SES schools.

The theoretical framework that was used to inform the research and development of YDM within the context of the PRIME Futures program is presented in Figure 1.1. As illustrated in Figure 1.1, the theoretical framework consists of three layers.

Subsumed within the underlying philosophy in Layer 1 are the set of beliefs and assumptions about students, teachers, schools and communities. They provide the epistemological and ontological overview for the framework.

A network of five components comprises the middle layer of the framework. On the left are the two sociocultural components (numbered 2—recognition and utilisation of students' cultural capital, and 5—whole-school and school–community partnership approach), which form a vertical symmetry with the two cognitive components on the right (numbered 3—systematic addition of cultural capital, and 4—focus on the structure of mathematics). These components were included to ensure that teachers focus on deep-level connections between the mathematics subsumed within the learning activities and their students' cultural capital. In particular, we want teachers 'to identify and pursue mathematically rich conversations

and connect them to their students' own lives, local experiences, and interests' (Enyedy & Mukhopadhyay, 2007, p. 170). We want teachers to more deeply investigate the term *relevant* in CRP and actively explore three interpretations of relevant identified in Enyedy and Mukhopadhyay (2007, p. 170): (a) interpretations that focus on familiarity of the content or context of the lesson and borrow these contexts from students' daily lives; (b) interpretations that focus on the motivational value of a lesson's perceived value to students' lives outside of school; and (c) interpretations that focus on the familiarity of the process and participation structures by which students engage with the lesson, and the degree to which students' existing repertoires for participation are made legitimate in the academic context.

Within the network of five components placed in the middle layer of the framework, integration between the sociocultural and cognitive components is provided by (a) direct two-way links between Components 2 and 3 and between Components 4 and 5; and (b) indirect two-way links via Component 6 (teacher as learner) at the core of the system. For example, when teachers are building on ideas from the students' existing mathematical cultural capital (Component 2) to facilitate the construction of big ideas of and/or about mathematics (Component 3), they will include in their plans opportunities for students to 'fold back' (Martin, 2008) in order for them to revisit/rework and thus deepen past knowledge.

By making the conceptual links between these five components explicit, we feel that the framework overcomes a major limitation of earlier iterations of the theoretical framework: the implicit nature of the conceptual links between these five components. It was felt that this had negatively affected the impact of the YDM

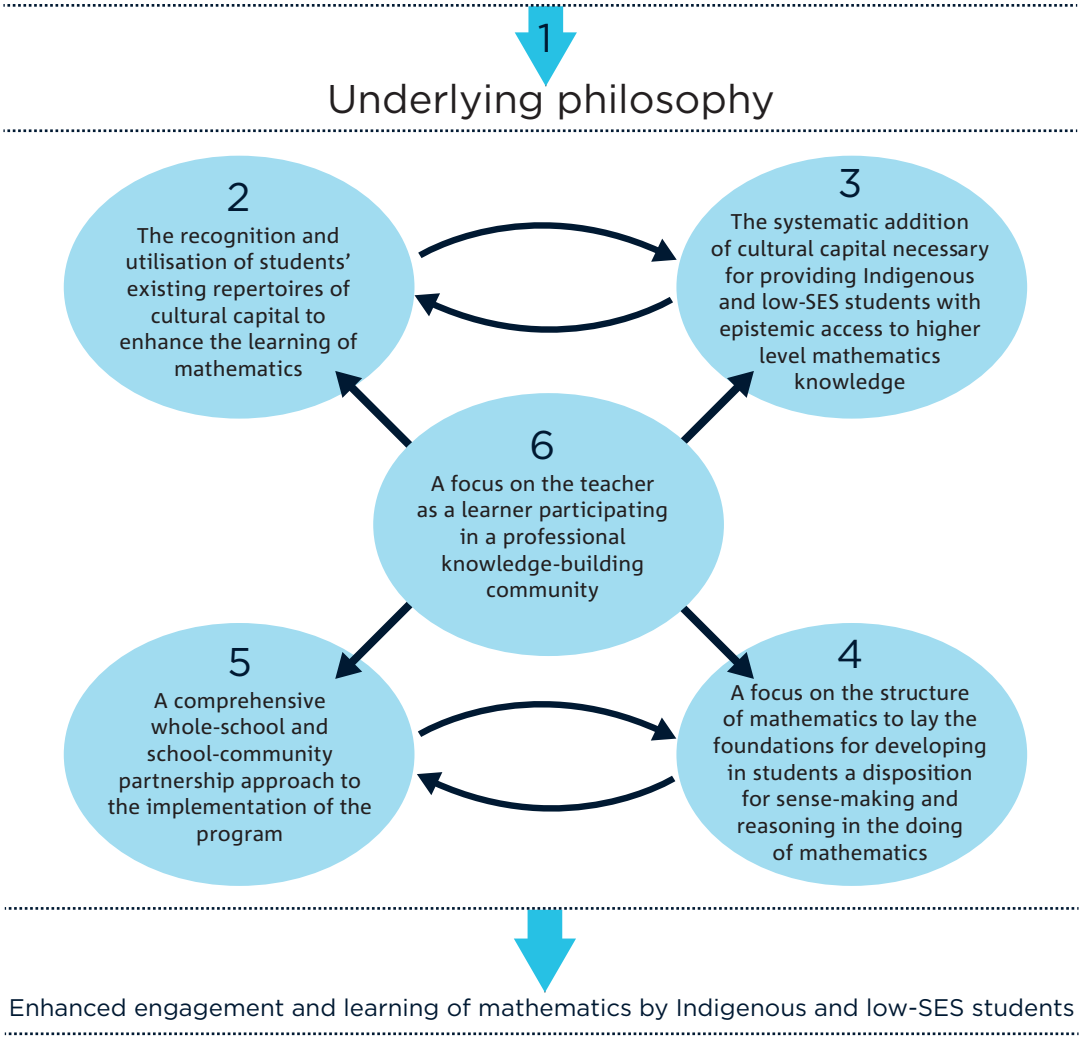


Figure 1.1 YDM theoretical framework (Anderson, Stütz, Cooper, & Nason, 2017)

in-service workshops, overview book and topic books. For example, in the Reality stage of the Reality–Abstraction–Mathematics–Reflection (RAMR) pedagogical framework presented in the overview book, teachers are directed to use their students' culture as a starting point for instruction. However, we have found that unless teachers learn the importance of this stage and how to gain and use knowledge about students' cultural backgrounds, it can be neglected. Thus, it is highly probable that explicit links between mathematical structures, language, and big ideas and the sociocultural aspects of learning mathematics are not made by the teachers.

The projected outcomes—the enhanced engagement and learning of mathematics by Indigenous and low-SES students—are found in Layer 3.

The following subsections describe the underlying philosophy and the five central components of the theoretical framework in more detail.

1.2.1 Component 1: Underlying philosophy

The underlying philosophy is based on the following set of six beliefs and assumptions about students, teachers, schools and communities derived principally from Goldenberg (2014), Gutiérrez (2007, 2008), Mills (2008), Parhar and Sensoy (2011), Sarra (2009, 2010) and YuMi Deadly Centre (2014):

1. All Indigenous and low-SES students are entitled to mathematics teaching and learning that empowers them to understand their world mathematically and solve problems in their reality.
2. All Indigenous and low-SES students can be empowered in their lives by mathematics if they understand it as a conceptual structure and a problem-solving tool.
3. All Indigenous and low-SES students can excel in mathematics while remaining strong and proud in their culture and heritage if taught actively, contextually, with respect and high expectations, and in a culturally safe manner.
4. A strong empowering mathematics program can profoundly and positively affect students' future employment and life chances, and have a positive influence on school and community.
5. All teachers can be empowered to teach mathematics with the above outcomes if they have the support of their school and system and the knowledge and resources to deliver effective pedagogy.
6. All Indigenous and low-SES communities can benefit from the above mathematics teaching and learning practices if school and community are connected through high expectations in an education program of which mathematics is a part.

Students are the focus of beliefs and assumptions 1–4. These four beliefs and assumptions collectively address Gutiérrez's (2007) four dimensions for successful intervention programs: access, achievement, identity and power. Belief and Assumption 1 addresses the dimensions of access and power, Belief and Assumption 2 addresses the dimensions of achievement and power, Belief and Assumption 3 addresses the dimensions of achievement and identity, while Belief and Assumption 4 addresses the dimension of power.

Beliefs and assumptions 5 and 6 focus on teachers, schools and communities. They are based on the idea that teachers can change from deficit-based notions about Indigenous and low-SES students' learning if provided with appropriate and effective professional development (PD) that helps them to develop the knowledge and dispositions to establish partnerships between school and community, revise teaching approaches and curriculum, and value Indigenous and low-SES students' cultural heritages (Owens, 2015; Parker, Bartell, & Novak, 2017; Warren, Quine, & DeVries, 2012).

1.2.2 Component 2: Recognition and utilisation of students' cultural capital

The exploration of the connection between culture and mathematics conducted in collaboration with Aboriginal mathematician and mathematics educator Dr Chris Matthews, has been a key component of the development of YDM during the past 10 years. The exploration was done for two reasons: (a) to value the cultural capital students bring to the classroom, and (b) to challenge the Eurocentric nature of Australian school mathematics. To achieve this, we had to ask the fundamental question: What is mathematics?

The outcome of this collaboration was the adaptation of Matthews' Goompi model of mathematics, presented in Figure 1.2, which encapsulates YDM's view on this fundamental question about the ontology and epistemology of mathematics. Mathematics starts from observations in a perceived reality. The observer chooses an aspect of a real-life situation (represented by a grey circle in Figure 1.2) and then creates an abstract representation of the real-life situation using a range of mathematical symbols. The observer uses the

mathematics in its abstract form to explore particular attributes and behaviours of the real-life situation and to communicate these ideas to others. To validate, extend and apply this mathematics, the observer critically reflects on their mathematical representation to ensure it fits with their observations of reality, to see if extensions and modifications can be made to further generalise the mathematics and to transfer the mathematics to solve other similar life problems.

Although this description is complete in terms of the creation of mathematics, it is missing one crucial aspect in its relationships, and this is the interplay or dichotomy between reality and mathematics. Our perceptions of reality are inexact, unlike the mathematics that emerges from abstraction from that reality. Thus, reality and mathematics are two ends of a spectrum—inexact to exact and back again. The crucial point here is that mathematics topics must be seen in both worlds. It is important that mathematics be understood in reality and seen in terms of error, uncertainty and diversity, as well as a logical structure. This is obvious for probability, statistics and measurement, but it also applies to arithmetic, algebra and geometry. Yes, mathematics is a pure construction of the mind, but it is also of useful application in the real world.

As shown in Figure 1.2, there are three other features of the model that are a consequence of the cycle from reality to mathematics and return; these three features were added to Matthews' (2009) Goompi model. Both abstraction and reflection are creative and problem-solving acts; mathematics as a language and structure is built around symbols that carry concepts, strategies and relationships from reality to the abstract and back to reality; and the mathematics and how it is used in reality is framed by the cultural bias of the person creating the abstraction and reflection.

The conceptualisation about the ontology and epistemology of mathematics provided by the YDM model of mathematics indicates that the following two sources of student cultural capital need to be exploited by teachers as starting points to facilitate the deep learning of mathematics by Indigenous and low-SES students: (a) mathematical identities, and (b) communities and cultures.

Mathematical identities

Included under the umbrella of student mathematical identities are prior mathematical experiences (both formal and informal), beliefs about mathematics, dispositions towards mathematics, and prior mathematics knowledge and skills (both formal and informal). If teachers are cognisant of these factors, they are more likely to be able to make the learning of mathematics more accessible and relevant for Indigenous and low-SES students (Buxton, 2017; Connolly, 2012; Grootenboer & Sullivan, 2013; Krakouer, 2015; Lewthwaite, Owen, Doiron, Renaud, & McMillan, 2014; Nam, Roehrig, Kern, & Reynolds, 2013; YuMi Deadly Centre, 2014).

Communities and cultures

Within each community, there are substantial repertoires of experiences, knowledge, events, values and 'dark funds of knowledge' that can be capitalised on in the classroom (Connolly, 2012; Moll, Amanti, Neff, & González, 1992; Moll & González, 2004; Yosso, 2005).

Teachers also need to learn from and about different aspects of their students' culture, such as their epistemologies and ontologies (ways of knowing and being), languages, backgrounds and interests (Achinstein & Aguirre, 2008; Buckskin, 2012; Buxton, 2017; Dockery, 2009; Martin, 2009; Parhar & Sensoy, 2011; Sarra, 2010). For example, many Indigenous and low-SES students arrive at school with culturally based ontologies and

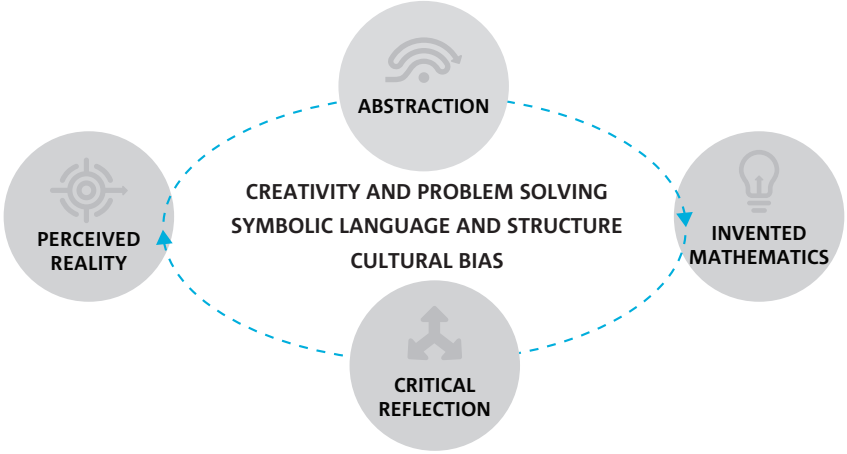


Figure 1.2 YDM model of mathematics (adapted from the Goompi model by Matthews, 2009)

epistemologies that are not congruent with those holding currency within the school (Abrams, Taylor, & Guo, 2013; Nam et al., 2013). According to Abrams et al. (2013), teachers need to find legitimate ways of integrating these students' different ways of knowing and being into their schooling to counteract the practice of teaching being detached from sociocultural contexts. Language affects students' conversion of representations and thinking styles when engaged in mathematics (Huang & Lin, 2013). Thus, teachers need to be aware of and recognise the usefulness of de-mathematised languages (e.g., Aboriginal, Torres Strait Islander, folk and everyday languages) in making mathematics accessible to many Indigenous and low-SES students (Buxton, 2017; Luitel, 2013). Understanding students' backgrounds and interests can help teachers to provide students with meaningful contexts in which to situate the learning of mathematics (Boaler & Staples, 2008; Buxton, 2017; Grootenboer & Sullivan, 2013).

1.2.3 Component 3: Systematic addition of cultural capital

Within YDM, mathematics education is conceptualised as a source of embodied cultural capital that will enable students (regardless of the nature of any prior capital they may, or may not, already have acquired) to understand and engage in mathematics discourse relevant to their future cultural, academic and professional lives (cf. Aikenhead, 1996; Claussen & Osborne, 2012). Thus, in Component 3, we identify two types of mathematical knowledge that we believe should be systematically provided to better prepare Indigenous and low-SES students to handle formal abstractions and more complex mathematics in later years of schooling and life: (a) big ideas of mathematics, and (b) big ideas about mathematics.

Big ideas of mathematics

'Big ideas' refer to key ideas that link numerous mathematics discipline understandings into coherent wholes (Charles, 2005). Mathematics big ideas (e.g., concepts such equivalence and part-whole relationships, principles such as the inverse principle, strategies such as problem-solving strategies, and models such as set and number line models) provide students with overarching conceptual schema that can (a) help them make sense of what they have experienced in and out of the classroom; (b) lead them to more flexible and generalisable knowledge use; (c) prepare them to make sense of and master new mathematical concepts, processes and strategies; (d) facilitate transfer of knowledge; and (e) improve problem-solving (Chalmers & Nason, 2017; Cooper, Carter, & Lowe, 2016; Niemi, Vallone, & Vendlinski, 2006).

Big ideas about mathematics

To better prepare them for more advanced mathematics that they may need in later school years and also in their adult work and lives, young students should be provided with opportunities to develop productive mathematical 'habits of mind' (Schoenfeld, 2016). Habits of mind are sets of dispositions or ways of thinking that describe how practitioners in mathematics seek to understand the world; these habits of mind become an interpretive lens through which the practitioners view and seek solutions to complex problems (Gurung & Hayne, 2009). Students should also be provided with opportunities to experience how mathematics functions and, in particular, engage in the problem-solving and creative aspects of mathematics (YuMi Deadly Centre, 2014). For example, students should be taught the role of mathematical symbols in providing both a language and a structure for mediating problem-solving and creativity. Students should experience both the power of the symbols and the meaning associated with the symbols telling stories (Matthews, 2009). Understanding productive mathematics habits of mind and that mathematics is a problem-solving and creative endeavour, both play crucial roles in helping students to legitimately participate in the discipline of mathematics (Chalmers, Carter, Cooper, & Nason, 2017; Cuoco, Goldenberg, & Mark, 2010).

1.2.4 Component 4: Focus on the structure of mathematics

The YDM model of mathematics (see Figure 1.2) places much emphasis on the structure of mathematics and on mathematics being a problem-solving tool. Consequently, a major focus of YDM is on students learning about concepts that are fundamental or basic to the structure of mathematics (cf. Davydov, 1975a, 1975b, 1990). Understanding these concepts lays the foundations for developing a disposition for sense-making and reasoning in the doing of mathematics (Venenciano & Dougherty, 2014).

To achieve this understanding, an approach grounded firmly in the real-world experiences of the students is proposed for the teaching of these concepts. Thus, teaching is situated in carefully structured sequences of learning activities that progress from the general to the specific and from pre-numeric to numeric. Based on prior research done in the YDM program and the application of Davydov's mathematics curriculum in Russia and the United States (e.g., Davydov, 1975a, 1975b, 1990; Dougherty & Zilliox, 2003; Schmittau & Morris, 2004; Venenciano & Dougherty, 2014), we contend that

this progression from general to specific and from pre-numeric to numeric should enable students to acquire deep and powerful understandings of mathematical structures and principles. YDM's structured sequences of learning activities have the following properties:

1. *Isomorphism*. They use effective models and representations with strong isomorphism to desired internal mental models, few distracters and many options for extension.
2. *Sequence*. They provide sequences of models/representations where there is increased flexibility, decreased overt structure, increased coverage and continuous connectedness to reality.
3. *Nestedness*. Ideas behind consecutive steps are nested wherever possible.
4. *Integration*. More complex and advanced mathematical ideas are facilitated by integrating models.
5. *Comparison*. Abstraction is facilitated by comparison of models/representations to show commonalities that represent the kernel of desired internal mental models (Cooper & Warren, 2011; Davydov, 1990; Warren & Cooper, 2009; YuMi Deadly Centre, 2014).

1.2.5 Component 5: Whole-school and school–community approach

To have optimal impact on Indigenous and low-SES students' learning of mathematics, a comprehensive approach involving whole-school processes and school–community partnerships was developed.

Whole-school processes

Approaches to improve mathematics learning need to be allied with whole-school processes (Fotheringham, 2012; Sarra, 2011; YuMi Deadly Centre, 2014). YDM has identified five whole-school processes that can facilitate improved mathematical learning by Indigenous and low-SES students:

1. Develop and implement a whole-school plan for improving student learning across all subject areas (Fotheringham, 2012; McTaggart & Curró, 2009; Sarra, 2009; YuMi Deadly Centre, 2014).
2. Develop whole-school policies for addressing challenging behaviour. Schools need a common behavioural management program used consistently in each classroom. Without this, unacceptable behaviour can prevent the best mathematics instruction activities achieving their goals (Sarra, 2009; YuMi Deadly Centre, 2014).
3. Develop whole-school policies for supporting attendance. These should not only focus on rewards for attendance; they also require an ongoing commitment by teachers and aides to monitor students, and changes in school and classroom processes to attract students to the classroom (McTaggart & Curró, 2009; Sarra, 2009; YuMi Deadly Centre, 2014).
4. Ensure all classrooms are culturally and socially safe and empowering. It is important to ensure teaching and learning pedagogy is meaningful to the social and cultural contexts of the local learner, particularly for Aboriginal and Torres Strait Islander students (Fotheringham, 2012; McTaggart & Curró, 2009; Sarra, 2011; YuMi Deadly Centre, 2014).
5. Set up processes for building pride in self and school/community. These need to be related to the strengths of the school and community and to a system of school-wide rewards and incentives (Fotheringham, 2012; Sarra, 2009; YuMi Deadly Centre, 2014).

School–community partnerships

Indigenous and low-SES students get better results in their education when schools and communities engage in two-way, connected partnerships to create a shared vision for students and agreed ways for achieving it (Fotheringham, 2012; Frigo et al., 2003; Frigo & Simpson, 2001; Trumbull & Pacheco, 2005; YuMi Deadly Centre, 2014). YDM has identified five strategies that the research literature indicates can be used to achieve this shared vision:

1. Recognise families as first educators and welcome them into the school (Fotheringham, 2012; Sarra, 2009; YuMi Deadly Centre, 2014).
2. Use various forums designed to ensure voices from the community are heard in the school (Fotheringham, 2012; Trumbull & Pacheco, 2005).
3. Connect leadership within the school and leadership within the community, often through principals using key community members as mentors (Fotheringham, 2012; Sarra, 2009; YuMi Deadly Centre, 2014).
4. Establish partnerships and relationships that describe the school vision and ways of achieving it (Fotheringham, 2012).
5. Expand notions about how members of the community can volunteer (Trumbull & Pacheco, 2005).

YDM's comprehensive approach involving whole-school processes and school–community partnerships is encapsulated in Figure 1.3, with its cycle of four imperatives: **school–community partnerships, local leadership, positive student identity** and . It aims to develop not only new capabilities but also shifts in thinking individually and collectively. The four imperatives are particularly important for Indigenous and other minority groups to increase community capacity within schools; that is, to empower Indigenous people and minority groups from the local community to have a voice.

Figure 1.3 Cycle of school change and leadership (YuMi Deadly Centre, 2014)

From this cycle of school change and leadership, a YDM methodology for facilitating school change has been developed. To operationalise this methodology, resources and PD workshops are designed so that:

- their focus encompasses school change and leadership (principals, community, system and administration support) as well as mathematics and its learning and teaching (teachers)
- they provide the RAMR pedagogical framework,[1] supported by examples of classroom activities designed to maximise learning outcomes by valuing local culture and knowledge, engaging student interest, building high teacher expectations and enabling positive student identity
- they provide a framework for principals and the trained teachers (called teacher-trainers) to work together to set up a supportive in-school training and trialling process
- they set up contact between school (principal and teacher-trainers) and YDC staff to provide online support for in-school training and trialling
- they provide information so that each school can use action research to provide feedback to both teachers and YDC to improve resources and processes.

1.2.6 Component 6: Teacher as learner

Any education reform seeking to promote academic success centred in students' cultural and community identities and their potential to engage in the critical pursuit of social justice is 'undergirded by teachers' conceptions of themselves as relationship-oriented, political, and caring; of knowledge and curriculum as dynamic and fallible; and of classroom, school, and community relations as collaborative, culturally centred, and supportive' (Matthews, 2003, p. 62). Thus, preparation for the successful introduction of CRP dictates a renewal of most teachers' knowledge about themselves, mathematics and the teaching of mathematics (Aguirre et al., 2012; Matthews, 2003; Owens, 2015; Parhar & Sensoy, 2011; YuMi Deadly Centre, 2014). For such renewal to occur, teachers need to adopt the role of learners who reflect on, critique and advance their repertoires of knowledge (Matthews, 2003; YuMi Deadly Centre, 2014).

[1] This framework is discussed in detail in section 1.2.6.

A review of the literature indicates that for this to occur, teacher PD programs need to focus on (a) content; that is, what teachers learn, and (b) process; that is, how teachers learn (Guskey, 2003; Meyer, Vines, & Shankland, 2012). This focus on content and process is reflected in Component 6 of the theoretical framework.

Content

In the theoretical framework, YDM proposes that teacher PD programs should focus on enhancing teachers':

1. *Mathematical identities and cultural capital*. Teachers bring many prior mathematical experiences, beliefs and dispositions about mathematics and mathematics knowledge and skills to the classroom that can greatly influence Indigenous and low-SES students' learning (Achinstein & Aguirre, 2008; Howard, 2003; Matthews, 2003; YuMi Deadly Centre, 2014). For example, the enactment of CRP may contradict teachers' beliefs and assumptions about the nature of mathematics, how it is taught and the teacher's role and identity as these relate to teaching Indigenous and low-SES students (Leonard, Brooks, Barnes-Johnson, & Berry, 2010). Thus, the implementation of a CRP-based program often requires teachers to set aside their own ways of knowing mathematics and instead focus on students' ways of knowing (Parker et al., 2017).

2. *Identity as a teacher*. To adopt a CRP approach that values multicultural knowledge (e.g., the use and application of mathematics in other cultures), teachers need to adopt the identity of a knowledgeable person who engages in mutual learning and a two-way flow and co-construction of knowledge with their Indigenous and low-SES students, teacher aides/ liaison persons and knowledgeable members of the local community (Bishop, Berryman, Cavanagh, & Teddy, 2008; Sarra, 2009; YuMi Deadly Centre, 2014).

3. *Knowledge base about cultural diversity*. Explicit knowledge about cultural diversity is imperative to meeting the educational needs of Indigenous and low-SES students (Enyedy & Mukhopadhyay, 2007; Gay, 2002). According to Gay (2002), Indigenous and low-SES groups' cultural values, traditions, communication, learning styles, contributions and relational patterns have direct implications for teaching and learning. If teachers do not comprehend this, they tend to reproduce their own mathematics learning experiences, drawing on traditional, teacher-centred pedagogies and de-contextualised curricula (Aguirre et al., 2012). Thus, the implementation of a CRP-based program requires a PD program that concentrates on teachers' pedagogical content knowledge, including how to identify and pursue mathematically rich conversations and connect them to the students' own lives, local experiences and interests (Enyedy & Mukhopadhyay, 2007).

4. *Knowledge base about the design of CRP curricula*. In addition to acquiring a knowledge base about cultural diversity, teachers need to learn how to convert it into culturally responsive curriculum designs and instructional strategies that situate the learning of mathematics in local and cultural contexts and make it more relevant and meaningful for the Indigenous and low-SES students (Gay, 2002).

5. *Knowledge base about the creation of classroom climates that are conducive to learning by Indigenous and low-SES student*s. Pedagogical actions are as important as multicultural curriculum designs in implementing culturally responsive teaching (Gay, 2002, p. 109). Thus, teachers need to learn how to use cultural scaffolding in teaching the Indigenous and low-SES students; that is, learn how to build on the students' cultures and experiences to expand their intellectual horizons and academic achievement. This begins by demonstrating culturally sensitive caring and building culturally responsive learning communities (Gay, 2002; Parhar & Sensoy, 2011; YuMi Deadly Centre, 2014).

6. *Knowledge base about communication with culturally diverse students*. Determining what Indigenous and low-SES students know and can do, as well as what they are capable of knowing and doing, is often a function of how well teachers can communicate with them (Gay, 2002; McTaggart & Curró, 2009; YuMi Deadly Centre, 2014). Understanding the communication styles of different cultural groups within a classroom is necessary to (a) avoid violating the cultural values of ethnically diverse students in instructional communications; (b) better decipher their intellectual abilities, needs and competencies; and (c) teach them style or code-shifting skills so they can communicate in different ways with different people in different settings for different purposes (Gay, 2002, p. 111).

7. *Knowledge base about the delivery of instruction to culturally diverse students*. The teaching of mathematics to Indigenous and low-SES students needs to be multiculturalised to match instructional techniques to the learning styles of diverse students (Bishop et al., 2008; Gay, 2002; YuMi Deadly Centre, 2014). Therefore, teachers need to develop rich repertoires of multicultural instructional examples to use in teaching culturally diverse students.

Process

A review of the literature indicates that teachers often experience difficulties, together with feelings of discomfort and anxiety, when asked to engage in the role of learners reflecting on, critiquing and advancing their repertoires in the seven aspects of teacher knowledge, beliefs and dispositions described above (Aguirre et al., 2012; Mathews, 2003; Parhar & Sensoy, 2011; Parker et al., 2017; YuMi Deadly Centre, 2014). For example, Aguirre et al. (2012) found that teachers need increased opportunities to learn about students' cultural funds of knowledge and o explicitly identify children's out-of-school experiences as resources to support mathematics learning. Parker et al. (2017) found that their teachers did not develop some of the more 'advanced' understandings related to power and privilege in society.

To address this issue, within the YDM theoretical framework we proposed three types of scaffolding that the literature indicates can be used to effectively facilitate learning of the seven aspects of what teachers should learn during the course of PD programs:

1. provision of curriculum development templates (e.g., YuMi Deadly Centre, 2014)
2. provision of exemplars (e.g., resource books, lesson plans, diagnostic tests) operationalising various aspects of the YDM theoretical framework (Renshaw, Baroutsis, van Kraayenoord, Goos, & Dole, 2013; YuMi Deadly Centre, 2014)
3. establishment and maintenance of professional knowledge-building communities of practice (Brett, Nason, & Woodruff, 2002; Cambourne, Ferry, & Kiggins, 2003; Nason, Chalmers, & Yeh, 2012; Owens, 2015; Snow, Griffin, & Burns, 2005).

1. Provision of curriculum development templates

The principal curriculum development template that YDM developed to facilitate teachers' learning about how to implement the YDM philosophy about the teaching and learning of mathematics is the YDM pedagogical framework. Subsumed within the **YDM pedagogical framework** are the **RAMR cycle** and the **Planning–Teaching cycle**.

RAMR cycle. The RAMR cycle (YuMi Deadly Centre, 2014) was designed to scaffold and provide teachers with the knowledge and confidence to write their own lesson and unit plans. The RAMR cycle has its genesis in the YDM model of mathematics (see Figure 1.2). The evolution of the RAMR cycle from the YDM model of mathematics required two steps. The first step was to deconstruct the YDM model's philosophical framework into components that can become pedagogical steps. To do this, the contexts of reality and mathematics and the processes of abstraction and reflection became four different types of instructional episodes. These were then linked into a cycle of instructional episodes that starts and ends with reality: the Reality–Abstraction–Mathematics–Reflection or RAMR cycle (see Figure 1.4). The second step was to flesh out the cycle by identifying key aspects of existing pedagogies that had been useful in teaching mathematics to Indigenous and low-SES students and integrating them into the four components of the cycle. In particular, the development of the RAMR cycle was much influenced by Wilson's Activity Type cycle[2] (Ashlock, Johnson, Wilson, & Jones, 1983), Payne and Rathmell's (1975) triangle,[3] Baturo, Cooper, Doyle, and Grant's (2007) levels of instruction[4] and generic strategies[5] framework, Alexander and Murphy's (1998) learner-centred principles,[6] and Bruner's (1966) three levels of knowledge.[7]

[2] Wilson's teaching cycle includes (a) initiating by teaching the idea informally in real-world situations, (b) abstracting to formal mathematical language and symbols, (c) schematising by connecting the new knowledge to prior knowledge, (d) consolidating through practice, and (e) transferring by solving problems and extending knowledge to new ideas. The cycle advocates continuous checking and diagnosis of student understandings.

[3] Payne and Rathmell's framework connects models (physical, virtual and pictorial), language and symbols and advocates an initial pedagogical sequence of story → models → language → symbol, then relates all the parts in all directions.

[4] Baturo et al.'s framework identifies three levels of instruction: technical (proficiency with the use of materials), domain (materials and activities that provide effective experiences for learning a topic) and generic (instructional strategies that hold for all topics).

[5] Baturo et al.'s framework identifies four generic strategies: flexibility (experiencing the idea in many ways), reversing (teaching in the opposite direction), generalising and changing parameters.

[6] Alexander and Murphy's five principles are (a) prior knowledge serves as the foundation of all future learning; (b) learning is as much a socially shared knowledge as it is an individually constructed enterprise; (c) learning, while ultimately a unique adventure for all, progresses through various common stages of development; (d) metacognition is central; and (e) affective factors play a significant role in the learning process.

[7] Bruner argued that three levels of knowledge—enactive, iconic and symbolic (which we renamed body, hand and mind)—are required and the mind moves forward and back through them, in learning and problem-solving.

Figure 1.4 illustrates an important innovative aspect of the RAMR cycle that differentiates it from many previous mathematical pedagogical models; namely, that it not only focuses on the development of a mathematical idea (right half the figure) but also on reconnecting the developed mathematical idea to the world and extending it (left half of the figure). Figure 1.5 illustrates how the RAMR cycle can facilitate the design of a structured instructional sequence or framework for the teaching of a mathematical idea. Prerequisite mathematical ideas are considered in the reality and mathematics components of the cycle, while extensions and follow-up ideas are considered in the reflection component.

The RAMR framework begins and ends with the reality of the students' lives. It starts with something that interests the students and then acts this out with kinaesthetic or whole-body activities to build visual images or pictures in the mind of the mathematical idea(s). It then moves to consolidation, which involves making connections as well as practice, and finally reflects back to the students' reality. The two core sections are abstraction and reflection, with reflection ensuring that the idea(s) are extended as far as they can, using the four generic actions: flexibility, reversing, generalising and changing parameters. The framework is not fixed, either in theory or in most schools' practices. Teachers use it for unit plans

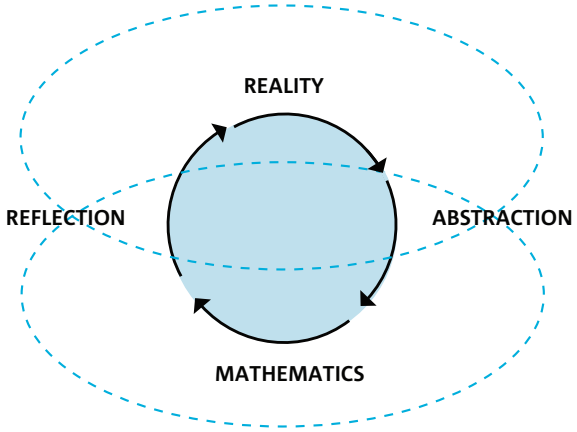


Figure 1.4 RAMR cycle (YuMi Deadly Centre, 2014)

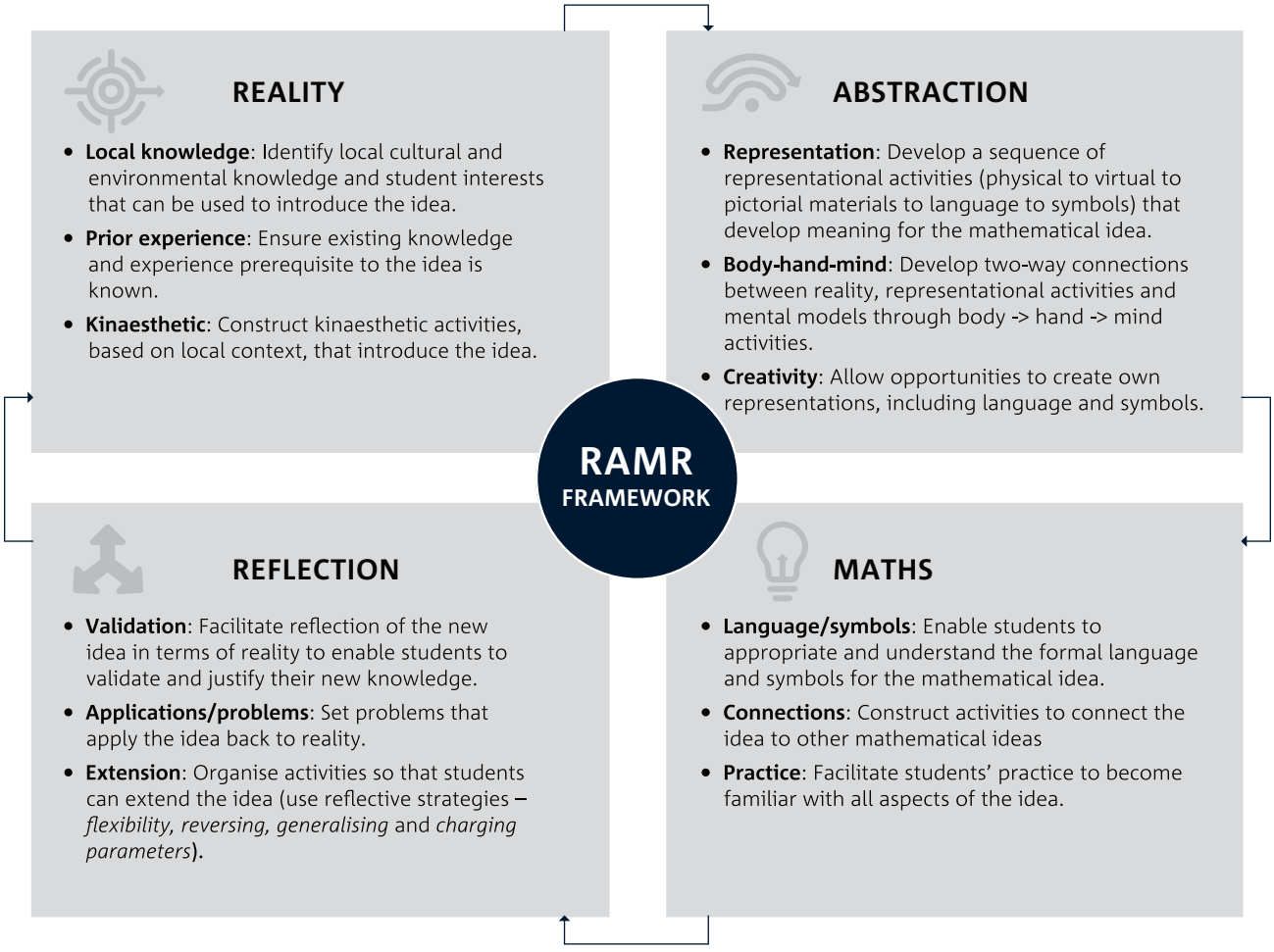


Figure 1.5 RAMR structured framework for teaching a mathematical idea

and lesson plans. They move back and forth between the parts of the framework and use the extension strategies in reflection across the whole framework.

YDM Planning–Teaching cycle. The RAMR cycle is only part, albeit a very important part, of the YDM pedagogical framework. The other important component is the YDM Planning–Teaching cycle (encapsulated in Figure 1.6). As illustrated in Figure 1.6, the cycle has seven components:

1. *Identification*. Determining the focus of the instruction for the period being planned. This is initially determined by the curriculum but modified by knowledge of students' mathematics progress up to the start of the lessons.
2. *Diagnosis*. Identifying and administering effective diagnostic assessment tools. The RAMR cycle assists here by showing what is needed for the starting step of the plan. Most diagnostic tests need modification to add in reality, kinaesthetic, connection and reflection items (particularly with respect to the four generic/reflection strategies).
3. *Analysis*. Using a spreadsheet (e.g., Excel) to analyse the students' responses to the assessment in terms of class needs and individual needs.
4. *Planning*. Determining sequences of instruction for the students so they can progress from where they are to where they should be.
5. *Teaching*. Having the mathematics and mathematics-education knowledge to effectively teach the plan. This is where the RAMR cycle is used—it helps develop the lessons for each step in the teaching plan.
6. *Management*. Having the general lesson knowledge to manage learning, in particular, to know after instruction which students know and do not know what has been taught, and what to do about the two groups.
7. *Reflection*. Having the ability (and knowledge) to reflect on each of 1 to 6 and to modify instruction to maintain effective learning.

The Planning, Teaching and Management components of this YDM Planning–Teaching cycle are based on Shulman's work on teacher knowledge to be able to teach in mathematics (and other disciplines). Shulman (1986, 1987) argued that there were three types of teacher knowledge: mathematics content knowledge, mathematics pedagogy knowledge and general lesson planning knowledge.

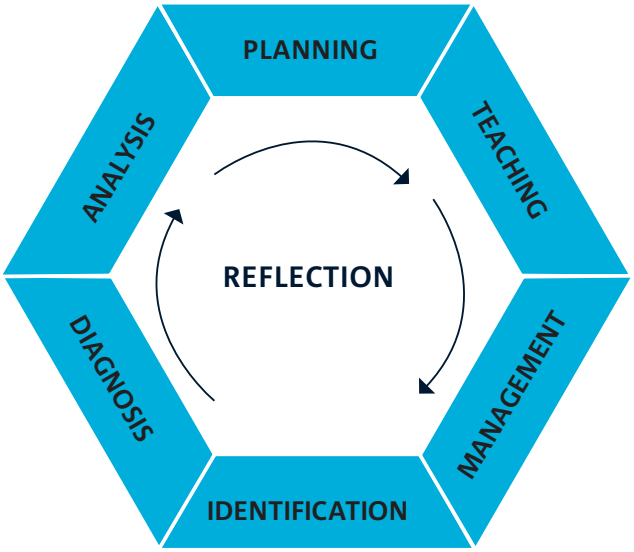


Figure 1.6 YDM Planning–Teaching cycle

The YDM Planning–Teaching cycle has been found to be very empowering for teachers. Along with the RAMR cycle, it forms a framework that enables teachers to develop their own plans and sequences and their own scripts and lessons for the specific needs of their students.

Overall YDM Planning–Teaching framework. Along with big ideas, connections and sequencing, the RAMR cycle and the Planning–Teaching cycle provide an overall YDM pedagogical framework for teaching and learning mathematics that empowers teachers to teach powerful mathematics effectively without scripts or detailed lesson plans provided by an external source.

2. Provision of exemplars

To facilitate the process of operationalising YDM, each participating school has been provided with eight books detailing the YDM approach to teaching mathematics and resources on how to implement this approach: *Overview, Number, Operations, Algebra, Geometry, Measurement, Statistics and Probability*, and *Review*. These materials are also available on a QUT Blackboard online learning platform for the participating teacher-trainers to access. The books provide exemplars of classroom activities designed to maximise mathematics learning outcomes by valuing local culture and knowledge, engaging student interest, building high teacher expectations and enabling positive student identity. In particular, many of the exemplars provided in the books were designed to emphasise sequencing, connections and big ideas (YuMi Deadly Centre, 2016).

3. Establishment and maintenance of professional knowledge-building communities of practice

The establishment and maintenance of professional knowledge-building communities of practice is achieved within YDM through PD programs and the mentoring of teachers by YDC practitioners/researchers. Research within this aspect of YDM has led to the development of the YDM effective professional learning cycle (see Figure 1.7). Particular influences in the development of this cycle were:

- the experience of seeing how differences in student situation, background and culture affect mathematics teaching, leading YDM to focus PD and resources on supporting teachers, not just preparing textual material
- experiences with PD in observing the positive effects on teachers of motivating, effective and innovative ways to plan and run lessons that they felt they could immediately use, mixed with theory on effective pedagogies that they saw would enable them to construct their own lessons
- the ideas of Hord (2004) that show the efficacy of professional learning communities and knowledge-building communities that point to the importance of group knowledge-building for students and teachers
- the theories of Clarke and Peter (1993) and Baturo, Warren, and Cooper (2004), arguing that implementation should be a cycle of affective readiness for change, pertinent external input, effective classroom trials, positive student responses and supportive reflective sharing.

Figure 1.7 highlights that positive student outcomes, along with initial readiness, are crucial to successful change. These are facilitated by:

- inputs of pertinent, relevant and innovative ideas and materials (YDM resources, PD activities and online learning modules)
- just-in-time support before and during in-school training and classroom trials (in planning and by modelling training and instruction)
- support of community, system, principal and other administration staff in achieving positive student outcomes
- responding to feedback in data gathered through an action research process during in-school training and classroom trials.

1.2.7 Application of the theoretical framework in the PRIME Futures program

As with all previous YDM research and development activity, the application of YDM's three-tiered theoretical framework (see Figure 1.1) in the PRIME Futures program was conducted using a design-research methodology (Kelly, 2004). Details about how the design-research methodology was employed during the application of the framework in the program are presented in Sections 1.3 and 1.4.

The results from the application of the theoretical framework are presented in Chapter 2 and discussed

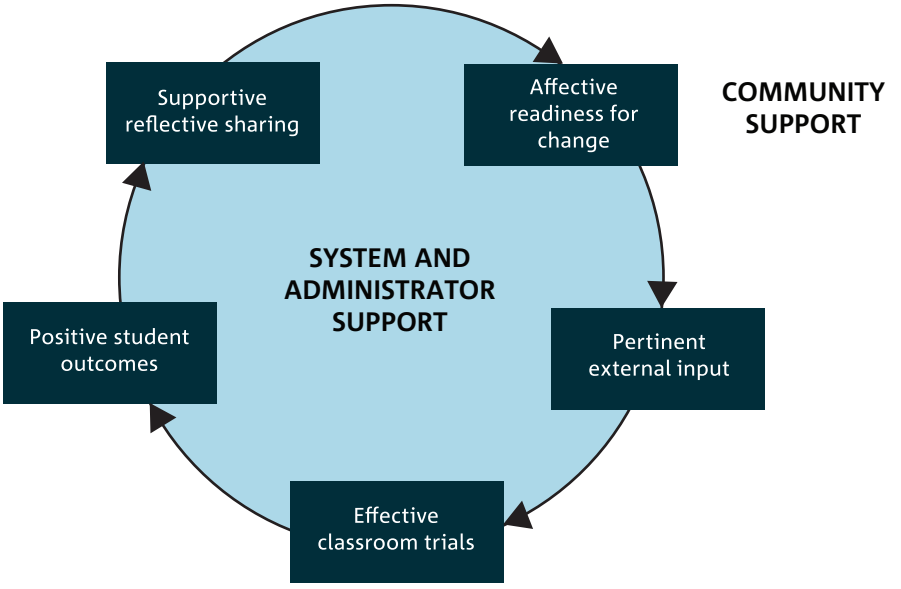


Figure 1.7 The YDM effective professional learning cycle

in Chapter 3. As one of the major goals of the design-research methodology is the advancement of theory (Kelly, 2004), in Chapter 4, during the discussion of the findings and conclusions, the theoretical framework will be revisited. Modifications to the theoretical framework based on our interpretation of the findings will be presented and discussed. The report will conclude with a revised theoretical framework to further advance theory informing research and practice in the teaching of mathematics in schools with Aboriginal, Torres Strait Islander and/or low-SES students.

1.3 The PRIME Futures methodology

This section describes the application of the YDM theoretical perspective to school change in the PRIME Futures program. Following a brief overview in Section 1.3.1, the case study methodology is presented in Section 1.3.2 and the data collection methods and response rates in Section 1.3.3.

1.3.1 Overview

YDC was contracted by CSIRO to use the YDM approach in the PRIME Futures program. Practical considerations (such as school management and YDC funding limitations) prevented YDC from directly working with every teacher of mathematics in the schools participating in the program. Consequently, a train-the-trainer approach was used, working with groups of up to nine schools in geographical clusters (labelled Clusters 1–10). Each school was invited to nominate four staff members to be trained to become teacher-trainers. We recommended that one of these was an administrator, and teacher aides were also eligible. YDC provided five PD workshops of two or three days each[8] across two years for these trainers, as well as a Sharing Summit at the end of each year. The school principal or a senior administrator was invited to attend the first day of the first and third PD workshops (at least). The five workshops covered the YDM philosophy and pedagogy; in-school processes for implementation and planning, school change, community involvement and sustainability; and the mathematical content for Years P–9 in all strands of the Australian Curriculum: Mathematics (Australian Curriculum, Assessment and Reporting Authority [ACARA], 2018).

Schools were asked to prepare a plan to enable the teacher-trainers to trial the YDM pedagogy, train other teachers in YDM using an action research approach, and regularly report back to YDC on progress in implementing the pedagogy. In other words, schools were asked to nominate four staff to be trainers, change agents and researchers, and to provide time and space for all other mathematics teachers to be involved. Besides the PD workshops, teacher-trainers were provided with books, resources and online access to training modules, videos, discussion groups and lesson plans, as well as access to YDC staff by phone and online. Overall, sequencing, connections and big ideas were central in PD workshops, as were examples of highly effective classroom activities. However, as the most powerful idea was the RAMR framework, significant time in the PD workshops was devoted to planning lessons using it. Schools were also shown how to involve their communities and parents in mathematics learning.

The implementation of YDM through the PRIME Futures program was a combination of centrally organised PD inputs, school organised in-school activities, informal ad hoc contact, and training-support and research activities (see Cooper & Carter, 2016). Specifically, the PRIME Futures program included the following components:

- teacher PD workshops (five workshops of two to three days each, delivered approximately every six months across two years)
- four follow-up visits to each school by YDC practitioners to support in-school trialling and training (one visit between each PD workshop)
- eight resource books with information on the YDM approach and how to implement it
- YDM online support (including learning modules and resources, email, help desk and discussion forums)
- action research training
- data collection
- a highly experienced YDC mathematics education practitioner as coordinator of each cluster.

Of these activities, YDC provided the initial inputs. These were centralised, formal and planned. However, the in-school training processes that followed the YDC inputs were school organised, informal and ad hoc. Yet, YDC experience shows that it is these latter activities that are the most powerful and effective in implementing YDM. The informal in-school processes provide a unity to the PD inputs and school staff's actions and, together with the formal inputs, enable opportunities for change, in spite of their apparent separateness.

[8] PD workshops in Clusters 1–8 were each of three days' duration, while in Clusters 9 and 10 they were each of two days' duration (see Section 1.4.2).

1.3.2 Case study design

To study and report on the PRIME Futures program, a case study design using ethnographic methods was selected. This required observation of the world from the point of view of the participants in the study (Hammersley & Atkinson, 2007); that is, the school managers and teacher-trainers in the selected schools and the YDC practitioners. Case studies apply ethnographic methods to the study of particular phenomena (Hammersley & Atkinson, 2007), such as the PRIME Futures program.

This case study took an interpretivist approach (Stake, 1995), where the emphasis is on the interaction and cooperation between the participants. Creswell (2008) described case study as focusing 'on a program, event or activity involving individuals' (p. 476). The case is a bounded system; that is, it is separated from other activities by clearly defined criteria such as place, time, personnel and activities (Creswell, 2008; Miles & Huberman, 1994; Stake, 1995). In this study, the case was bounded in terms of activities, by focusing on the implementation of the PRIME Futures program; personnel, by limiting the study to the school managers and the teachers and students of mathematics; time, by focusing on the period of the YDC contract with CSIRO (August 2015 to October 2019); and process, by focusing on teaching and learning practices. A case study is 'an in-depth exploration … based on extensive data collection' (Creswell, 2008, p. 476). This study sought to collect a variety of detailed data about the operations of the PRIME Futures program within these boundaries.

1.3.3 Data collection

Methods

Data was collected from and about the participating schools and teachers throughout the PRIME Futures program. Data was collected using 14 different methods, as shown in Appendix A, including workshop evaluation forms, online teacher and principal surveys, continuous teacher reflective journal entries and YDC cluster coordinator reports.

Workshop evaluation forms were completed anonymously and invited participants to rate each session. Some participants chose to add comments about some of the sessions. Where these comments have been quoted in this report, they indicate only the cluster of the respondent.

Biannual surveys of teachers and school principals asked about the quality and implementation of the program as well as student and teacher outcomes. Surveys conducted during the program included questions on general improvements in teaching, student performance and progress in implementing YDM in the school. These surveys are referred to in this report as 'biannual surveys'.

After examining the responses to the biannual surveys, it was decided that the interpretation of some of the survey data could be ambiguous. This led YDC staff to review the literature about the use of self-reported variables and retrospective methods to evaluate training programs (see literature reviews in Appendices B and C) and to choose a pre-post retrospective design (Allen & Nimon, 2007) for the final survey. The survey collected data about the same variables as the biannual surveys but measured the change in those variables by asking respondents to rate the circumstances that applied both before and after the program. This survey is referred to as the 'exit survey'.

Teachers and principals at schools in Clusters 1–4 received four biannual surveys. Because the PRIME Futures program commenced later in subsequent clusters (see Appendices D and E), the need to conclude and report on the program by October 2019 meant that the teachers and principals in Clusters 5–10 received only three of these surveys. The surveys were sent to all teachers participating in the program at the time of the survey, whether or not they had attended the latest workshop. This may have included those who had left the participating school or those on extended leave. Although surveys were sent to school principals, YDC practitioners reported that they were often delegated to other school managers for completion, especially in large schools.[9]

Exit surveys were sent to the principals of every school remaining in the program at the time of the final PD workshop for each cluster and to teachers in those schools who had attended any of the first four PD workshops. Those teachers who had only attended the final PD workshop were excluded from the survey because they would not have had sufficient time to implement YDM.

Teachers were asked to maintain continuous reflective journals and upload these via an open-ended online template. This was sent annually to all teachers participating in the program (based on PD attendance), and YDC practitioners reminded teachers about submitting the journals at each PD workshop. To preserve the anonymity of the quotations of teachers' comments made their reflective journals, their school has been identified by a number (indicating the cluster number) and a letter (indicating the school); for example, 3D would be school D in Cluster 3. Each teacher is identified by a unique number; for example, teacher 17.

[9] This means that throughout this report references to school principals may include other school managers.

This number was automatically generated by the journal software as soon as the teacher accessed their journal, whether or not they submitted any entries.

Surveys and reflective journals were limited to those teachers who attended the PD workshops. Data was not collected from the 'second generation' teachers who had been trained at school by those who had attended the PD workshops. While this excluded a potentially valuable source of information, it was considered that sending surveys to all teachers in a school would be viewed as an unreasonable imposition on those teachers and would result in a very low response rate. It is unlikely that the relevant education authorities would have been willing to cooperate with such an approach.

Additional qualitative information was collected from the YDC cluster coordinators, and qualitative data on embedding Indigenous perspectives in schools was gathered through interviews with Indigenous community members in most clusters. Full details of the 14 data collection methods are provided in Appendix A. All data collection processes received prior ethics approval from QUT and the relevant state government education authorities.

The requirement to obtain informed consent from caregivers before data could be collected about students, and the practical difficulties in obtaining that consent in relation to every student in a class, effectively prevented the collection of data about student outcomes directly from students. However, teachers were encouraged to share information about outcomes in their classes in some survey questions and in their reflective journals.

The data were summarised and analysed by YDC. Survey results were tabulated for each cluster. For consistency, when the responses to the surveys in each cluster were collated and averaged for Clusters 1–10, the responses to the fourth survey from Clusters 1–4 were excluded from the totals, as noted below each table where applicable. Teacher reflective journals were analysed thematically (coded by four YDC staff members), with representative extracts coded as PD workshops, Indigenous perspectives, teacher capacity, program implementation and student outcomes. Sub-themes were also identified, and these are reflected in the structure of Chapter 2. The YDC cluster coordinator reports had many similarities, so they were amalgamated and summarised under the same themes.

The de-identified and aggregated data formed the basis of regular reports to CSIRO and the BHP Foundation and was used to provide feedback to the schools and teachers involved in the program. On completion of the active phase of training for each cluster of schools, a cluster report was prepared and will be provided to the participating schools and relevant state governments (a condition of granting permission to work with the government schools in each jurisdiction). Finally, on completion of the program, the data for the entire program was aggregated and forms the basis of the data presented in Chapter 2 of this report.

Response rates

As discussed above, quantitative data was collected through online surveys of program participants at biannual intervals. Reflective journal templates were sent to participating teachers at the time of the first PD workshop each teacher attended and then annually (i.e., on up to three occasions), but teachers were encouraged to make regular entries in these throughout the program. Because the PRIME Futures program commenced at different times in different clusters (see Appendices D and E), the timing of the requests for data was determined in relation to the date of the first PD in that cluster. In other words, the dates of sending out data requests varied. This may have resulted in higher response rates in the clusters that commenced earlier as there was more time to send out reminders to those who had failed to respond to the first request.

Quantitative survey results are based on 569 teacher responses and 202 principal responses received in three rounds of biannual surveys and one exit survey over a period of two and a half years. For consistency, as the fourth survey was conducted in Clusters 1–4 only, the number of responses from that survey are excluded from Table 1.1. As shown in Table 1.1, the average response rate for school principals was 73% and for teachers was 57%.

Table 1.1 Principal and teacher survey response rates

SURVEY TYPE	SURVEY 1 (BIANNUAL)	SURVEY 2 (BIANNUAL)	SURVEY 3 (BIANNUAL)	EXIT SURVEY	TOTAL
Principal	55/74 (74%)	55/72 (76%)	49/66 (74%)	43/63 (68%)	202/275 (73%)
Teacher	163/284 (57%)	152/251 (61%)	129/214 (60%)	125/251 (50%)	569/1000 (57%)

Note. Principal survey response rate = number of principal survey responses/number of schools in the program at the time of the survey for each cluster. Teacher survey response rate = number of teacher survey responses/number of teachers attending the workshop prior to the survey in each cluster, except for the exit survey (see below).

Table 1.2 Teacher reflective journal response rates

	CLUSTER										
	1	2	3	4	5	6	7	8	9	10	TOTAL
Number	7/40	8/43	7/24	27/40	17/43	11/36	9/35	5/50	3/32	6/35	100/378
Percent	18%	19%	29%	68%	40%	31%	26%	10%	9%	17%	26%

The number of expected total responses for the biannual teacher surveys was taken from the number of teachers attending the PD workshop immediately prior to the survey (according to the PD sign-on sheet). Staff turnover in schools and changes to the teachers sent to the PD workshops resulted in the number of participants varying across the duration of the program, so this method was considered the most accurate way to estimate the expected number of total responses per survey. However, some responses may have come from teachers who attended previous workshops but not the most recent workshop, as the surveys were sent to all teachers participating in the program at the time of the survey, whether or not they had attended the latest workshop. The exit survey was sent to all teachers who had participated in the program at some stage and potentially were able to provide some useful information (excluding teachers from schools that had withdrawn from the program and teachers who had attended PD 5 only).

Occasionally, the principal or teacher survey respondents chose not to answer a particular question in the survey; consequently, the number of responses shown for each cluster in the data tables presented in Chapter 2 may not add to the exact number of total responses shown in Table 1.1 (e.g., responses to the principal exit survey may add to less than 43 and responses to the teacher exit survey may add to less than 125).

Teachers were also asked to provide qualitative data through their individual reflective journals, for which they were given an open-ended template asking for elaboration on YDM implementation, teacher change and student outcomes, with space to provide additional comments. Table 1.2 shows the response rates for each cluster, with a total of 100 teachers submitting journals from a possible 378 program participants (excluding those participants who only attended PD 5, which was too late to prepare and submit journals). This was a response rate of 26%.

As Table 1.2 shows, significantly more reflective journals were received from Cluster 4 teachers than from the teachers in most other clusters, and the content of those journals was more comprehensive. One reason for this may have been that almost all the schools in this cluster had been involved in prior YDM training through earlier projects.

1.4 Case description

Given the selection of a case study methodology to report on the PRIME Futures program, a detailed description of the case is required.

1.4.1 PRIME Futures implementation

The PRIME Futures program targeted Foundation to Year 9 students in metropolitan and regional schools across Australia. CSIRO required that the program include a minimum of 60 schools, 120 teachers and 1500 Indigenous students before the end of Term 2 in the 2019 school year.

Schools were selected purposefully, based on three factors:

- CSIRO proposed that the program be implemented in those geographical areas where the BHP company was active
- given the Indigenous focus of the CSIRO project, schools with higher than average Indigenous student populations were targeted
- operational efficiency required that the program be delivered in geographical clusters of between six and nine schools.

These factors were not always compatible. After consultation with CSIRO, schools were selected in Queensland (six clusters), South Australia (two clusters) and Western Australia (two clusters).

After obtaining approval from CSIRO and the relevant state governments (in respect of government schools) and QUT ethics approval, schools were approached to join the program. Each school was invited to nominate up to four teachers and/or teacher aides to attend the five programmed PD workshops over two years. While the school principals were welcome to attend any PD workshop, they were particularly invited to attend two specific days of PD.

Seventy-five schools commenced the program, of which 22 schools had previously been involved in other YDM projects. Sixty-two schools completed the full program of training, potentially reaching 32,317 students of whom 6975 (22%) were from Indigenous backgrounds (see Appendix E). During the course of the program, 12 schools withdrew and two schools amalgamated to form one school.

To manage the workload for YDC, the PRIME Futures program was deployed in three phases, as follows:

- Phase One commenced in Term 4, 2015 with two clusters in Queensland initially comprising 15 schools and principals, 57 teacher-trainers and 2007 Aboriginal and Torres Strait Islander students.[10]
- Phase Two commenced in 2016 with two additional clusters in Queensland (commenced Term 3, 2016) and two clusters in South Australia (commenced Term 4, 2016) initially comprising a further 29 schools and principals, 133 teacher-trainers and 2093 Aboriginal and Torres Strait Islander students.
- Phase Three commenced in Term 2, 2017 with two additional clusters in Queensland and two clusters in Western Australia initially comprising a further 31 schools and principals, 125 teacher-trainers, and 4073 Aboriginal and Torres Strait Islander students.

Appendices D and E provide further details of the geographical clusters, implementation timeline and cluster statistics.

The PRIME Futures program provided intensive training and school visits during the first two years of a school's involvement in the program. Where the active phase of a school's involvement was completed before the end of the contract with CSIRO (this applied to schools in Phases One and Two of the program), YDC practitioners continued to provide support to the schools until the end of the program in late 2019.

10 One school that started in Cluster 2 moved to Cluster 3 when that cluster commenced in Term 3, 2016. It is only included in the Phase Two statistics so as not to be counted twice.

1.4.2 Professional development

As mentioned above, the program offered a total of 15 days of PD (usually), scheduled in five workshops of three days each (usually) over a two-year period (i.e., at six-monthly intervals).

The two Western Australia clusters (Clusters 9 and 10) followed a different structure for PD workshops than the other PRIME Futures clusters, with each workshop consisting of two days rather than three days. This was a directive from the Western Australia Department of Education, who advised that teachers could not be released for more than two days at a time. To accommodate this arrangement and ensure sufficient time to cover the workshop content, the Cluster 10 workshops were initially lengthened to four sessions per day running from 8:00 am to 5:30 pm with three catering breaks. However, after the first two workshops, this was reduced to three sessions running from 8:30 am to 5:00 pm with two breaks, which was found to be more productive and cost-effective.

For the first PD in Cluster 1 (based in Emerald and surrounding towns, Central Queensland), a two-day catch-up PD was arranged for three of the schools, as they wanted to send new teachers who arrived at the schools at the beginning of 2016, too late to attend the scheduled PD 1 workshop that occurred in November 2015.

The content of the five PD workshops was planned as follows:

- **PD 1**: Overview of the PRIME Futures program, YDM methods, and teaching methods and student activities for Number, relating to the Australian Curriculum strand of 'Number and Algebra' (ACARA, 2018).
- **PD 2**: Teaching methods and student activities for Operations and Measurement, relating to the Australian Curriculum strands of 'Number and Algebra' and 'Measurement and Geometry' (ACARA, 2018).
- **PD 3**: Teaching methods and student activities for Algebra and Geometry, relating to the Australian Curriculum strands of 'Number and Algebra' and 'Measurement and Geometry' (ACARA, 2018).
- **PD 4**: Teaching methods and student activities for Statistics and Probability, relating to the Australian Curriculum strand of 'Statistics and Probability' (ACARA, 2018).
- **PD 5**: The content was determined by the interests and requests of participants, with a focus on ensuring the sustainability of YDM methods in the schools and clusters after completion of the PRIME Futures program. The cluster-driven nature of this PD workshop resulted in variations in the content across clusters, demonstrated by the examples below.

In Cluster 1, during PD 5 the participants visited one of the secondary schools or one of the primary schools (depending on interest) to observe a YDM lesson.

In Cluster 4, the participants decided to travel to a YDM Centre for Excellence school located in Toowoomba to observe that school in action and meet with the teachers there. It included a presentation by the school's administration team, visits to classrooms across the school to see the program in action and discussions with the school's maths team about how they implemented YDM in their school.

In Cluster 5, at the request of the participants, there was a full day of Indigenous content and context. Teachers and principals met local experts and Elders at significant local Indigenous sites. They explained the significance of these sites and the links to the families still in the community.

In Cluster 6, a Project Officer for Aboriginal Education from the South Australian Department for Education examined and unpacked current departmental directives, programs and support for Indigenous students.

In Cluster 7, PD 5 included a sharing day where schools or individual teachers presented something they had done in their classrooms.

Within this broad framework, YDC cluster coordinators were free to determine how they would arrange the daily programs to meet the objectives of each PD workshop, taking into account the nature of the teachers and schools in their cluster, feedback from participants (both verbal and through the daily PD evaluation forms) and the cluster coordinators' own teaching styles. This resulted in slightly different PD formats in each cluster.

1.4.3 School visits

YDC practitioners visited each school participating in the PRIME Futures program four times to support the implementation of YDM in the school. Visits were scheduled at six-monthly intervals (in the alternate school terms to the PD workshops). The duration of each visit was a half or full day, depending on factors such as school preferences and travelling time between schools.

The school visits enabled the YDC practitioners to support and mentor the work of the teacher-trainers who had attended the PD workshops and were challenged to train the other mathematics teachers in the school in YDM methods. They provided an opportunity for the YDC practitioners to informally gather information about the implementation of the program in each school (practitioners prepared a report to YDC after each visit).

The schedule for a visit at any individual school was determined by the school. Time spent by practitioners during visits included but was not restricted to activities such as:

- meeting with principals and/or other key members of the leadership team
- meeting heads of departments (HoDs—secondary schools)
- meeting with the key teachers involved in the schools
- meeting with other support staff
- spending time with teachers in classrooms and providing feedback after lessons
- observing lessons
- demonstrating lesson (in part or whole).

A YDC Indigenous researcher also visited some schools in each cluster to assist in maintaining links with the local Indigenous community and to conduct interviews with representatives of those communities.

1.4.4 Resources

The PRIME Futures program involved an extensive time and cost commitment by schools and teachers. Although the YDC costs were met by the BHP Foundation through CSIRO, schools and teachers were asked to devote significant resources towards the PRIME Futures program.

Each school was required to bear the cost of their employees' absences from their usual duties to attend PD workshops. The 10–15 days of workshop time across two years for each participant teacher was a huge cost to schools. The cost for a replacement teacher for one day was approximately $400 at the start of the program. Therefore, a school sending four teachers to every workshop would be looking at a cost of $3200–$4800 per workshop or a total of $16,000–$24,000 over the two-year duration of the program (without allowing for salary increases or overnight accommodation in cases where teachers needed to travel several hours to the PD venue). In the experience of one YDC practitioner and former HoD in a large city secondary school, the school was allocated $10,000 per year for teacher relief, with any additional funds having to be found in other items of the school budget. The cost of replacing teachers attending the PDs prevented some schools from accepting the invitation to join the program.

Despite YDC delivering the training in geographical clusters, some teachers were required to travel for several hours to attend the PD workshops. Overnight accommodation would be required for some of these teachers. The cost of travel and accommodation was borne by the school. Attendance at the annual YDC Sharing Summit, while not an essential part of the PRIME Future program, was encouraged. This required travel to Brisbane and at least one night's accommodation. In many cases, teachers contributed to these costs from their own resources.

Teachers attending the PD workshops were asked to train the other mathematics teachers in YDM methods. The cost of this for the school could include releasing the teacher-trainers from their usual duties to observe lessons by other teachers and/or engage in team teaching, and the provision of time in staff meetings or on student-free days for training in YDM methods. Teacher-trainers also required time to prepare for meetings and/or demonstration lessons and to assist teachers in developing lesson plans.

11 The maths mat is a 10 × 6 grid (usually made of shade cloth and masking tape) that is large enough to be laid on the classroom floor and for students to stand in each section of the grid.

As an active pedagogy, YDM encourages teachers to use particular classroom teaching resources; for example, the maths mat.[11] Some schools dedicated sections of their grounds to YDM, incorporating grids painted on the paving and Indigenous artwork. Some of these resources are available commercially, others can be made by teachers and students. Storage of resources is also an issue for schools to consider. However, they all represent a cost for the school.

1.4.5 Overview of the 10 geographical clusters

A summary of the number of schools, teacher-trainers and students in each cluster is presented in Appendix E. Each cluster was different. Their characteristics are summarised below.

Cluster 1

Commenced in PRIME Futures program: Term 4, 2015

Geographical location: Emerald area, Central Queensland

Schools involved: The cluster initially comprised eight schools with about 2243 students of which 469 were from Indigenous backgrounds (21%, ranging from 8% to 100%). All but one school had previously been involved in other YDC projects; one of these schools chose to participate in the PRIME Futures program only intermittently. One small primary school (approximately 100 students) discontinued the program at the end of Term 2, 2016, due to a regional directive to focus on literacy, having attended two PD workshops and received one school visit.

The seven remaining schools in Cluster 1 consisted of three primary schools, three secondary schools and one P–10 campus, with about 2140 students of which 412 (19%) were from Indigenous backgrounds. With the exception of one school, all were Queensland Department of Education (i.e., government-operated) schools. The largest of the secondary schools had an enrolment of around 750 students, one had about 350 students, and the third a much smaller and more transient population of around 100 students. Two of the primary schools had enrolments of approximately 400 and 300, while the third primary school and the P–10 school were smaller with about 130 students each. These varying enrolment patterns alone meant the seven schools experienced quite different challenges in the implementation of the program.

Comments: Although there were three towns that had both a participating secondary school and a participating primary school, it cannot be said that the cluster consisted of secondary schools and their feeder schools. The original model for the program was based on this concept; however, some of the other primary schools in the area could not or chose not to participate in the program.

As the first to complete the PRIME Futures program, Cluster 1 teachers initiated and set up the closed Facebook group called 'YuMi Deadly Teacher Connect'. This group now has a membership of approximately 200 teachers from around Australia contributing inspiring posts to share their ideas with each other, and is helping to sustain YDM in all schools that have received training.

Cluster 2

Commenced in PRIME Futures program: Term 4, 2015

Geographical location: Townsville area, North Queensland

Schools involved: Cluster 2 initially comprised eight schools, but for school-related operational reasons one school changed to Cluster 3 in late 2016, having only attended the first Cluster 2 PD. The remaining seven schools comprised about 5214 students of which 1538 were from Indigenous backgrounds (29%, ranging from 20% to 100%). Three schools had previously been involved in other YDC projects; one of these schools chose to participate in the PRIME Futures program only intermittently.

The seven schools in Cluster 2 were in the south-western suburbs of Townsville. The group consisted of three primary schools, three secondary schools and one P–12 campus. Six of the schools were operated by the Queensland Department of Education.

Two secondary schools had around 800 students while the third had nearly 2000 students. Two of the primary schools had enrolments of approximately 500 while the third had approximately 150 students. Enrolments at the P–12 school varied considerably throughout the program. The differences in school size meant that the seven schools experienced quite different challenges in the implementation of the program.

Comments: Although close together geographically, the cluster did not comprise secondary schools and their feeder schools. The original model for the program was based on this concept; however, some of the feeder primary schools in the area did not meet the criteria for participation in the program.

The winner of the 2017 CSIRO Indigenous STEM Teacher Award was a participant in this cluster, and one of the secondary schools was a finalist for the 2018 CSIRO Indigenous STEM School Award.

Cluster 3

Commenced in PRIME Futures program: Term 3, 2016

Geographical location: Townsville area, North Queensland

Schools involved: Cluster 3 initially comprised six schools with 3171 students of which 530 were from Indigenous backgrounds (17%, ranging from 7% to 47%). For school operational reasons, one of the schools in Cluster 2 moved to Cluster 3 after having attended the first Cluster 2 PD workshop; therefore, it did not send participants to the first PD in Cluster 3. Two schools had previously been involved in other YDC projects. Two schools discontinued the program at the beginning of 2018 due to other commitments, having attended three PD workshops and received three school visits.

Comments: Cluster 3 was a unique and diverse cluster of schools. It was the only PRIME Futures cluster to include only two schools from within the state system, one primary and one secondary, while four schools were from the independent and Catholic sectors. The cluster had only one P–6 primary school and one P–10 school, with the remainder being secondary schools. Further diversity was created by one school being an all-girls boarding school, one school being a flexible learning centre (FLC) and one school being situated in a town approximately one hour's drive from Townsville. Consequently, the clientele of each of these schools differed greatly.

Cluster 4

Commenced in PRIME Futures program: Term 3, 2016

Geographical location: North Brisbane area, Queensland (although one school came from the South Brisbane area)

Schools involved: Cluster 4 initially comprised seven schools with 5673 students of which 741 were from Indigenous backgrounds (13%, ranging from 8% to 19%). Seven of the eight schools had previously been involved in other YDC projects. Two schools discontinued the program at the end of 2016 due to changes in the leadership team and other commitments, having attended the first PD workshop and received one school visit. The remaining six schools comprised two secondary schools with Years 7–12 enrolment and four primary schools with Years P–6 enrolment.

Comments: While the schools had been chosen as a cluster due to their location, only three of the schools worked within the same administrative region and only one of the primary schools operated as a feeder school to one of the secondary schools. This meant that the six schools were operating largely in isolation; therefore, systemic and regional directives often overshadowed or lessened the impact of participating teachers' efforts to implement the program successfully in their schools.

One of the secondary schools was unable to provide regular and continuous participants to attend the training. Consequently, over the life of the program, several different teachers attended only one or two days of training each. At the completion of training, only one teacher remained a participant from this school and this teacher had only attended three of the five PD workshops.

Two of the primary schools and remaining secondary school that provided ongoing staff for the training also took the opportunity to have some of their paraprofessional staff included in the training. The inclusion of these staff, who work across several classes and year levels in their schools, meant that a higher number of students were being given access to YDM pedagogy and teachings. Also, as these teacher aides or paraprofessionals often work with struggling or disengaged students, it was an opportunity to gauge if YDM would have an effect on the engagement and understandings of these students.

Cluster 5

Commenced in PRIME Futures program: Term 4, 2016

Geographical location: Port Lincoln, South Australia

Schools involved: Cluster 5 comprised eight schools with 2065 students of which 365 were from Indigenous backgrounds (18%, ranging from 9% to 73%). None of these schools had previously been involved in other YDC projects.

This cluster was unique in that all eight schools already operated as a partnership and were viewed as one group of connected schools. The cluster was made up of five primary schools, a high school, a community learning centre and a special school. One of the primary schools is a junior primary school catering for approximately 300 students from Reception (R) to Year 2, another of the primary schools caters for approximately 500

students from Years 3 to 7, while a third primary school caters for approximately 200 students from R to Year 7; these three schools are feeder schools for the high school, which caters for approximately 800 students across Years 8–12. The remaining two primary schools and the community learning centre are smaller schools of about 75 students each that have multi-age or composite classes. The special school (24 students) did not participate in the program as fully as the other schools throughout the two and a half years.

Comments: This cluster received the backing of the South Australian Department for Education in both support for this program and financial support for relief teachers to allow the teachers to attend. The three smaller schools only had only 4–6 teaching staff each so were unable to send four participants from each school. It was decided that if able, other larger schools could send more than four requested staff to each PD. As all PDs were held on campus at one of the larger primary schools, this school often had up to eight additional staff observing the PD but not directly participating. Members of the South Australian Department for Education also attended several of the PD workshops.

As the PRIME Futures program was unique in this area, there was a degree of media attention. A journalist and photographer from a local paper attended the first PD workshop and an article appeared in the local news. During the final PD, print, radio and the local television station conducted interviews with presenters and participants. This was featured on local television and radio and in the local press.

One of the teachers at the community learning centre was awarded South Australian Primary Teacher of the Year in 2017 for his work at the school, and one of the centre's students was a finalist for the 2018 Aboriginal and Torres Strait Islander Student Maths Award given by CSIRO.

Cluster 6

Commenced in PRIME Futures program: Term 4, 2016

Geographical location: North Adelaide area, South Australia

Schools involved: Cluster 6 comprised seven schools in the Para Hills and Flinders Park education districts of Adelaide with about 2773 students of which 457 were from Indigenous backgrounds (16%, ranging from 10% to 95%). None of the schools had participated in previous YDC projects.

The schools in this cluster were diverse both demographically and administratively. The seven schools were spread across a wide geographical area and were members of four different education partnerships. There were four primary schools catering for Reception (R) to Year 7 students, two secondary schools (Years 8–12) and an R–12 Aboriginal school. The Aboriginal school and one of the primary schools were small with under 100 enrolments each, while the other three primary schools were larger with enrolments ranging from about 250 to 550 students at the start of the program. One of the secondary schools had close to 1000 students, including boarding students in Years 8–10, while the other had about 500 students, including boarding students in Years 11–12. All the boarding students were from remote Aboriginal communities in South Australia, the Northern Territory and Western Australia and lived in a residential college located separately from the school campuses.

Comments: At the start of 2017, the smaller secondary school merged with the smallest primary school to become one R–12 school with a new name; however, they remained physically located on separate campuses and for the purposes of this report are referred to by separate pseudonyms in Chapters 3 and 4.

The diversity of the schools in terms of location, enrolment patterns, clientele and administration meant that the seven schools experienced a variety of challenges in implementing the program. During the two and a half years of program delivery, many changes both with staff and with school structures (such as the merger of two schools described above) impinged on the delivery and the uptake of the program throughout this cluster. The three schools in the Elizabeth partnership were the most successful with implementation; however, there was evidence of success to varying degrees in all schools.

Cluster 7

Commenced in PRIME Futures program: Term 2, 2017

Geographical location: Metropolitan and south-east Brisbane, Queensland

Schools involved: Cluster 7 comprised six schools with 4131 students of which 467 were from Indigenous backgrounds (11%, ranging from 9% to 33%). Three schools had previously been involved in other YDC projects.

The cluster consisted of one state primary school (Prep–Year 6), three state secondary schools (Years 7–12) and two FLCs. Two of the secondary schools had 600–800 students while the other was very large, with more than 2000 students. The primary school had an enrolment of approximately 450. The two FLCs are part of the Xavier Flexi Schools Network and cater for students aged 13–20 years in Years 7–12.

Comments: FLCs typically have relatively small enrolments (100–120 students). They work with (usually disadvantaged) young people who may have disengaged from mainstream education. Attendance may be infrequent. To cater for this clientele, FLCs particularly value and embrace variety in pedagogy.

The varying enrolment patterns and clientele of the six schools meant that they experienced different challenges in the implementation of the program.

One of the secondary schools in this cluster was a finalist for the CSIRO 2018 Indigenous STEM School Award.

Cluster 8

Commenced in PRIME Futures program: Term 2, 2017

Geographical location: Cairns area, Far North Queensland

Schools involved: Cluster 8 comprised eight schools with 5851 students of which 1887 were from Indigenous backgrounds (32%, ranging from 14% to 74%). None of these schools had previously been involved in YDC projects. One school withdrew from the program at the beginning of 2019, having attended four PD workshops and received three school visits.

Cluster 8 was a unique and diverse cluster of schools. It included two Catholic schools and six from the state system; there were two primary schools and six secondary schools. Further diversity was created by the inclusion of one boarding school and only two schools within the central Cairns area, with the rest being located in regional towns within an hour's drive of the Cairns CBD. The clientele of each of these schools also differed greatly with the percentage of Indigenous students varying widely.

Comments: Several students from schools in this cluster were finalists or winners of the Aboriginal and Torres Strait Islander Student Maths Award given as part of the overall CSIRO Indigenous STEM Education Project. In 2017, three students from one of the secondary schools were finalists with two winning the award, and in 2018, two students from another of the secondary schools won the award.

Cluster 9

Commenced in PRIME Futures program: Term 2, 2017

Geographical location: Geraldton area, central Western Australia

Schools involved: Cluster 9 initially comprised nine schools in the with a total of 3459 students of which 1309 (38%) were from Indigenous backgrounds. None of these schools had previously been involved in other YDC projects. All but one of the participating schools were located in the town of Geraldton and comprised five state primary schools (P–6) with enrolments ranging from approximately 150–500 students, two state secondary schools with enrolments of around 800 students each, and an FLC with approximately 70 students. The other school was P–12, located in a small community approximately 90 km from Geraldton and with approximately 100 students. Four primary schools withdrew from the project early in 2018 (see below) and the FLC also withdrew a little later. The remaining four schools were the two secondary schools, one primary school and the P–12 school and comprised 1988 students of which 741 were from Indigenous backgrounds (37%, ranging from 21% to 100%).

Comments: A group of four primary schools withdrew from the project early in 2018, having attended two PD workshops and received one school visit. This group already operated as a cluster and cited overlap between the PRIME Futures program and other programs already operating within their cluster as the reason for their withdrawal from PRIME Futures. The existing programs, being locally based and supported, were seen as being easier to sustain. The FLC withdrew from the program in Term 2, 2018, having only attended PD 2 and received two school visits, citing incompatibility of YDM with the commercially available package they were using in their teaching program.

At the start of the program, the two secondary schools were preparing for a significant change in enrolments. Initially structured as a Senior College (Years 10–12) and a Junior College (Years 7–9), both schools started a transition in 2018 to become 7–12 schools by 2020.

Cluster 10

Commenced in PRIME Futures program: Term 2, 2017

Geographical location: Albany area, southern Western Australia

Schools involved: Cluster 10 initially comprised eight schools, with 3080 students of which 410 were from Indigenous backgrounds (13%, ranging from 6% to 51%). One small school withdrew from the program in Term 4, 2017, after one PD and one school visit. The remaining seven schools comprised about 3017 students of which 378 were from Indigenous backgrounds (13%, ranging from 6% to 27%). None of the schools had previously been involved in other YDC projects.

Comments: Most of the Cluster 10 schools were situated in Albany or nearby towns, providing a relatively close-knit cluster community. Within Albany, there were three primary schools and one secondary school. These had enrolments ranging from about 350 to 550 students for the primary schools and 800 students for the secondary school. Three schools were located in communities surrounding Albany, one a small primary school with about 50 students, another catering for approximately 700 students from Prep to Year 12, and the third catered for approximately 150 students from Prep to Year 10.

The school that withdrew from the program gave two reasons. First, with four teachers attending the training, the entire teaching staff needed to be released, which was not feasible for such a small school. Second, the school had adopted the Explicit Direct Instruction (EDI) model as their mode of operation across the school. The principal was reluctant to completely change the teachers' ways of working, even though it was explained that the RAMR model could fit with EDI.

Cluster 10 was unique among the PRIME Futures clusters in providing a local network coordinator as a single point of contact for organising the PD workshops and liaising with the schools, which was very useful for administrative matters. For other matters, and to build relationships with schools and teachers, YDC staff liaised directly with principals and teachers at the school level. Also unique to this cluster was the role of the Department of Education Indigenous community engagement officer at the start of the program, who linked education and community very well. The ending of her role saw a marked change in the connections between school and community.

1.4.6 Cultural factors

There was considerable variation in the nature of the 75 schools that started the program. There were 37 primary schools, 26 secondary schools, seven schools with both primary and secondary year levels, four FLCs and one special school. Seven of the clusters (numbers 1, 2, 3, 5, 6, 7 and 8) were centred around regional centres (Emerald, Townsville and Cairns in Queensland, Port Lincoln in South Australia and Albany and Geraldton in Western Australia). The other three clusters were urban, located in the outer suburbs of Brisbane and Adelaide. Some clusters had to cope with the geographical dispersion of the schools within the cluster.

Some schools were large metropolitan schools, others served small rural communities. As mentioned, four of the schools were FLCs, supporting students who had not succeeded in mainstream education. Most schools were in the government sector, but there were also seven non-government schools in addition to the FLCs. Some schools had very large proportions of Indigenous students (in one school 100% of the students were from Indigenous backgrounds) and others relatively few. Four schools catered for residential (boarding) students.

At the beginning of the program, many schools already had well-developed links to their local Indigenous communities and employed community members within the school. Other schools had almost no contact with their local Indigenous community. Given the Indigenous focus of the CSIRO project generally, and the PRIME Futures program in particular, building links with the community was seen as an important aspect of the program. Where necessary, QUT practitioners assisted schools in building or strengthening those links. In some clusters, community members were interviewed as part of the data collected about the schools.

Sessions called 'Indigenous perspectives' were programmed as part of three of the five PD workshops and involved a YDC Indigenous researcher and members of the local Indigenous community. Participants were shown how to find information about the local Indigenous contexts and draw on them as the 'reality' part of the RAMR framework, and how to draw on local Indigenous resources. Teachers were encouraged to share their experiences and resources with each other.

The program did not treat students differently based on their cultural backgrounds. The focus was on good pedagogy, drawing on the shared culture and interests of all Australian students. Improving teacher capacity was seen as the way to improve outcomes for all students.

1.5 Summary

In this chapter, we have described the theoretical perspective of the mathematics pedagogy known as YuMi Deadly Maths (YDM) and how it was applied in the PRIME Futures program. The case study approach was outlined, followed by a detailed description of the professional development program and clusters that formed the PRIME Futures case.

Chapter 2 will present the outcomes of the PRIME Futures program for schools, teachers and students.

2 RESULTS

This chapter reports on the outcomes of the PRIME Futures program. It is based on analysis of the data collected by YDC. As previously described, data collection methods included workshop evaluation forms, biannual teacher and principal surveys (three or four surveys each), an exit survey for teachers and principals, and continuous teacher reflective journal entries. Data gathering instruments asked questions about the perceived quality and implementation of the program as well as perceived teacher and student outcomes.

With 75 schools involved in the program, the data is, of necessity, aggregated. Quantitative data is summarised in tables and graphs. Recurring themes in the qualitative data are presented, supported by examples, anecdotes and quotes. Where the data about individual schools and/or clusters reveals interesting departures from the norm, they have been highlighted in this chapter.

The results of the data collected for the case study have been organised thematically into five sections, as follows:

- **Professional development workshops**. This section presents mainly quantitative data about attendance at the PD workshops and qualitative data about the participants' views on the effectiveness of those workshops, expressed in the workshop evaluation forms and the teachers' reflective journals. It also represents the views of the YDC cluster coordinators about the PD workshops and the information they obtained during their school visits.
- **Indigenous perspectives and community engagement**. This section combines information collected from several sources: the PD workshop programs, resources, discussions and evaluation forms; YDC cluster coordinators' observations and interviews with school principals and teachers during their school visits; interviews with local Indigenous community members; survey responses by school principals and teachers to questions relating to the engagement of the local Indigenous community and the use of Indigenous contexts in their teaching; and comments from the teachers' reflective journals.
- **Teacher capacity**. This section reports on changes in the perceived abilities, skills and expertise in mathematics of teachers as classroom practitioners as a result of their involvement in the PRIME Futures program. Data about teaching capacity was collected through the online biannual and exit surveys and from teacher reflective journals.
- **Program implementation**. This section reports on YDM implementation in two stages: teachers' use of YDM in their own practice and the training of other teachers in the school in YDM. The section combines information collected from several sources: survey responses by school principals and teachers to questions relating to program implementation; teachers' reflective journals; and YDC cluster coordinators' observations and interviews with school principals and teachers during their school visits.
- **Student outcomes**. This section reports on changes in student engagement and achievement. The data presented were collected through the online biannual and exit surveys and from teacher reflective journals and reports from the cluster coordinators.

Cluster coordinators' reports were an important source of information for this chapter. They were based on:

- the coordinators' own observations and discussions with school principals and teachers during PD workshops and school visits
- presentations, conversations and comments by participants during PD workshops
- the teacher reflective journal entries for that cluster, all of which were read and responded to by the relevant cluster coordinator
- telephone conversations with, and emails from, participants throughout the program.

Cluster coordinators were able to provide examples and vignettes to support their conclusions. Many of these are presented in text boxes throughout the chapter.

2.1 Professional development workshops

2.1.1 Attendance

Table 2.1 and Table 2.2 summarise attendance by teachers and school leaders at PD workshops throughout the program. Total attendance over five PD workshops of two to three days each was 425 teachers and 39 principals/deputy principals. These tables count the number of different individuals attending one or more PD workshops, not the aggregate attendance at all workshops.

Table 2.1 shows the attendance by cluster for all 75 schools that participated in the program at some stage, as well as for the 62 schools that completed the program. Only 59 teachers (14% or 16%, respectively) attended all five PDs, while 161 teachers in the 75 schools (38%) or 134 teachers in the 62 schools (35%) attended only one PD. However, 47 of those who attended only one PD were new teachers invited to attend PD 5 for an introduction to the YDM pedagogy. Removing these 47 teachers from the totals brings the percentage who attended only one PD down to 30% or 26%, respectively.

Table 2.1 Number of PD workshops attended by teachers

NO. OF PDS ATTENDED	CLUSTER										TOTAL 1–10	%
	1	2	3	4	5	6	7	8	9	10		
One	28	21	8	15	11	8	19	18	8	25	161	38%
Two	9	4	2	1	7	11	3	16	14	2	69	16%
Three	3	10	11	7	6	7	4	7	1	3	59	14%
Four	11	8	2	10	11	3	10	6	6	10	77	18%
Five	1	4	2	7	9	9	8	5	3	11	59	14%
Totals (75 schools)	**52**	**47**	**25**	**40**	**44**	**38**	**44**	**52**	**32**	**51**	**425**	**100%**
One	24	21	4	8	11	8	19	16	2	21	134	35%
Two	8	4	2	1	7	11	3	15	3	2	56	15%
Three	3	10	7	7	6	7	4	7	1	3	55	15%
Four	11	8	2	10	11	3	10	4	6	10	75	20%
Five	1	4	2	7	9	9	8	5	3	11	59	16%
Totals (62 schools)	**47**	**47**	**17**	**33**	**44**	**38**	**44**	**47**	**15**	**47**	**379**	**100%**

Note. Across the life of the PRIME Futures program, 12 schools altogether in Clusters 1, 3, 4, 8, 9 and 10 withdrew and two schools in Cluster 6 amalgamated into one school (see Appendix D for further details).

The PD workshops were designed with the expectation that the same teachers would attend each workshop, so the content of each PD was developed to build on the previous one. When cluster coordinators became aware that the expected continuity of attendance was not occurring, they modified the workshop content so that each PD would stand alone.

School principals were invited to attend for one day of two of the five PD workshops, and 31 of them attended Day 1 of PD 1. In some cases, principals nominated a deputy principal to take their place, and this is included in Table 2.2. Table 2.2 shows that few principals or deputies attended for more than one day. However, cluster coordinators reported that in some cases, other school managers such as curriculum coordinators or heads of mathematics attended either as participants or in place of the school principal. Accordingly, Table 2.2 probably understates the number of school leaders involved in the program.

2.1.2 Feedback from teachers

Workshop evaluation forms

Participants were asked to complete written evaluation forms at the end of each day of PD, rating each of the three sessions per day. Almost all the participants did so. Participants rated each PD session on a five-point scale (1 = not useful; 5 = very useful). The mean rating for each PD workshop in each cluster is shown in Table 2.3, together with the number of participants according to the sign-on sheets. The overall weighted average across Clusters 1–10 was 4.22. Table 2.3 shows that the participants' ratings were remarkably consistent, both across PD workshops and across clusters. PD 5, where the participants had input into the nature of the sessions offered, was rated most highly on average at 4.42. However, it should be noted that the attendance at PD 5 in some clusters was much lower than for the other PD workshops.

Table 2.2 Number of PD workshops attended by school principals/deputy principals

NO. OF PDS ATTENDED	CLUSTER										TOTAL
	1	2	3	4	5	6	7	8	9	10	1–10
One	1	3	0	4	4	3	2	4	4	6	31
Two	2	0	0	0	0	0	0	0	0	1	3
Three	0	0	0	1	0	0	0	0	0	0	1
Four	0	0	0	0	1	0	0	0	0	1	2
Five	0	0	0	0	2	0	0	0	0	0	2
Total	**3**	**3**	**0**	**5**	**7**	**3**	**2**	**4**	**4**	**8**	**39**

Table 2.3 Average rating of PD workshops by participants

PD		CLUSTER										WEIGHTED AVERAGE AVERAGE
		1 (N=6)	2 (N=5)	3 (N=1)	4 (N=4)	5 (N=6)	6 (N=1)	7 (N=4)	8 (N=5)	9 (N=2)	10 (N=7)	1–10 (N=41)
1	Rating	4.35	4.11	4.03	4.26	3.92	4.35	4.10	4.13	3.68	4.36	4.13
	No.	31	31	16	37	35	25	28	36	31	34	304
2	Rating	3.86	4.00	4.33	4.22	4.17	4.08	4.18	3.92	3.87	4.33	4.08
	No.	23	30	15	25	34	25	22	30	25	24	253
3	Rating	3.97	4.24	3.99	4.04	3.93	4.40	4.31	4.29	4.42	4.28	4.17
	No.	19	23	18	26	34	24	22	25	12	23	226
4	Rating	3.96	3.91	4.35	4.14	4.23	4.52	4.33	4.40	4.46	4.55	4.28
	No.	18	21	7	23	24	20	23	18	10	25	189
5	Rating	4.37	4.75	4.81	4.49	4.09	4.63	4.48	4.66	4.26	4.29	4.42
	No.	18	9	7	9	23	17	24	15	4	39	165
Cluster average		4.10	4.20	4.30	4.23	4.07	4.40	4.28	4.28	4.14	4.36	4.22
Total participants		55	50	25	45	51	41	46	56	36	59	464

Notes. Rating scale: 1 = not useful; 5 = very useful. The final column is a weighted average, adjusting for the different number of participants in each cluster. The total number of participants for each cluster is the number of different individuals (principals and teachers) who attended at least one day of one PD workshop.

Participants were also asked to comment on the usefulness of the sessions each day. There was a diversity of opinions: many aspects that some teachers found most useful others found least useful or vice versa, suggesting that the ratings were influenced by the individual needs and circumstances of each participant.

In some cases, PD 5 involved visits to schools to observe lessons and/or additional sessions on Indigenous content and context. These sessions were very highly rated.

Participants were also given the opportunity to comment on the usefulness of sessions and suggestions for improvement. Many participants noted that their confidence in teaching mathematics had grown. Reasons mentioned for this included:

- assurance of being 'on the right track'
- ways of making maths more relevant to students and improving student understanding
- greater understanding/knowledge of pedagogy and strategies
- explaining/transitioning between different representations and pedagogical models
- increased understanding of mathematical concepts and connections between those concepts
- ability to see the 'big picture'
- more ideas for games and activities to enhance teaching
- links to reality
- the simplicity of approaches
- excitement, inspiration, motivation
- increased ability to support colleagues in YDM implementation.

One out-of-field teacher mentioned that he did not gain confidence because he realised what he did not know.

Suggestions for improvement included:

- requests for information on how to incorporate YDM into EDI (from Queensland schools only)
- further clarification of RAMR
- more hands-on/demonstrations
- working in smaller groups
- more information on the links between 'traditional' assessment and the YDM program
- providing opportunities for school leaders to share thoughts/contexts
- providing a list of materials and/or more handouts
- to speak louder and repeat instructions.

Some participants found the introduction sessions about YDM dry, were overwhelmed by the amount of information and 'lots of talk', and were confused by some presentations.

Some participants stated that they wanted the content to focus more on their level of teaching (i.e., primary school or secondary school). YDC coordinators responded by modifying later PD programs to include sessions that split concepts into earlier and later understandings (see Section 2.1.3).

Teacher reflective journals

Some teachers chose to comment about the PD workshops in their reflective journal. The comments in this section are typical of many about the PD workshops from teachers in all clusters.

Teachers appreciated the quality of the PD workshops for inspiring and improving their mathematical understanding and teaching skills:

- *Totally inspired. Makes me a better teacher. Makes me enjoy teaching again. Gives me a purpose. Allows me to better provide lessons that actually provide a broad scope of learning opportunity.* [Teacher 97, School 7B]
- *The workshops highlighted the required progression in maths and the importance of the basics, which has transferred into our teaching.* [Teacher 7, School 2B]

Many teachers stated that the workshops had inspired them to change their teaching approach:

- *Having now attended 9 days' worth of YuMi Deadly Maths PD, I now feel like I have a better idea of the approach … I know my maths teaching has improved and my students' learning has improved because of it.* [Teacher 87, School 4E]
- *The YDM [workshops] are fabulous. Every time I participate in one I feel my understandings of mathematical concepts deepening. I am finding better ways to teach my students and therefore feel like they are making greater gains in their learning. They have been instrumental in changing the way I teach each mathematical concept.* [Teacher 14, School 4A]
- *After attending the first session of PD … I have had nothing but positive experiences. I have enjoyed learning more about how to teach maths, learning how we can actually confuse students with the 'compromises' we make to just get students to understand the level of maths we are teaching for that grade/year. I have always loved incorporating hands-on resources, but I have struggled to transition students past the need to use these resources as a crutch. The workshops have presented an opportunity for me to see how this happens.* [Teacher 24, School 4B]

Teachers appreciated the ideas that they could incorporate in their own teaching and/or take back to their schools:

- *The workshop has consolidated my knowledge about embedding YuMi Deadly Maths into my program and given me lots of practical resource ideas to take back to the classroom.* [Teacher 40, School 4E]
- *I have made a box of resources inspired by the PD and I love getting it out and trying new things with my students.* [Teacher 36, School 4F]
- *YDM workshops are a great resource to get ideas from. These are all in the books but having them completed practically sparks the idea in a teacher's mind and shows that even complex activities can be completed quite simply.* [Teacher 116, School 1D]
- *The workshops we have completed have helped me to think outside the square and teach more hands-on/whole-body activities. Some of the fluency activities I do already link in very well with YuMi … I have reflected and found a lot of my teaching was with hands-on activities. From doing the training and implementing this pedagogy I have found the whole-body activities to be very successful and they encourage lots of discussion and mathematical reasoning … YuMi has allowed me to embed student interest and reality into my planning for teaching.* [Teacher 66, School 6D]
- *They [YDM workshops] are great—hands-on and lots of ideas that we can take back to school. The resources are cheap and easy and ideal for our context.* [Teacher 99, School 7A]
- *The Elders and Aunties were so open, inviting and humble. An inspiring PD. I can see so many ways I will embed the knowledge I gained today into my lessons for many KLAs.* [Teacher 30, School 4F]

Many teachers were enthusiastic about how the workshops would enable them to engage their students in mathematics:

- *I really enjoyed the workshops … and love the way YuMi allows us to engage our students with the hand, body and mind.* [Teacher 26, School 4E]

- *I feel that the YDM workshops made me think differently about the way I would engage students and plan my lessons. … I have enjoyed exploring the various options for abstraction stages. I have utilised the number mats quite a bit, which were fantastic and flexible (flexible in the way that they could be used across many different topics).* [Teacher 103, School 7A]

- *The workshops have been invaluable. They have helped me be more flexible in my teaching style, keeping in mind the big ideas. I have used many ideas from the workshops, some great activities.* [Teacher 106, School 10A]

Some teachers enjoyed the opportunity provided by the PD workshops to interact with colleagues from other schools:

- *[re workshops] Very useful to spend time with primary school teachers as we are 'isolated' from each other and the understanding I gained of how they need to teach will help me in 'filling gaps' in understandings of my older students.* [Teacher 80, School 4H]

- *It's always great to spend time with teachers from other schools and see how they have interpreted and are implementing YuMi.* [Teacher 62, School 2B]

- *The workshops have been invaluable and I have loved interacting with other teachers in discussing what has worked and not worked in their approaches. Teacher interaction on successful RAMR lessons is essential to ensure [the] transfer of ideas and improvement in teaching. This not only assists the teachers but also gets ideas flowing about what other areas of maths the approach might suit.* [Teacher 5, School 2A]

Some teachers commented on the value of the YDC Sharing Summit:

- *Our involvement in the Summit was great. It reignited our passion in this area and gave us ideas and questions we need to explore with our team.* [Teacher 28, School 4A]

- *Attended YuMi Sharing Summit—useful to see how other schools are implementing YuMi and get some more great ideas for activities.* [Teacher 30, School 4F]

2.1.3 YDC cluster coordinator reports

In each cluster, the PD workshops were coordinated by a single YDC practitioner (an experienced teacher of mathematics at either the primary or secondary level), designated as the cluster coordinator. Every attempt was made to ensure the cluster coordinator was present at every PD workshop (an occasional substitution was needed as a result of the unavoidable absence of the cluster coordinator). The cluster coordinator was supported by at least one other YDC practitioner. There was more variation in the second practitioner to accommodate YDC workload and staffing requirements. In every case, the YDC practitioners were experienced teachers with a track record of excellence in mathematics teaching. Where possible, the combination of practitioners at each workshop had both secondary and primary expertise. An Indigenous YDC researcher conducted the sessions focused on Indigenous perspectives and community engagement. This section is a distillation of the comments made by the coordinators of the 10 clusters about the PD workshops.

There was a feeling by some participants that the program should have been conducted as separate primary and secondary workshops. The YDM teaching approach encourages teachers to look back at early concepts and be aware of possible learning experiences to rectify gaps in student knowledge. Similarly, teachers are encouraged to look forward to future concepts to ensure early concepts are presented in a way that promotes successful future learning. When explained to them, most (but not all) participants accepted this approach and were appreciative of the strategies presented. However, cluster coordinators also addressed this issue by splitting some PD sessions into 'early understandings' and 'later understandings' rather than a strict primary/secondary divide. In some cases, primary teachers chose to attend the later understandings sessions and vice versa, to see YDM from a different perspective.

It has already been noted that there was considerable variation among the 10 clusters. Some clusters had to cope with the geographical dispersion of the teachers.

In Cluster 1, the schools were spread out across the cluster's geographical area, located in four different towns with travel time of approximately four hours between them. This led to difficult choices over which schools should host the PD workshops to enable equity of access for the participants.

The schools in Cluster 6 were diverse geographically. In an effort to meet the geographical needs of the schools and to build a homogenous group for this cluster it was decided, by the cluster, to hold the PD workshops at various school campuses rather than the government Professional Development Centre (as initially planned). This proved beneficial and was a strength of the delivery.

A further challenge for small regional schools was the difficulty in finding relief staff to replace teachers attending PD workshops. This made it difficult for the schools to send as many teachers to the PD as they wished. In some clusters, schools showed great commitment to the program, as having many teachers attending 10–15 days of PD across two years meant that all of the area's relief teacher pool was required and the teachers remaining at school were required to take additional classes.

The extended duration of the PRIME Futures program had a significant impact on teacher participation at PD workshops. Teacher transfers, relocations and extended leave all had an impact on the continuity of teacher participation. Some schools in Clusters 1 and 2 did not want to attend PD 1, held in November 2015,[12] because they wanted to involve the new cohort of teachers expected to arrive at the beginning of the following year. This was accommodated in Cluster 1 by repeating PD 1 in February 2016 for the schools that had not attended the previous year.

The high cost of a school's participation in the PD program has already been described in Section 1.4.4. A school in Cluster 3 was initially enthusiastic about YDM, with extensive plans to embed YDM into teaching and learning plans evident in the initial visits. However, the school withdrew from the program before it ended, citing the additional costs and staff unavailability as the reason.

The scheduling of some PD workshops coincided with busy times in the assessment calendar, particularly for secondary schools. This was unfortunate, but in some cases, it was difficult to select a time that suited both primary and secondary participants and other YDC scheduling commitments. The teachers from participating secondary schools should be acknowledged for their commitment to the program at those times.

Conflicting priorities within schools also influenced teacher participation. In some cases, the schools chose to share the PD opportunities among their teachers by deliberately nominating different teachers to attend each of the five PD workshops. This affected continuity and left the new participants feeling they had missed out on the basics as, in the opinion of one cluster coordinator, it takes at least two PD workshops to become familiar with the approach and materials. The result in some cases was attendance by teachers who were not well-chosen for the task.

Some teachers participated in the PD sessions for themselves but did not transfer that knowledge to either use those skills in their classrooms or share with other staff.

One secondary school sent many different participants to the PD; this meant that most trainees only attended one or two PD workshops in total. In the later stages it was agreed that the staff chosen for the training were possibly not the best fit as they did not have the flexibility in their program and curriculum to include the necessary components of YDM. However, after some negotiation this school did send along two teachers who worked specifically with Aboriginal students.

12 The contract with CSIRO required that the program commence during Term 4, 2015.

The selection of staff for programs such as PRIME Futures is a vital component for successful implementation, as the teacher-trainers not only have to be willing to take on the additional load of learning new skills, internalising and then using these skills but must also be willing to impart this knowledge to others with a passion and vigour that encourages others to step outside their safe zone. YDC practitioners reported that for schools to maximise the value of their investment in PRIME Futures the school management needed to consider carefully which staff should attend the PD training. School leaders often chose young and inexperienced teachers to attend the PD rather than those who were well established in the school and able to make a difference by initiating change. Not only are younger, inexperienced teachers less able to initiate change, they are more likely to move on from the school, with the resulting loss to the school of the resources expended on those teachers.

All the participating teachers faced considerable pressures from the need to manage their normal school commitments during their absence. Teacher attendance at a two-day or three-day PD workshop demands significant preparation for the classes during their absence. The commitment of schools and teachers to attending these workshops provides an indication of how the program was valued.

These factors meant that there was considerable turnover of participants at the various PD workshops in most clusters. Despite this, it is evident from the other data gathered about the program that teachers found the YDM pedagogy—particularly the RAMR framework and its emphasis on kinaesthetic learning—a valuable teaching approach, and that their students responded positively to the pedagogy. The other data is presented in the later sections of this chapter.

2.1.4 Summary

The PRIME Futures workshops were well-received by participants, with high average ratings of all PD sessions—in between 'useful' and 'very useful'. There were many enthusiastic comments on workshop evaluation forms and in the teachers' reflective journals. Teachers appreciated the quality of the PD workshops, commenting that the workshops had led to improvements in their mathematical understanding and teaching skills and had inspired them to change their teaching approach. Teachers appreciated the ideas that they could incorporate in their own teaching and/or take back to their schools and were enthusiastic about how the workshops would enable them to engage their students in mathematics. Some teachers enjoyed the opportunity provided by the PD workshops to interact with colleagues from other schools.

YDC cluster coordinators reported that some teachers would have preferred more focus on the year levels that they taught. Coordinators also identified some issues that, in their opinion, diminished the effectiveness of the PD sessions. They included:

- the geographical dispersion of some of the clusters
- the type of teachers selected to train as teacher-trainers
- the difficulty of replacing teachers attending the workshops (both the unavailability and the high cost of relief teachers)
- a lack of continuity of workshop attendees
- school schedules and priorities that conflicted with the objectives of the PRIME Futures program.

These results are discussed in more detail in Section 3.1.

2.2 Indigenous perspectives and community engagement

The PRIME Futures program targeted 75 schools in regional or outer urban areas of Australia. Given the Indigenous focus of the program, one of the selection criteria for the inclusion of schools in the program was relatively high Indigenous enrolments. Accordingly, Indigenous students comprised 22% of enrolments of schools in the program (see Appendix E), compared to a national average in 2017 of 5.6%. Several schools catered almost exclusively for Indigenous students. This included state government schools in Queensland, South Australia and Western Australia with almost 100% Indigenous enrolments, a Catholic boarding school in Queensland, and two secondary schools in Adelaide (South Australia) that catered for students from a residential college housing Indigenous students from remote communities in South Australia, the Northern Territory and Western Australia.

This section draws together the information collected about the Indigenous elements of the PRIME Futures program. It starts with information about the Indigenous sessions conducted at the PD workshops, then discusses data collected from school visits, interviews and surveys about engagement with the local Indigenous community. Since PRIME Futures training has included the use of Indigenous contexts as a way of engaging students, the section also examines changes in teachers' use of Indigenous contexts in their teaching. Finally, it presents some information about the engagement of Indigenous students.

2.2.1 PD sessions relating to Indigenous perspectives

The PD workshops included three sessions on Indigenous perspectives and community engagement conducted by an Indigenous YDC researcher, Associate Professor Grace Sarra. These sessions were often supported by local Indigenous community Elders. The three sessions were titled:

- Perceptual Positioning
- Big picture—Hidden Histories
- Engoori.

Perceptual Positioning

This short introductory session was usually undertaken early in PD 1. In some clusters, local and traditional Indigenous Elders and community members who had been invited to open the workshop stayed on to co-present and support the session. The purpose of the session was for teachers and school groups to look at the current practices in their school. Participants analysed what they see, feel and hear at their school in response to the questions 'How are you embedding Indigenous perspectives in your school?' and 'How are you supporting Indigenous community access and input into your school?' using a Y chart. As part of this process, participants were introduced to the concept of *Perceptual Positioning* (a model for collaboration used by the Stronger Smarter Institute, https://strongersmarter.com.au/) where participants consider a situation from three perspectives:

- P1—what I think, feel and believe in a particular situation
- P2—what the other person thinks, feels and believes in that situation
- P3—what is happening for the group, by examining the individuals and their patterns of interactions and responses (both enabling and disabling).

Teachers identified the things their schools were doing well and the things that could or should be improved and then shared these with the group. The ensuing discussions focused on developing cultural change within the school and its community and the best practice in embedding Indigenous perspectives in classrooms and schools. Working in school groups, teachers left this session with a plan that involved supporting current practices and extending practices in their schools.

In the workshop evaluations, many participants chose to include comments about this session. Many enjoyed the session and found it informative:

- *Loved the Indigenous presenter's info, knowledge and real-life experiences could have listened to her all day.*
- *Loved the Perceptual Positioning.*
- *Indigenous Perspectives was interesting to discuss how schools believe it impacts the community.*
- *It was good to place Indigenous Perspectives early to keep it in our mind.*
- *The cultural competencies was [sic] crucial.*

- *Enjoyed the Y chart bringing it back to school relevance.*
- *Welcomed the opportunity to examine Indigenous perspectives in relation to my personal and school 'habits'.*
- *Indigenous perspectives session was great, especially talking in school groups.*
- *Indigenous perspectives was thought-provoking and initiated useful discussions.*
- *During [the] talk one of the men gave an example of how the Yarrabah groups 'shared' the dugong and how this concept of 'sharing' is different to ours. More real-life examples like this in regard to the Indigenous students would be good.*
- *I enjoyed [the] presentation and focus on why we change perspective and how it is that we can be culturally aware.*
- *Served as a good reminder to seek information and support my Indigenous students.*

Several participants nominated the session as the most useful of the day:

- *[The] session was engaging and relevant.*
- *Indigenous perspectives looking at different ways we can connect, understand and build relationships.*
- *Indigenous perspectives, heard things I didn't know.*
- *The importance of community and using this to understand the practices 'realities'.*
- *Indigenous perspective in developing an understanding and partnership.*
- *Indigenous perspectives—the 'white' perspective of math.*

Some participants did not find the session relevant:

- *Indigenous perspectives not useful, as we only have a handful of Indigenous students in our school, so they make up a very small minority.*
- *Indigenous perspectives is difficult to get right due to the differences in experience and relationships, interesting to discuss cultural differences—family relationships.*
- *Indigenous perspective was not specific enough.*
- *Indigenous perspective was not related specifically to our Noongar people.*

Others made suggestions for improvement:

- *Would have liked to have seen a more supportive environment to discuss and ask questions on Indigenous perspectives.*
- *Indigenous perspective was too theoretical, it needs to be more clear direction as to what the schools should aspire to achieve.*
- *More on how Indigenous students may apply these perspectives to their learning.*
- *Indigenous perspectives, would prefer more clarity on strategies, ideas and real-life connections.*
- *Needed to be improved—Perspectives could have been more active, possible examples of Indigenous perspectives, what might it look like, was dry and could have been more hands-on, was not active.*

Finally, some teachers felt that the focus of the session could have been extended to other disadvantaged groups:

- Main difficulty lies with teaching disadvantaged students, not necessarily Indigenous students.
- Cultural perspectives interesting but singling out ATSI people may be ignoring other peoples, all eye-opening, particularly how we can become more welcoming to Indigenous parents.

Big Picture—Hidden Histories

Increasing knowledge among school staff of Aboriginal and Torres Strait Islander cultures and histories is an important part of improving learning outcomes for Indigenous students. Accordingly, a PD session on Indigenous history was presented in all clusters using a set of eight posters that covered a timeline from Pre-contact to Contemporary times (Queensland Department of Education, 2014). It looked at the history of Australia from an Aboriginal and Torres Strait Islander perspective, presenting an account of the impact of policy implementation on Indigenous people. It considered the ongoing generational trauma that Indigenous people live with and how this may affect relationships, educational issues and community engagement. Local Indigenous Elders often attended this session to give a local perspective.

However, the posters had also been used throughout Queensland as a professional development program for schools, teachers and other staff called 'Crossing Cultures—Hidden History' (Queensland Department of Education, 2014). While some of the Queensland

teachers had undertaken the training previously, there were still a significant number who were unfamiliar with many of the historical references. These posters were then used to examine the mathematics that could be drawn from each poster's symbols and history; for example, timelines, balance and population.

In the workshop evaluations, many participants commented on the Indigenous history session. Some teachers found the session valuable:

- *I found the Indigenous history very interesting.*
- *Indigenous perspectives gave great reasons why.*
- *I valued the group discussion about Indigenous perspectives.*
- *Very insightful, Indigenous perspectives led by Grace was very informative and the Elders were experts in their field.*
- *For me the Indigenous perspectives and community engagement was an eye-opener as I am fairly new to the county.*
- *ATSI[13] [sic] perspective gives us a greater understanding of background for our kids.*
- *Indigenous perspective really useful, extremely helpful and inspiring.*
- *Most useful session was the Indigenous perspectives.*
- *Highly useful the Indigenous perspectives and community engagement.*
- *Indigenous perspectives, they need to come to our school to share this.*
- *The Indigenous session provided knowledge and understanding to apply perspective in the classroom, interested in doing further PD on this.*
- *Embedding Indigenous perspectives was extremely helpful.*
- *Indigenous perspectives excellent, however very thought-provoking hence draining extremely tiring afternoon.*
- *Indigenous perspectives was a wake-up call.*
- *Community engagement, Indigenous perspectives gave clear information about culture and ideas.*
- *Indigenous perspectives [was most useful] as I can use this and unpacking it was useful.*
- *Was extremely informative and relevant. Instructors had an abundance of knowledge.*
- *Indigenous perspectives and community engagement excellent examples using artefacts.*
- *I thoroughly enjoyed the Indigenous perspective unit, it was good to think outside the box about the connections we can make.*
- *Really enjoyed [the] session, very informative.*
- *Liked all the sessions but the Indigenous perspectives suits me well.*

Many teachers appreciated and enjoyed learning more about Indigenous history:

- *History of Indigenous culture and different thinking were valuable.*
- *Most useful were the Indigenous history poster section.*
- *I liked the posters and the Qld perspective.*
- *A great insight into Aboriginal perspectives (the sadness shown when confronted by history).*

Some teachers commented on the usefulness of the posters:

- *Embedding Indigenous perspectives was very useful. The posters were very interesting as a resource. Presenter was great.*
- *The Indigenous posters were an interesting activity to understand the links between history and mathematics.*
- *The posters used in this session were amazing and the discussion that came from the process was really collaborative. Having Jack [local Indigenous worker and Elder] there really helped the process.*

Other teachers enjoyed the links to mathematics:

- *Learning about Indigenous perspectives and thinking about how I can incorporate it into maths.*
- *Like the connections with local stories and maths [as they] are relevant to my year level at school.*
- *Loved the session on Indigenous history and looking at the mathematics in the images.*

However, some teachers could not see how they might use the information in their teaching:

- *Our school has a low number of Indigenous students and I couldn't see how I could use Indigenous history in maths, how would we implement the posters in our schools?*
- *Was interesting—hard to bring ideas to math.*

13 Aboriginal and/or Torres Strait Islander

- *Already knew lots of the Indigenous perspectives stuff, the Indigenous session was full of information that everyone should know, but didn't give us any insights into how to use that in the classroom.*
- *I felt the cultural session was good but too much focusing on the ART this would have been more valuable if the activities were based around these topics.*
- *This session on 'Aboriginal paintings' felt like unnecessary.*

Several Queensland teachers commented that they had attended similar sessions in the past:

- *The Indigenous session is something I have done many times, very good but when you have already done it? Indigenous session was more a history lesson and not a practical connection to teaching Aboriginal students.*
- *Indigenous perspective covered before in other PDs and while linked to students' perceptions, was not math specific. I have done the Indigenous perspectives many times.*
- *Have done this 3 years in a row.*
- *Found Indigenous perspective superfluous.*
- *Indigenous session [was least useful] as we have done Crossing Cultures at other PDs.*

The posters and the discussions were not meant to relate directly to teaching in the classroom, but were used more generally in three ways:

- to give the participants an understanding of how past events can still impinge on Aboriginal and Torres Strait Islanders' interactions, mindset and ability when dealing with authority figures and institutions in the present day
- to draw out mathematical concepts
- to encourage participants to seek out and use local artefacts to create relevant teaching resources that include Aboriginal and Torres Strait Islander perspectives.

The posters and the symbols used to represent significant events in Indigenous history were useful in stimulating discussion and informing those who may have had a limited understanding of past events. From the participants' comments, there appears to be a consensus that the posters used in this PD session were relevant in giving an insight into the history of Indigenous peoples in this country.

Engoori

The final PD session used Engoori processes. Engoori is an Indigenous strength-based approach, which acknowledges that having a conversation with structure, purpose and process is often the most powerful action that can take be taken when dealing with complex challenges (Murri Matters Pty Ltd, 2014a). Historically, Engoori was used as a method of diplomacy between conflicting ideologies and groups. It was a set of diplomatic protocols to create and maintain robust challenging cultures that embrace diversity to enable forward progress with challenging issues. The Engoori story belongs to 'Tjimpa' of the Mithaka people of south-west Queensland. The Engoori processes used in an educational context were developed by Scott Gorringe and David Spillman. It is a key element of the Stronger Smarter Leadership Program (Stronger Smarter Institute, n.d.). According to Gorringe's website:

> *Engoori offers ways [for teachers] to challenge their assumptions as well as those of others in well-structured conversations. This will enable teachers to engage effectively and positively with peer-based feedback that enables reflective practices for deeper professional learning. Engoori processes enable the teacher to also enhance children's social and emotional wellbeing in order to foster productive learning environments and reduce behaviour management.* (Murri Matters Pty Ltd, 2014b, para. 3)

Working in school groups, participants were invited to prepare charts as a framework for interactive discussion, analysis and reflection. The discussions focused on their schools' actions in four dimensions: (a) organisational culture and environment, (b) Indigenous leadership, (c) community engagement, and (d) teaching and learning. Within those dimensions, participants were asked to consider three questions:

- Who are we?
- What patterns, behaviours and practices do we need to change?
- What behaviours do we need to embed?

Fifty-three charts were prepared across the 10 clusters and were analysed thematically using nVivo software. Figure 2.1 summarises the key ideas (i.e., ideas that were mentioned by five or more schools; the numbers in brackets indicate how many schools mentioned the idea). The data in Figure 2.1 suggests that many schools had some measures in place to acknowledge and include Indigenous perspectives in their teaching programs, personnel, community engagement and other school activities. However, the responses to the third question (*What behaviours do we need to embed?*) suggests that there is scope for improvement.

ORGANISATIONAL CULTURE AND ENVIRONMENT

Who we are

- Principal/school leadership stable (9)
- High staff turnover (5)
- Indigenous teachers, aides or liaison officers (11)
- Indigenous culture is part of school culture (30)
- Diverse cultures (34)
- Specialised educational programs (16)
- Care beyond school (8)
- Students have behavioural and social needs (15)

What we need to change

- Pedagogies, consistency across classes/year levels, collaboration between staff (6)
- Communication (6)
- Cultural inclusivity (15)
- Increase students' cultural awareness through use of visible symbols (5)
- Focus on attendance, behaviour, punctuality (18)

What we need to embed

- Positive school culture and attitudes, high expectations (9)
- Teacher awareness and support of Indigenous issues (12)
- Sustainable embedded programs to support Indigenous students and culture (9)
- Greater involvement of Indigenous students (6)

COMMUNITY ENGAGEMENT

Who we are

- Visits from community groups (27)
- Indigenous celebrations, activities, excursions (24)
- Specialised school programs for students (37)
- Involvement of Elders, community members, parent groups (23)
- Indigenous teacher aides and staff (7)
- Communication with parents and mentors (8)

What we need to change

- School programs to support students and community (12)
- Support from community-based external professionals (8)
- Parental and family involvement in the school (30)
- Elder involvement in the school (6)
- Parent reference group, stronger connections with parents, Indigenous aides (10)
- Increase cultural celebrations and visits (6)

What we need to embed

- Community events (19)
- Access to Elders, community members, events, past students (21)
- Teachers engaging with community (6)

INDIGENOUS LEADERSHIP

Who we are

- Leadership, staff, HoD of ATSI perspectives (9)
- Teacher aides, specialist Indigenous advisers (23)
- Indigenous student leaders: school captain, student leaders, cultural captains (20)
- Indigenous community leaders/role models (17)
- Indigenous programs (14)
- Formal celebration and acknowledgement of Indigenous people (5)
- Common voice, valued knowledge (9)

What we need to change

- More Indigenous staff/access to Indigenous advisers (11)
- More leadership roles for Indigenous students (17)
- Increase links between school and community (14)

What we need to embed

- Increased networking with community leaders (6)
- Increased ownership and involvement of Indigenous students and community in school programs and activities (14)
- Promote inclusivity, resilience, high expectations (5)

TEACHING AND LEARNING

Who we are

- School culture: strong and inclusive (10)
- Specialised school programs (17)
- Pedagogies (29)
- Resources (9)
- Support for students (6)
- Learning wall (tracking individual student progress) (5)
- Curriculum change (13)
- Indigenous perspectives embedded elsewhere in the school (5)

What we need to change

- Staff beliefs, deficit models (5)
- Indigenous consultation (6)
- Peer teachers, mentors, access to local Elders (6)
- Pedagogy (8)
- Resources (9)
- Flexibility with planning/curriculum (8)
- Embed Indigenous perspectives better/consistently (21)
- Positive disposition for maths (5)
- Provision for transient students (5)

What we need to embed

- YDM: teacher buy-in and consistency, new staff induction/ sustainability (10)
- Planning time and expectations, integrated curriculum, marry different mathematical pedagogies (14)
- Collaborative learning, resources, hands-on maths in secondary, participate in YDM (20)

Figure 2.1 Summary of Engoori charts developed by PD participants in all clusters

Other PD activities

In Clusters 5, 6 and 10 the PD sessions included a 'walk on country' or other cultural experience facilitated by the local Indigenous Elders.

Examples of cultural experiences

- In PD 5 of Cluster 5 (Port Lincoln), teachers and principals met at significant local Indigenous sites with experts and Elders who explained the significance of these sites and the links to the families still within the schools and community. Teachers visited the Poonindie Mission and church, the Wombat Pit, the fish-traps, Port Lincoln Aboriginal Co-op and other places.
- In PD 4 of Cluster 6 (Adelaide) the community members from the Anangu Pitjantjatjara Yankunytjatjara Lands cooked kangaroo tail and shared their experiences with participants, which not only gave them an enriching experience but also a point of reference when planning units and maths experiences to embed Indigenous perspectives.

The feedback from these sessions commented on how useful it was, and they received high ratings on the evaluation forms.

In the South Australian clusters, teachers were given information about current South Australian Department for Education directives, programs and resources to embed programs with Indigenous perspectives and support Indigenous students.

Clusters 5 and 6 chose to devote a part of PD 5 to Indigenous perspectives.

2.2.2 School visits and interviews with community members

Implementation plans for the PRIME Futures program indicated an intention to develop active and productive partnerships with parents/caregivers and the community. The Engoori process showed that many schools in the program already had strong links to their local Indigenous community. The teacher aides employed in the schools were often from that community and provided a continuity within the school that is not possible with the more transient teachers posted to schools from elsewhere. Many of the schools employed, or had access to, Indigenous community engagement officers. Their roles (and position titles) varied from school to school, depending on the nature of the school and the local area. In many of the clusters, these coordinators were interviewed by the Indigenous YDC researcher. The following list of activities undertaken within the schools was prepared from those interviews:

- promoting a cultural awareness framework, including educating teachers and students about:
  - the Indigenous history of the local area
  - special features of the local area
  - the local language
  - Indigenous arts and crafts
  - how Indigenous people use maths and science
- fostering links between the school and the local Indigenous community
- building trusting relationships with students
- supporting teachers in the classroom to deliver lessons based on Indigenous perspectives
- supporting teachers by bringing together parents, students and teachers to deal with issues; for example, misbehaviour
- cross-referencing resources
- PD training with staff
- fostering links with other schools.

Interviewees also detailed the types of activities that some schools engaged in:

- Elders' advisory committee
- bush food gardening projects
- homework centre and playgroup involving the local Indigenous community
- Indigenous art projects
- Elders' storytelling talks
- celebrating NAIDOC and other significant Indigenous events at the school.

Interviews were conducted with 13 community representatives in eight clusters. Most of them held positions in the schools or school authority, such as teacher aides, teachers or Indigenous support workers. One was a teacher of Year 9 mathematics. The 13 people interviewed all described general programs in their schools and regions that aim to improve outcomes for Indigenous students, supporting them and their families, and assisting teachers to understand the Indigenous culture. However, most of the interviews revealed that, although generally aware of the PRIME Futures program in the school, they did not know much about YDM. Some had seen YDM lessons in action (mainly from a distance) and commented on the success of the hands-on nature of the teaching for Indigenous students. However, except for those who had attended YDM training, few had detailed knowledge of the program. They had rarely been called upon to assist teachers with Indigenous contexts for teaching mathematics.

An exception occurred in a Cluster 6 school.

Interview with an Aboriginal Education Officer (AEO) from one of the Cluster 6 schools

The AEO mentioned that the PRIME Futures program was successfully promoted and implemented in the school. Together with students, she was invited to attend in-school workshops that were delivered by YDM-trained teachers. The AEO elaborated on the increased engagement, enjoyment and improved achievement of students in mathematics through links to reality, intercultural and hands-on approaches to mathematics learning and teaching. She explained that the maths was linked to woodwork or cooking and students excelled in STEM subjects. The AEO mentioned that teachers were very committed to several STEM programs that the school was involved with. One aim was increased integration of Indigenous perspectives in the curriculum.

Notwithstanding these initiatives, YDC practitioners visiting the schools reported that in some schools there was still scope to strengthen the links between YDM and these existing programs. Sometimes teachers saw the existing whole-school programs as sufficient and did not see the need to develop classroom activities that incorporated the local Indigenous culture. Consequently, there was little connection between the school programs and classroom activities in their schools.

Indigenous parents can be reluctant to talk to teachers to offer help in putting their culture up front and helping teachers to understand why their students see things from a different perspective. In the same way, most teachers could visit cultural or significant celebrations, but choose not to. However, classroom activities do not necessarily need to be based on ‘traditional’ Indigenous culture.

In some regional and remote communities, it was observed by YDC practitioners that sport is very popular in the local Indigenous community and draws the community together. For example, as Australian Rules football has widespread support in rural and remote Australia, YDC practitioners observed that one school in Western Australia used programs based on the game as a way of engaging Indigenous students. Similarly, the local popularity of Johnathan Thurston, an Indigenous man who captained the North Queensland Cowboys Rugby League team based in Townsville, meant that classroom activities based on Rugby League were highly engaging for students in North Queensland, both Indigenous and non-Indigenous. These examples demonstrate that activities do not need to be based on ‘traditional’ Indigenous culture to promote community or Indigenous student engagement.

It was evident in some schools that there was little or no inclusivity of the local Indigenous community and culture. Some teachers lacked knowledge of and were unwilling to participate in, anything relating to Indigenous culture, despite the strong Indigenous history of their region. Often this was justified by stating that they did not have any Indigenous students in their class or school:

Indigenous perspectives not useful, as we only have a handful of Indigenous students in our school, so they make up a very small minority. [Anonymous comment on PD evaluation form from a teacher in Cluster 1]

When teachers are planning lessons, it is difficult to incorporate Indigenous perspectives without strong links to, and knowledge of, the culture of the local community. Indigenous students are the most readily available source of such knowledge within the classroom. YDC practitioners have observed teachers' willingness to capitalise when issues are raised by the Indigenous students in their class and this is to be commended.

The following secondary school lesson on ratios and rates provides an example of a teacher's willingness to capitalise on an issue that arose in the classroom. The lesson was planned using the school orchard to investigate the rate of fruit per tree and so on. An Indigenous student also collected 'bush tucker' from native trees adjacent to the orchard. Much of the bush tucker was damaged by animals/pests, so the teacher quickly adapted the lesson to look at ratios of usable versus non-usable fruit in a randomly collected sample of bush tucker, then extended the lesson to look at the amount of fruit required to make a kilogram of 'bush tucker' jam. Students then used ratios to determine the amount of fruit that needed to be collected to ensure sufficient usable fruit for the amount of jam required.

Teachers from several schools in Cluster 4 drew from the PD sessions on Indigenous perspectives to develop lessons that incorporated Indigenous content as a reality for the lesson. For example, a lesson about angles used Indigenous weaving and basket making as the stimulus. After this lesson was shared with other participants, other schools within the cluster used that lesson.

The YDM approach promotes a culture within a class that is more likely to encourage Indigenous students to share examples from within their culture on which the teacher can build meaningful experiences.

2.2.3 Support of the local Indigenous community

Results from the biannual principal surveys show that the school principals perceived that PRIME Futures had minimal impact on the support from the local Aboriginal and Torres Strait Islander community for their school's activities, with the average level of influence rated between 'very little' and 'somewhat' (see Table 2.4).

Table 2.4 Principal perceptions of support from the local Aboriginal and Torres Strait Islander community (biannual surveys)

HOW HAS THE **PRIME FUTURES** PROGRAM INFLUENCED THE SUPPORT OF THE LOCAL ABORIGINAL AND TORRES STRAIT ISLANDER COMMUNITY FOR THE SCHOOL'S ACTIVITIES?											
	CLUSTER										AVERAGE
	1 (N=25)	2 (N=24)	3 (N=12)	4 (N=16)	5 (N=19)	6 (N=13)	7 (N=11)	8 (N=18)	9 (N=17)	10 (N=21)	1–10 (N=157)
Support for increased school attendance	1.70	1.20	2.20	1.31	1.15	1.38	1.44	1.20	0.79	1.31	1.34
Support for the school's mathematics program	2.20	1.90	2.42	1.81	1.57	1.92	1.56	1.53	1.76	2.18	1.87
Support for teaching ATSI knowledge to students	2.00	1.60	2.25	1.94	1.60	1.54	1.50	1.53	1.79	2.29	1.78

Note. Rating scale: 0 = not at all; 1 = very little; 2 = somewhat; 3 = moderately; 4 = extensively. Four biannual surveys in Clusters 1–4; three biannual surveys in Clusters 5–10. For consistency, the Clusters 1–10 column excludes the fourth survey results from Clusters 1–4 (n = 19 responses).

These biannual survey results are supported by the exit survey, which used retrospective pre-post methods to show that, in general, school principals observed only a small increase in support from the local Aboriginal and Torres Strait Islander community for their school's activities since the PRIME Futures program commenced (see Table 2.5 and Figure 2.2).

However, the small increase is on a very low base, representing a change in support from 'very little' to 'somewhat'. While there is some variation between clusters, caution should be exercised in interpreting data based on a small number of responses. The aggregated figures for all clusters (n = 41) may be more reliable.

Table 2.5 Principal perceptions of support from the local Aboriginal and Torres Strait Islander community (exit survey)

HOW HAS YOUR SCHOOL BEEN SUPPORTED BY THE LOCAL ABORIGINAL AND TORRES STRAIT ISLANDER COMMUNITY FOR THE SCHOOL'S ACTIVITIES **BEFORE** AND **AFTER** YOUR SCHOOL'S PARTICIPATION IN THE PRIME FUTURES PROGRAM?												
		CLUSTER										AVERAGE
		1 (N=6)	2 (N=5)	3 (N=1)	4 (N=4)	5 (N=6)	6 (N=1)	7 (N=4)	8 (N=5)	9 (N=2)	10 (N=7)	1–10 (N=41)
Support for increased school attendance	Before	1.50	1.80	3.00	1.00	1.40	3.00	2.25	1.20	2.50	2.43	1.82
	After	1.80	2.00	4.00	1.50	1.40	3.00	2.50	1.20	3.00	3.00	2.10
	Difference	**0.30**	**0.20**	**1.00**	**0.50**	**0.00**	**0.00**	**0.25**	**0.00**	**0.50**	**0.57**	**0.28**
Support for the school's mathematics program	Before	1.80	0.80	3.00	1.00	1.00	2.00	1.75	0.80	3.00	1.57	1.34
	After	2.50	1.20	4.00	1.50	1.20	2.00	2.25	1.00	3.00	2.43	1.82
	Difference	**0.70**	**0.40**	**1.00**	**0.50**	**0.20**	**0.00**	**0.50**	**0.20**	**0.00**	**0.86**	**0.48**
Support for teaching ATSI knowledge to students	Before	1.80	2.40	3.00	1.25	1.20	1.00	2.00	1.40	2.50	2.43	1.87
	After	2.50	2.40	3.00	2.00	1.40	1.00	2.75	1.80	3.00	2.43	2.21
	Difference	**0.70**	**0.00**	**0.00**	**0.75**	**0.20**	**0.00**	**0.75**	**0.40**	**0.50**	**0.00**	**0.34**

Note. Rating scale: 0 = not at all; 1 = very little; 2 = somewhat; 3 = moderately; 4 = extensively.

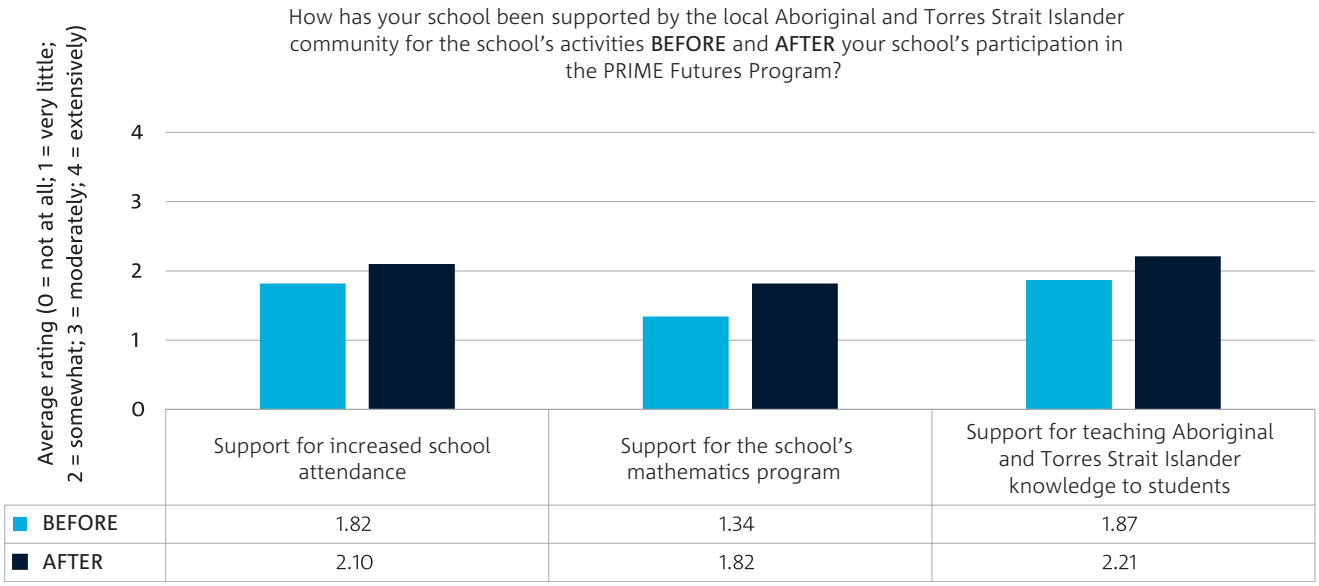


Figure 2.2 Principal perceptions of support from the local Aboriginal and Torres Strait Islander community (exit survey; n = 41)

2.2.4 Teacher knowledge and use of Indigenous contexts

Teachers have shared information about their use of Indigenous contexts in their teaching, both through responses to survey questions and in their reflective journals.

Teacher and principal surveys

Some of the teacher and principal surveys that investigated teachers' use of YDM methods included prompts about the use of Indigenous contexts as part of a broader question. Responses to those parts of the questions have been extracted and amalgamated in this section. However, these results have also been included in the tables in later sections so that the full context of the survey questions can be understood.

Table 2.6 shows that teachers initially rated their knowledge about the local Indigenous culture and community before the program commenced as between 'poor' and 'satisfactory'. Ratings at the end of the program show that participation in the program, involving up to three workshop sessions on Indigenous perspectives, has generally improved their knowledge of local Indigenous culture and community.

These results are confirmed by responses to another survey question (see Table 2.7), in which an average of 18% of teachers identified a lack of information about the local Indigenous culture and community as one of the obstacles to adopting YDM methods.

Table 2.6 Teacher knowledge of local Indigenous culture and community (exit survey)

RATE YOUR KNOWLEDGE OF THE LOCAL INDIGENOUS CULTURE AND COMMUNITY **BEFORE** AND **AFTER** YOUR PARTICIPATION IN THE PROGRAM											
	CLUSTER										AVERAGE
	1 (N=9)	2 (N=11)	3 (N=3)	4 (N=21)	5 (N=15)	6 (N=22)	7 (N=10)	8 (N=10)	9 (N=5)	10 (N=19)	1–10 (N=125)
Before	1.20	2.00	2.00	1.48	2.33	2.00	1.50	2.20	2.00	2.16	1.90
After	2.10	2.70	2.33	2.52	2.93	2.71	2.30	2.60	3.00	2.84	2.65
Difference	**0.90**	**0.70**	**0.33**	**1.04**	**0.60**	**0.71**	**0.80**	**0.40**	**1.00**	**0.68**	**0.75**

Note. Rating scale 0 = very poor; 1 = poor; 2 = satisfactory; 3 = good; 4 = excellent.

Table 2.7 Teacher knowledge of Indigenous contexts (biannual surveys)

WHAT OBSTACLES HAVE YOU ENCOUNTERED IN USING THE YDM APPROACH IN YOUR CLASSROOM?											
	CLUSTER										AVERAGE
	1 (N=61)	2 (N=68)	3 (N=30)	4 (N=85)	5 (N=54)	6 (N=51)	7 (N=43)	8 (N=35)	9 (N=21)	10 (N=43)	1–10 (N=441)
I lack information about the local Indigenous culture and community	23%	15%	20%	19%	28%	25%	30%	6%	5%	7%	18%

Note. Four biannual surveys in Clusters 1–4; three biannual surveys in Clusters 5–10. For consistency, the Clusters 1–10 column excludes the fourth survey results from Clusters 1–4 (n = 50 responses).

The results suggesting a lack of teacher knowledge are mirrored by a similar exit survey question that asked teachers about their pedagogical use of Indigenous contexts, with results showing their usage ranged from 'very little' to 'moderate' (see Table 2.8).

Table 2.8 Teacher use of Indigenous contexts in their mathematics classroom (exit survey)

TO WHAT EXTENT HAVE YOU USED THE FOLLOWING IN THE TEACHING OF MATHEMATICS **BEFORE** AND **AFTER** YOUR PARTICIPATION IN THE PROGRAM?												
		CLUSTER										AVERAGE
		1 (N=9)	2 (N=11)	3 (N=3)	4 (N=21)	5 (N=15)	6 (N=22)	7 (N=10)	8 (N=10)	9 (N=5)	10 (N=19)	1–10 (N=125)
Indigenous contexts	Before	0.90	1.60	1.00	0.90	1.60	1.27	1.20	1.70	1.20	1.11	1.25
	After	1.90	2.60	2.00	2.33	2.87	2.59	2.30	2.50	3.20	2.26	2.50
	Difference	**1.00**	**1.00**	**1.00**	**1.43**	**1.27**	**1.32**	**1.10**	**0.80**	**2.00**	**1.15**	**1.25**

Note. Rating scale: 0=not at all; 1= very little; 2=somewhat; 3=moderately; 4=extensively.

However, it is encouraging to see that, on average, the use of Indigenous contexts had doubled as a result of participation in the program (see Table 2.8) and that 38% of teachers had attempted to use some Indigenous contexts in their teaching (see Table 2.9).

Table 2.9 Teacher use of Indigenous contexts in their mathematics classroom (biannual surveys)

HOW HAVE YOU APPLIED THE YDM APPROACH IN YOUR MATHEMATICS CLASSROOM?											
	CLUSTER										AVERAGE
	1 (N=61)	2 (N=69)	3 (N=30)	4 (N=86)	5 (N=54)	6 (N=51)	7 (N=43)	8 (N=35)	9 (N=21)	10 (N=43)	1–10 (N=444)
I have used some Indigenous contexts	33%	35%	10%	29%	69%	45%	37%	40%	52%	30%	38%

Note. Four biannual surveys in Clusters 1–4; three biannual surveys in Clusters 5–10. For consistency, the Clusters 1–10 column excludes the fourth survey results from Clusters 1–4 (n = 49 responses).

Table 2.10 confirms that teachers and school principals largely agreed about the extent to which the program had improved teachers' capacity to use Indigenous contexts in their mathematics classroom, with an average rating just under 'moderately' for both cohorts.

Table 2.10 Teacher capacity to use Indigenous contexts in their mathematics classroom (biannual and exit surveys)

TO WHAT EXTENT HAS THE **PRIME** FUTURES PROGRAM IMPROVED CAPACITY TO TEACH MATHEMATICS WITH REGARD TO INDIGENOUS KNOWLEDGE?											
	CLUSTER										AVERAGE
	1	2	3	4	5	6	7	8	9	10	1–10
Principals' perceptions	2.60	2.50	3.00	2.60	2.64	2.93	2.79	2.23	3.00	3.04	2.73
No. of responses	n=31	n=29	n=13	n=20	n=25	n=16	n=14	n=23	n=19	n=28	n=200
Teachers' perceptions	2.30	3.00	2.20	2.77	2.53	2.95	3.10	3.10	3.75	2.95	2.85
No. of responses	n=21	n=25	n=5	n=43	n=15	n=22	n=10	n=10	n=4	n=19	n=124

Note. Rating scale: 0 = not at all; 1 = very little; 2 = somewhat; 3 = moderately; 4 = extensively. Five principal surveys in Clusters 1–4 (four biannual and one exit), four principal surveys in Clusters 5–10 (three biannual and one exit); two teacher surveys (fourth biannual and exit surveys) in Clusters 1–4, exit survey only in Clusters 5–10. For consistency, the Clusters 1–10 column excludes the fourth biannual principal (n = 18 responses) and teacher (n = 50 responses) survey results from Clusters 1–4.

Teacher reflective journals

Many teachers described the inclusion of Indigenous perspectives in their lessons and as a focus at staff meetings. Teachers were drawing on the expertise of Indigenous staff members such as teacher aides to assist them:

- *Asked our [Indigenous] teacher aide to support our Maths Program—providing her with our units and then each week asking her to do a specific activity. She worked with Indigenous students in small groups.* [Teacher 18, School 4C]
- *Teacher aide with [a] background in embedding Indigenous perspectives and Indigenous program facilitation assisted with real-life money and shopping activities … included Aboriginal and Torres Strait Islander perspectives within numerous activities, not all Math … invited Indigenous guests to tell stories and used Indigenous texts.* [Teacher 49, School 4C]
- *I asked parents to explain to me what it was like for them when they went to school and what they would like for their child to explore with maths. I had parents of Aboriginal children come in and do some maths with my kids. We did this outdoor and the kids responded well.* [Teacher 26, School 4E]
- *We have allocated a series of local area Indigenous perspectives across year levels so that our students increase their exposure to [the] local context in learning.* [Teacher 34, School 4F]
- *At our next staff meeting, it is around Aboriginal perspectives, which is an area that our teachers say they need more work in.* [Teacher 28, School 4A]
- *I am not in a teaching role with students … My role is only working with the educators and leaders … connect teachers and leaders across schools to share their learning and build capacity and expertise … Increasing the connections to Aboriginal and Torres Strait Islander perspectives is a commitment to action for many … school sites have held a staff meeting with a particular emphasis on the Aboriginal and Torres Strait Islander perspectives with 3 sites having the support of their Aboriginal Education teachers and Aboriginal Community Education Officers leading the meeting.* [Teacher 121, School 5C]

Some teachers described how they have included Indigenous perspectives in their lessons:

- *… different perspectives of tracking time. It gave me the chance to talk about how in Western culture (our culture), we tend to calculate time in a linear fashion … I liked to be able to show my students through my knowledge of Indigenous culture that there are other ways to view time, that the Indigenous Australian concept of time is more cyclical and more accurate due to taking cues of right times by looking at other environmental factors.* [Teacher 24, School 4B]
- *Year 6: Taught a series of lessons on angles incorporating Indigenous stories and artwork. Lessons were held outside and were hands-on.* [Teacher 30, School 4F]
- *I have included Aboriginal and TSI [sic] perspectives through the use of natural resources and environment, group learning situations, involving older Indigenous students and through creating relevancy for the children, i.e. relating what they are learning about to their worlds and to our community.* [Teacher 38, School 4G]
- *We included Aboriginal and Torres Strait Islander text as part of the statistics assessment where students compare letter frequencies for the same text in different languages.* [Teacher 5, School 2A]
- *Discussed when in the real world people might measure with their body, this led to [Indigenous language] words for body parts. Students then found things around the school, particularly in the natural environment, to measure with their body and then with metric measurements. Students … created a poster using English, [the Indigenous language] and mathematical language to describe what was measured.* [Teacher 126, School 10D]
- *Tried integrating some Aboriginal perspective … Some of the things I did were simple changes of the names and languages used in problems. I used problems that involved nature and environment rather than focusing on cities and businesses. Here are some examples I did: Changing [the] setting of problems to rivers, fishing, desert, hunting, animals from the usual textbook-style questions. Using speeds of animals such as kangaroos instead of cars. Coordinates and locations are rivers, trees, rocks instead of streets and buildings etc.* [Teacher 60, School 6A]
- *Shared some possible ATSI curriculum links to shape in our 4/5 class. Suggested looking into shapes, patterns, symmetry and the story used in ATSI artworks and provided the symbols that can be replicated to create student artworks and convey meaning … Invested time and money into the production of reusable items.* [Teacher 42, School 5A]
- *When looking at shapes around the school we viewed several of the Aboriginal paintings that are on display within our school, students discussed some of the different shapes that they could view within the pictures this also elicited comments about patterns they could see as well as counting skills … We are working with our AET to give our students more of a [Indigenous] perspective and understanding of the land.* [Teacher 64, School 6C]
- *My co-teacher is wanting to incorporate more Indigenous perspectives throughout all teaching and we are both identifying and sharing with each other what we can [do] that have an Indigenous perspective.* [Teacher 64, School 6C]

Involving the local Indigenous community was mentioned as a challenge by some teachers:

- *Indigenous perspectives: This is an area that we need to look more into … we need to involve our community more. I think we need to talk with other schools about how they have made sure they have done this properly and respectfully … Crossing Cultures: I believe this is an area we need to work more on.* [Teacher 28, School 4A]
- *It has been difficult to get perspectives from Aboriginal and Torres Strait Islander local peoples.* [Teacher 83, School 3A]

2.2.5 Indigenous student engagement and achievement

Principal surveys

The data in Table 2.11, which is based on exit surveys of school principals, suggests there was an improvement in the engagement and achievement of Indigenous students during the period of the school's engagement with the PRIME Futures program.

Table 2.11 Principal perceptions of improved Indigenous student engagement/achievement in mathematics (exit survey)

PLEASE GIVE YOUR OPINION ON THE EXTENT OF INDIGENOUS STUDENT ENGAGEMENT/ACHIEVEMENT IN MATHEMATICS **BEFORE** AND **AFTER** YOUR SCHOOL'S PARTICIPATION IN THE PROGRAM.												
		CLUSTER										AVERAGE
		1 (N=6)	2 (N=5)	3 (N=1)	4 (N=4)	5 (N=6)	6 (N=2)	7 (N=4)	8 (N=5)	9 (N=2)	10 (N=7)	1–10 (N=42)
Indigenous student engagement in mathematics	Before	1.80	1.80	2.00	2.00	1.83	1.50	1.00	1.40	2.00	1.86	1.71
	After	3.00	2.60	3.00	2.75	3.00	2.00	2.50	1.80	3.00	2.71	2.64
	Difference	**1.20**	**0.80**	**1.00**	**0.75**	**1.17**	**0.50**	**1.50**	**0.40**	**1.00**	**0.85**	**0.93**
Indigenous student achievement in mathematics	Before	1.60	1.40	2.00	1.50	1.67	1.00	1.00	1.60	1.50	1.29	1.40
	After	2.80	2.00	3.00	2.25	2.50	2.00	1.75	2.00	2.00	2.14	2.19
	Difference	**1.20**	**0.60**	**1.00**	**0.75**	**0.83**	**1.00**	**0.75**	**0.40**	**0.50**	**0.85**	**0.79**

Note. Rating scale 0 = very poor; 1 = poor; 2 = satisfactory; 3 = good; 4 = excellent.

Teacher reflective journals

Teachers reported that the use of Indigenous perspectives had a beneficial effect on their Indigenous students:

- *The integration of Aboriginal perspective to my lessons had a great impact in my teaching. Aboriginal students were more responsive to questions/tasks. Students were also more involved in discussions.* [Teacher 60, School 6A]
- *This approach has seen my ATSI students shine. I love how confident they have become. Through connecting learning with their home context they can see its relevance so much more. In the past, I think my ATSI students were engaging mainly just to please me. Now I see their excitement and it's so obvious that that was the case. Recently in a visiting Dance workshop, one of the boys said to me halfway through a dance routine 'Hey Mrs …, this is a repeating pattern, eh? Just like in maths?'. Body Hands and Mind. Yay!* [Teacher 77, School 5E]
- *In taking the YuMi Deadly Maths we've [been] doing for our whole body, we were doing a lot of things the Indigenous students might be accustomed to … The students were really good in coming up with their own stories. I came up with the barge one [barge could only take 20 people and there was 25] and they were like 'aww Miss sometimes one of my families mum or dad catches the barge and they go and get groceries on the mainland'. … So they could understand how that would relate. … It's just been great to see the Indigenous students so engaged. … And a lot of the time they're giving the answers because they're listening, they're engaged they've got some connection to it so they're more willing to give the answers to it.* [Teacher 10, School 1B]
- *I have always started lessons and/or topics with the reality of the content and will continue to do this. … I used images of nature to discuss reflectional symmetry. … Students actually led a discussion about how Aboriginal art often has symmetry patterns repeated throughout. … Students were very respectful during these conversations and found that it was actually interesting how some patterns are repeated within an Aboriginal painting.* [Teacher 52, School 1C]
- *Indigenous students require definite procedures and outcomes that can be easily seen. They need to see success within a couple of minutes or their interest will be lost. Having marks on a line of where to place something will work because they have somewhere to place it. Just having a continuum and placing probability events that are open to interpretation will not work as they had no definite place to put each piece of paper.* [Teacher 116, School 1D]
- *When we were looking at … time … we discussed how Aboriginal people look at seasons differently and use the sun to tell them the time of day, a different measure of how time is used.* [Teacher 128, School 10D]

My Flip the Fish Lesson was a full RAMR cycle over 1 singular lesson, set in Week 1 of a new unit. The lesson objective was for students to understand 3 types of transformations and early understandings of properties of shape size, angle, side length. I taught this lesson to Year 8 … In planning this RAMR lesson I started with the Body and Hand, then the Mind and Maths moments. Planning for incorporating the Indigenous perspective I considered the terms FLIP, SLIDE and TURN and how they applied to my reality. For me, Flip made me think of flipping pancakes which led me to do a google search under the term Indigenous Cooking Methods. On U-Tube [sic] I found I quickly came across the cooking a mullet video. Perfect! From there I took concepts mentioned or visually represented in the cooking a fish over the fire and embedded them with the Body activity. I was able to embed the concept of cooking a mullet in the Indigenous method by using the dot painting of the fish as my shape for Flips, Slides and Turn on the mat which was the class Cartesian Plane. The reflection at the end of the lesson allowed students to view the video once more but this time viewing it to identify the flip and slide, both mathematical concepts.

I asked an Indigenous student the following day. What did you think of the lesson yesterday? His reply, '*Good Miss*'. I asked again, '*Why was it good?*' He responded simply with, '*It had Indigenous stuff*' and he was smiling as he shared this with me. … When I use Indigenous perspectives and students become mildly disruptive, other students and Indigenous students have made the firm statement 'Respect the culture' as a way of saying listen up, be respectful. I believe the idea of respecting culture resonates with other cultures in the classroom and students pull themselves into line. Master stroke! [Teacher 97, School 7B]

- *Year 6: Taught a series of lessons on angles incorporating Indigenous stories and artwork. Lessons were held outside and were hands-on. It was so incredibly engaging and collaborative. … She [prac student] incorporated yarning circles at the beginning and end of math lessons, referred to beetles and bugs as an intro to a chance and data lesson and incorporated more hands-on activities instead of worksheets into her lessons. … She couldn't believe how well the students responded to this activity and how engaged they all were!* [Teacher 30, School 4F]
- *I have found that kinaesthetic activities in particular are beneficial for our Indigenous students.* [Teacher 47, School 1C]

2.2.6 YDC cluster coordinator reports

YDC cluster coordinators reported that teachers attending the PD were professional in their approach to the workshops, actively participating in the activities and supporting and cooperating with the presenters. However, feedback indicated the Indigenous cultural sessions produced some strong reactions in a small number of teachers, especially in Cluster 1 (Emerald). These reactions were either positive or negative, depending on the teachers' exposure to these issues. Conversely, in Cluster 4 (Brisbane North) these sessions were welcomed by the teachers, who perhaps had not had as much opportunity to investigate these areas as may have occurred in some of the more regional clusters. In many clusters, teachers sought additional learning about Indigenous perspectives, leading to the inclusion of additional sessions on Indigenous perspectives in PD 5.

In Cluster 10 (Albany, Western Australia) a Department of Education Indigenous community engagement officer was working within the cluster when the PRIME Futures program started. The YDC cluster coordinator commented that she did a fantastic job of ensuring the Albany schools were involved with Indigenous perspectives and ways

of learning, providing a valuable bridge between the community and the schools. She was very supportive of the program, and the Indigenous community in Albany is also very supportive of education in general. It was disappointing that, after the first two PD workshops, government funding cuts for education resulted in the 11 Indigenous engagement officers employed across the state being made redundant, which severed the easy connection between the community and the schools.

2.2.7 Summary

The results presented in this section reveal that:

- The teacher-trainers generally appreciated the PD sessions on Indigenous perspectives and found them enjoyable, useful and informative. In a few cases, the sessions produced some strong reactions, both positive and negative, depending on the teachers' perspectives.
- Many of the schools had access to Indigenous community engagement officers to assist in areas such as local Indigenous knowledge, working with Indigenous students and classroom support, as needed. Of those officers interviewed, most had heard of the PRIME Futures program, but few had been actively involved in the program.
- In many cases, principals and teacher-trainers believed that the school did not receive meaningful support from the local Indigenous community. Further, while the PRIME Futures program had resulted in an increase in the level of that support, the change was minimal.
- The PRIME Futures program did result in an increase in teachers' knowledge of local Indigenous culture and community. However, the improvement was small and started from a low base. Most teacher-trainers had tried to increase their use of Indigenous contexts in mathematics lessons, but many of them wanted to learn more in this area.
- According to the school principals, the PRIME Futures program had led to some improvement in the engagement and achievement of Indigenous students.

These results are discussed in more detail in Section 3.2.

2.3 Teacher capacity

Chapter 1 outlined the nature and objectives of the PRIME Futures program. One of the aims was to improve teachers' capacity to be effective teachers of mathematics. Teaching capacity refers to 'the perceived abilities, skills, and expertise' (Great Schools Partnership, 2013, para. 1) of teachers as classroom practitioners. In the case of the PRIME Futures program, the focus was on mathematics education.

This section reports on the impact of the PRIME Futures program on teacher capacity. The way in which the program sought to build teacher capacity has been detailed in Chapter 1.

Improvements in teacher capacity were assessed using several methods:

- principals were asked about their teachers' capacity to teach mathematics as part of the biannual surveys
- teachers were also asked about their assessment of their capacity to teach mathematics as part of the biannual surveys
- in the exit survey, teachers were asked to report on how frequently they used YDM in their classes and to use a pre-post retrospective method to describe the change in their use of key YDM pedagogical strategies
- some teachers commented on the changes in their pedagogy in their reflective journals.

The responses to these data collection instruments are summarised in this section.

2.3.1 Teacher and principal surveys

Table 2.12 shows the principals' perceptions of their teachers' capacity in the biannual and exit surveys. The average results show a marked improvement in the teachers' capacity in all categories surveyed, rating it as 'moderate' (or very close to moderate).

Table 2.12 Principal perceptions of improved teacher capacity (biannual and exit surveys)

TO WHAT EXTENT HAS THE **PRIME FUTURES** PROGRAM IMPROVED CAPACITY TO TEACH MATHEMATICS WITH REGARD TO:											
	CLUSTER										AVERAGE
	1 (N=31)	2 (N=29)	3 (N=13)	4 (N=20)	5 (N=25)	6 (N=16)	7 (N=14)	8 (N=23)	9 (N=19)	10 (N=28)	1–10 (N=200)
Confidence	2.80	2.90	3.15	3.00	3.08	2.67	2.93	2.39	2.82	3.54	2.93
Mathematical knowledge	2.60	2.60	3.00	2.68	3.00	2.67	2.57	2.26	2.83	3.26	2.76
Pedagogical skills	2.80	3.10	3.08	3.00	3.16	2.87	3.21	2.65	3.07	3.54	3.08
Indigenous knowledge	2.60	2.50	3.00	2.60	2.64	2.93	2.79	2.23	3.00	3.04	2.73
Expectations of students	2.70	3.00	3.15	2.47	3.04	3.14	2.50	2.05	2.88	3.07	2.82

Note. Rating scale: 0 = not at all; 1 = very little; 2 = somewhat; 3 = moderately; 4 = extensively. Four biannual surveys and one exit survey in Clusters 1–4; three biannual surveys and one exit survey in Clusters 5–10. For consistency, the Clusters 1–10 column excludes the fourth biannual survey results from Clusters 1–4 (n = 18 responses).

The principals' perceptions were confirmed by a similar survey of the teachers, who reported slightly higher improvements in teacher capacity (see Table 2.13).

Table 2.13 Teacher perceptions of improved teacher capacity (one biannual survey and exit survey)

TO WHAT EXTENT HAS THE **PRIME FUTURES** PROGRAM IMPROVED CAPACITY TO TEACH MATHEMATICS WITH REGARD TO:											
	CLUSTER										AVERAGE
	1 (N=21)	2 (N=25)	3 (N=5)	4 (N=43)	5 (N=15)	6 (N=22)	7 (N=10)	8 (N=10)	9 (N=4)	10 (N=19)	1–10 (N=124)
Confidence	2.90	3.00	3.00	3.00	3.07	3.27	3.00	2.60	4.00	3.53	3.10
Mathematical knowledge	2.90	2.80	2.80	2.80	2.84	3.13	2.90	2.80	3.75	3.21	2.93
Pedagogical skills	3.10	3.20	3.00	3.20	3.21	3.27	3.10	3.10	3.75	3.42	3.26
Indigenous knowledge	2.30	3.00	2.20	3.00	2.77	2.53	3.10	3.10	3.75	2.95	2.85
Expectations of students	2.50	2.80	2.60	2.80	2.79	2.80	2.80	3.00	4.00	3.16	2.91

Note. Rating scale: 0 = not at all; 1 = very little; 2 = somewhat; 3 = moderately; 4 = extensively. Fourth biannual survey only and exit survey in Clusters 1–4; exit survey only in Clusters 5–10. For consistency, the Clusters 1–10 column excludes the fourth biannual survey results from Clusters 1–4 (n = 50 responses). 2.3.2

2.3.2 Teacher reflective journals

This section summarises common themes with excerpts from the teacher reflective journals relating to a perceived change in teacher capacity, particularly in mathematical and pedagogical knowledge and skills.

The reflective journals demonstrate that teachers have changed their approach to teaching, based on YDM:

- *I have changed my entire timetable and we do maths every afternoon. [Teacher 10, School 1B]*
- *I try and include body/hand/mind activities in all Math lessons.* [Teacher 13, School 1A]
- *My units/concepts now begin with an activity where students do some kind of activity out of their seats. Students enjoy this opportunity as it gives them opportunities to move, socialise, work with other students and learn from other students. This adds a lot more variety to the lessons.* [Teacher 134, School 8D]
- *I have learnt that I need to regularly do activities and continually revisit reality when teaching the mathematics phase as they tend to revert to thinking that mathematics is 'irrelevant'.* [Teacher 52, School 1C]
- *Year 4 … placing fractions on a number line … we discussed if we thought the fractions were in the correct place. Lots of discussion and thinking took place, which enabled learning to take place—'math talk' so important.* [Teacher 19, School 4A]

Many teachers talked of the changes in their pedagogy:

- *I am beginning to be more confident in my approach to teaching students maths with hands-on materials. I am actively thinking about how I can get the students to physically make or solve maths problems and get them more familiar with math concepts … I feel so much more confident as a maths teacher and look forward to increasing my confidence even further as I get to practice and refine my teaching in using the YDM pedagogy.* [Teacher 24, School 4B]
- *It [YuMi Maths] is now ingrained into my maths teaching.* [Teacher 71, School 5D]
- *The biggest change I have noticed about my pedagogy is that I am now teaching DEEPER rather than MORE OF THE SAME. For example … Now they [students] need to show me more than one way to solve a problem … I used to think that I had to know something really well to teach it. Now, I am willing to have a go at teaching a concept in different ways and I love learning along with the children. I have more confidence in my own abilities, I now acknowledge that I will make mistakes along the way and that when this happens, it is usually a deep learning experience for us all.* [Teacher 36, School 4F]
- *YuMi has made me want to transform my teaching style dramatically to a more active room in all areas with desks arranged in a non-traditional style with more discussion on more real-world topics and attempt to build on knowledge. I envisage a new style of teaching and room altogether for me personally.* [Teacher 18, School 4C]
- *I have always found that movement can stimulate student learning and help to refocus them on the learning task … prior to becoming involved in the YDC CSIRO PRIME Futures project I had reduced the amount of student movement during learning activities, particularly in mathematics. Using the RAMR cycle and my involving in the project I 'bit the bullet' so to speak and became determined to involve the students in more Body activities.* [Teacher 126, School 10D]
- *What I have gleaned from the sessions is that my initial Primary background has stood me in good stead, especially with the struggling students in Years 7 to 9, whom I now teach Mathematics. Many of the interactive methods I used in the past are what I can use today, some with slight alterations to accommodate YuMi ideas.* [Teacher 139, School 9A]

Many teachers considered that the improvements in their teaching arose from the use of the RAMR cycle:

- *YuMi just make so much sense to me now! Following the RAMR … is just so crucial to building a strong foundation of mathematical knowledge.* [Teacher 30, School 4F]
- *I now approach most mathematical concepts with the question 'What reality is this concept based on?' Most times I can find simple ideas (usually straight from the school environment) that the students can connect with … I am still working through my own understanding of how to write these lesson plans down in a format that fits with how I teach. I am still developing my ideas of what goes in each part of the RAMR … I am always looking for a reality the students can connect with and then the maths lessons develop from there. Most of the lessons I teach in maths are very hands-on and reality based.* [Teacher 14, School 4A]
- *The biggest reflection after learning about YuMi is the abstraction process and the order in which we need to introduce concepts to our students. My approach has now changed so that I am not launching into the maths straight away.* [Teacher 99, School 7A]

- *I have changed the way I think about planning my maths lessons … I have enjoyed how the students can verbalise their thinking processes while completing the hands-on activity at the beginning … I have changed the way I structure my lessons to ensure that I have relevant reality and abstraction activities at the beginning to engage students in the learning process. I find that this is a great way to develop prior knowledge and thinking, as well as discover any misconceptions, prior to the 'maths' stage.* [Teacher 103, School 7A]

- *I have changed my approach to teaching new concepts. By using hands-on activities and the RAMR strategy …* [Teacher 104, School 7C]

- *I am moving toward YuMi style teaching as fast as I can create the resources and budgets allow. I will continue to RAMR my lessons and units where possible and continue to promote this teaching approach.* [Teacher 97, School 7B]

- *I found the planning difficult to start off with and identified as part of my performance development that I needed to further my planning in mathematics and the adapted RAMR model that I used has supported this. I found that my plans were always fluid and continually developing … A lot of my lessons have changed to ensure that they are hands-on and manipulative. If they do involve a worksheet, it has multiple purposes e.g. children need to cut, paste to sequence and arrange. I really enjoy the connections to reality as that is important for all students to make the connections. The body activities have also been critical and I am working towards developing more of these … I have found that the hands-on and manipulative aspects have been the best part to support my students.* [Teacher 64, School 6C]

- *I have learnt to plan out the content better … students need to see the 'flow' and clear link between these phases [reality, abstraction and mathematics] in order for it to be effective. … it is better to teach abstraction before mathematics so that students have a chance to discover content for themselves and make clear links between reality, abstract[ion] and mathematics.* [Teacher 52, School 1C]

- *I have been looking and checking at my own tasks and assessments. The aim was to incorporate YuMi approach in my teaching with the ultimate desire to improve students' participation, engagement and achievement in Maths. I did some simple integration of YuMi and tried to RAMRise some of my tasks to see the impact on students' attitude towards maths. Despite some challenges, I'd say that there seems to be a significant change to the way my class was received by my students.* [Teacher 60, School 6A]

- *I'm constantly thinking about how to RAMR. I can even identify RAMR in action in teaching phonics. … Continue to connect lessons to students' reality and knowledge.* [Teacher 21, School 4D]

Other teachers attributed their improvement in teaching to their increased use of reality:

- *My ability to now connect to students' reality, while considering abstraction, has definitely improved.* [Teacher 46, School 5C]

- *Every time I teach using this style, I feel I get a deeper understanding of how to break down a topic as well as how to apply Maths to real life. … I really enjoy the opportunity to be involved in alternative ways of teaching topics in Maths. I've always believed that Maths should be taught by tapping into students' reality and the real world where maths is applied.* [Teacher 134, School 8D]

- *Each lesson I ask 'What maths have you done in the real world over the last week?' The aim is to make children mindful and appreciative of the maths they do on a daily basis. And the other major aim I have is to make maths fun.* [Teacher 128, School 10D]

- *I knew that maths was best taught using, not just concrete materials, but the children themselves, and I have tried to incorporate that into daily teaching but it was not always possible. It was how I was taught at Teacher's College. There was a very big emphasis on that particular pedagogy but over the years some of that has slipped away, usually with the encroachment of other programs that schools have invested in … I will remind myself that we start with the real world, move onto the concrete, then the abstract … then reflect … every time where possible.* [Teacher 118, School 9E]

- *I have adopted more hand, body and mind activities. … I have created more of my own resources and have continued to follow YuMi Deadly Maths pedagogy. I have enjoyed using knowledge gained in fractions and decimals and transferring it into money … I'm making sure I focus on the reality at the beginning of each topic.* [Teacher 71, School 5D]

- *I have changed my initial approach and introduction of new concepts. I now relate a question I am trying to solve to real-life situations that students might have also faced. I am now introducing more manipulatives and movement into the lessons and initiating more 'think aloud' strategies to get students explaining why they are doing/thinking a certain way. … Showing them how easy it is gives them joy and empowerment …* [Teacher 5, School 2A]

- *A key message I took away from the YuMi training was the importance of connecting to students' reality. … I used the [practitioner's] language and some of her questioning in my lesson today. Wow! The kids commented how easy it was to read large numbers once they knew the pattern. … They could all read numbers in the millions. Great lesson!* [Teacher 56, School 5C]

Many teachers have increased their use of body–hand–mind pedagogical methods:

- *I formed a greater understanding of what abstraction means and to include 'body, hand and mind' activities.* [Teacher 87, School 4E]

- *I have changed the way I teach maths with my students in that I now try to have them out of their seats and actively engaged in what they [are] learning … leave formal terminology until a little later in the sequence of lessons and then immerse them in [it] during their activities.* [Teacher 38, School 4G]

- *Try to think of more hands-on activities. Not be afraid to get students up and using their whole bodies. … YuMi had made me more aware that there are alternative methods for teaching particular concepts that students may find easier.* [Teacher 55, School 2D]

- *When completing a Yr 4 posttest … I continue to see a gap with the students' knowledge of locating numbers on a number line. … It is surprising the challenge of teaching density to students. After completing my lesson, where students were required to place random numbers between 49 and 152 on an empty line I was able to recognise the need to break down further and scaffold the group with further materials. … I understand how much visual representations, mathematical language in words and numbers is so important. … Exposure to all ways hands, body and mind supports the students' development.* [Teacher 19, School 4A]

- *I have really enjoyed incorporating more HANDS-ON/ WHOLE body tasks and have found this is the best way to engage all learners. I always link in with real life and make connections to why we learn things in all areas of my teaching as this often is a key strategy to engage students and remind them everything we learn has a specific purpose. … I always finish my lessons with a REFLECTION … my biggest change is incorporating more WHOLE body activities and VISUALISATION … I really enjoy this approach to teaching and it complements my personal teaching style well. … YuMi has allowed me to embed student interest and reality into my planning for teaching. … I have found it easier this year to begin with a YuMi approach to teaching. I have been able to revisit activities I used with my class last year and refine my practice making any changes I felt necessary … have been able to trial some new activities also.* [Teacher 66, School 6D]

- *We have always used hands but the body is another dimension that has been valuable to incorporate. I find that I am using the body more in all learning areas.* [Teacher 42, School 5A]

- *Trainings helped raise awareness of the importance of hands-on activities and activities that use the body and mind. I also began to understand the importance of reversing everything you do to increase understanding and flexibility in maths. The RAMR planning tool was a valuable tool to learn about and it was good that we had time to practice planning with it.* [Teacher 63, School 6B]

- *[I] now feel more comfortable going back to basics to build the knowledge from the ground up with the support of the books received at PD. … I now feel more comfortable in filling in the gaps in students' knowledge. … My focus around maths has changed in that I will be focusing on a more kinaesthetic approach.* [Teacher 47, School 1C]

- *I am really trying to apply the new maths concepts to their local surroundings. From there we are using our body as much as possible to get a good grasp of the concepts involved with our new learning. I now understand that after they can use their bodies outdoors they are more willing to have a go in the classroom using different materials. Once they have been through this process they are equipped to think about concepts in their mind.* [Teacher 75, School 5E]

Many teachers referred to a deepening of their knowledge of mathematics:

- *I do feel that I have a much deeper knowledge about mathematics than previously! I feel better equipped to do a better job with my teaching.* [Teacher 121, School 5C]
- *RAMR Place value: It gave me a good understanding of students' knowledge of number prior to teaching the unit. This was particularly important given new students were in my class.* [Teacher 71, School 5D]
- *I have always used the FOIL method but have never truly understood it as clearly as I do now after working through the array method.* [Teacher 9, School 2A]
- *I think the AHA moment was more mine. For so long I was teaching to just move the decimal across. So I applied the 'move the zero' technique and made a little slider thingy. Students understood scientific notation and how to go from little to big and big to little, and was then able to use it to solve all problems.* [Teacher 17, School 4B]
- *The abstraction activities provided have worked well in my class. Very engaging and I could easily see that many students still did not understand our base 10 system and how we read/make numbers. … Wipe out has been a great game to see which students have got it and which I need to touch base with again—also a learning curve as many students don't know how to use a calculator properly. … I am getting better at making sure I am encouraging the students to point and say each place value—again, an easy way for me to check their understanding and for them to consolidate. … Shows how tweaks in our content knowledge helps us to teach more effectively and help students to make connections.* [Teacher 56, School 5C]
- *Observing the YuMi presenter model a lesson at this point in time was highly beneficial, and has provided me with a more concrete starting point as to where to next. During the observation, I was able to consider how I might slightly tweak the lesson as it unfolded, for my Year 3's. While the lesson was being delivered to a Year 5/6, this was actually really great for my personal understandings about the topic, as it provided a picture of where to next—where it leads with larger numbers and indeed parts of numbers.* [Teacher 46, School 5C]
- *I have found the YuMi Deadly resources really helpful in breaking down the way to teach measurement. … I feel a lot more confident teaching measurement and have learnt so much about the way to teach measurement! … Continue to understand Math concepts in different ways, exploring new ways of including Maths … was really good to be able to formally share what we had learnt over the past 3 years.* [Teacher 73, School 6E]
- *From doing the training and implementing this pedagogy I have found the whole body activities to be very successful and they encourage lots of discussion and mathematical reasoning. … As a class we have been working through different activities to build up number sense. I had a big focus on fluency this term also to fill in some gaps with the students to build automaticity and fluency with solving number problems. We played a few games of bums on seats to build up understanding of place value which students enjoy.* [Teacher 66, School 6D]
- *Time activity: I was able to see from this that there were still some misconceptions with the time conversions specifically in regards to 12:00 am and 12:00 pm being changed to 24 hr time. … Showing this linearly and side by side will hopefully clear up the misconception …* [Teacher 105, School 7C]
- *I have been embedding deeper learning of fractions to year one than previously. … Capacity prior knowledge lesson to start—initially no understanding of capacity … Practical activity of holding water or sand—then much better brainstorming.* [Teacher 94, School 8B]
- *We did a lot of work on looking at what each attribute was prior to any comparing or ordering when in the past I would [have] skipped this. I believe this has helped the students have a better understanding of measurement and has helped them with their explanation of how to measure and compare. I have also liked the ideas of how to teach mass, capacity, volume and area. In the past I would have only touched on these areas but I have so much more knowledge of how to teach these types of measurements and how to look at informal units with them. I have really enjoyed teaching measurement and feel I have done a much better job than in the past!* [Teacher 73, School 63]

Some teachers described how YDM has assisted them to diagnose student problems:

- *YuMi has increased my flexibility within how I approach the teaching of math concepts. It makes me think outside the box and encourages me to differentiate more easily to meet the needs of my students.* [Teacher 34, School 4F]
- *Using the body activity actually shows me what they understand … I also have a better understanding of using informal units in these areas making assessing of my students' understanding much easier. … The way I teach number has definitely changed and the students are starting to see more links between different activities we are doing.* [Teacher 73, School 6E]

- *I am beginning to realise that it is much easier to see where students are at with a concept when the activities provided are relatable and whole body. … Another amazing outcome of using the RAMR has been the connections being made between myself and the students. A common love for chocolate or using local areas for the location activity has strengthened our understanding of each other and by getting to know each other better has allowed for greater ease of teaching. … The communication between teacher and student is more authentic.* [Teacher 14, School 4A]

Teachers stated that their enjoyment of teaching mathematics has increased:

- *One of the most exciting changes has been in my attitude toward teaching maths! I have to admit that on occasions I used to skip it if I could justify it. I enjoy teaching maths now. I love the framework and I can see the skills building and the connections being made. I have always started new units with Prior Knowledge Brainstorms but now with Reality focus it is so much richer and more meaningful. I will continue to do this differently. … My view of maths has changed. I am now more focused on making connections to my students' experiences and throughout the curriculum.* [Teacher 77, School 5E]
- *Getting them involved and understanding. Getting things that relate to their life. … I was starting to enjoy teaching maths a lot more.* [Teacher 10, School 1B]

2.3.3 Summary

In summary, the data on teacher capacity pointed to improvements in the program participants and their colleagues. Thematic analysis of the data suggests that these changes were due to changes in pedagogy (the use of the RAMR pedagogy that included real-life contexts and kinaesthetic activities), improved knowledge and understanding of mathematics, and enhanced enjoyment of teaching.

These general conclusions are discussed in more detail in Section 3.3.

2.4 Program implementation

Implementation of YDM pedagogy and practices occurred in two stages:

1. After attending the PD workshops that explained and demonstrated YDM, teachers incorporated it into their own practice (referred to as *individual implementation*).
2. The teacher-trainers who attended the PD workshops then trained their colleagues in YDM and supported them in adopting the pedagogical approach (referred to as *whole-school implementation*).

To monitor the individual implementation of YDM, the teachers were invited to provide information in response to the biannual surveys and in their reflective journals about how they used YDM and the associated challenges they experienced. At the end of the program, teachers were asked to use a pre-post retrospective method to describe the change in their use of key YDM pedagogical strategies.

The whole-school implementation of YDM was monitored by asking teachers in the biannual surveys to advise on the extent, nature and outcomes of the training provided to their colleagues. In the exit survey, they were asked to use a pre-post retrospective method to assess the extent to which their colleagues were using key YDM methods at the end of the program. Additionally, principals were asked about the implementation of YDM in their schools. Finally, YDC cluster coordinators were asked about their observations of the extent to which YDM was being taken up within the schools.

The results from these various sources of data are summarised in this section.

2.4.1 Individual implementation

Teacher surveys

Table 2.14 summarises the data collected progressively throughout the program on the use of YDM in teachers' own mathematics classrooms. It shows that approximately two-thirds of teachers had tried some YDM activities and/or developed their own lesson plans based on YDM methods. These responses were reasonably consistent. An average of 25% of teachers had changed to a RAMR approach in most or all lessons, with fewer teachers in Cluster 9 (Geraldton) and Cluster 1 (Emerald region) reporting this change in pedagogy.

Less consistency was evident in other areas advocated by YDM: pre-post tests, Indigenous contexts, and reduced reliance on textbooks and worksheets.

Table 2.14 Teacher application of YDM methods in their classrooms (biannual surveys)

HOW HAVE YOU APPLIED THE YDM APPROACH IN YOUR MATHEMATICS CLASSROOM?											
	CLUSTER										AVERAGE
	1 (N=61)	2 (N=69)	3 (N=30)	4 (N=86)	5 (N=54)	6 (N=51)	7 (N=43)	8 (N=35)	9 (N=21)	10 (N=43)	1–10 (N=444)
I have used one or more activities	79%	73%	67%	72%	67%	75%	79%	74%	76%	58%	73%
I have used my own YDM lesson plans	66%	61%	57%	64%	81%	53%	70%	49%	33%	74%	61%
I have reduced use of textbooks/worksheets	66%	47%	23%	53%	59%	45%	44%	37%	24%	37%	44%
I have used some Indigenous contexts	33%	35%	10%	29%	69%	45%	37%	40%	52%	30%	38%
I have used a YDM lesson plan developed by someone else	39%	34%	10%	50%	37%	43%	42%	23%	5%	49%	36%
I have used pre/post tests	10%	36%	33%	38%	26%	22%	30%	17%	29%	23%	26%
I have changed to a RAMR pedagogical approach in most/all lessons	10%	22%	33%	19%	46%	37%	28%	23%	5%	33%	25%

Note. Four biannual surveys in Clusters 1–4; three biannual surveys in Clusters 5–10. For consistency, the Clusters 1–10 column excludes the fourth survey results from Clusters 1–4 (n = 49 responses).

Table 2.15 shows teachers' perceptions of obstacles in implementing YDM. The greatest obstacles for teachers were the time needed for the preparation of YDM lessons (45%), the resources needed (24%) and knowledge about Indigenous contexts (18%).

Table 2.15 Teacher perceptions of obstacles in implementing YDM (biannual surveys)

WHAT OBSTACLES HAVE YOU ENCOUNTERED IN USING THE YDM APPROACH IN YOUR CLASSROOM?											
	CLUSTER										AVERAGE
	1 (N=61)	2 (N=68)	3 (N=30)	4 (N=85)	5 (N=54)	6 (N=51)	7 (N=43)	8 (N=35)	9 (N=21)	10 (N=43)	1–10 (N=441)
The YDM approach requires a lot of preparation	70%	46%	37%	27%	30%	37%	53%	74%	38%	33%	45%
I lack suitable classroom resources	41%	27%	23%	12%	20%	18%	33%	29%	19%	12%	24%
I lack information about the local Indigenous culture and community	23%	15%	20%	19%	28%	25%	30%	6%	5%	7%	18%
My school's mathematics program is not suited to YDM methods	31%	3%	0%	8%	0%	14%	0%	0%	10%	7%	8%
I have little support from colleagues	3%	6%	7%	24%	0%	0%	7%	3%	14%	5%	7%
I have little support from HoD/HoC/Principal	11%	7%	23%	11%	0%	0%	2%	6%	5%	0%	6%
Other	23%	22%	27%	27%	17%	37%	19%	29%	38%	28%	26%

Note. Four biannual surveys in Clusters 1–4; three biannual surveys in Clusters 5–10. For consistency, the Clusters 1–10 column excludes the fourth survey results from Clusters 1–4 (n = 50 responses).

Table 2.16 Teacher use of the YDM approach in their mathematics lessons (exit survey)

TO WHAT EXTENT ARE YOU CURRENTLY USING THE YDM APPROACH IN YOUR MATHEMATICS LESSONS?											
	CLUSTER										AVERAGE
	1 (N=9)	2 (N=11)	3 (N=3)	4 (N=20)	5 (N=15)	6 (N=22)	7 (N=10)	8 (N=10)	9 (N=5)	10 (N=19)	1–10 (N=124)
In all lessons	0%	9%	0%	15%	47%	14%	0%	0%	0%	11%	13%
In most lessons	22%	36%	100%	50%	27%	38%	10%	43%	60%	53%	40%
In some lessons	67%	36%	0%	15%	7%	19%	80%	43%	40%	32%	31%
Rarely	11%	9%	0%	10%	7%	0%	10%	14%	0%	0%	6%
Not at all	0%	9%	0%	0%	0%	10%	0%	0%	0%	0%	3%

Table 2.17 Teacher perceptions of change in their teaching approaches (exit survey)

TO WHAT EXTENT HAVE YOU USED THE FOLLOWING IN THE TEACHING OF MATHEMATICS ***BEFORE*** AND ***AFTER*** YOUR PARTICIPATION IN THE PROGRAM?												
		CLUSTER										AVERAGE
		1 (N=9)	2 (N=11)	3 (N=3)	4 (N=21)	5 (N=15)	6 (N=22)	7 (N=10)	8 (N=10)	9 (N=5)	10 (N=19)	1–10 (N=125)
RAMR	Before	0.30	0.60	0.67	0.75	1.07	0.27	0.20	0.78	0.67	0.68	0.60
	After	2.40	2.50	3.33	2.76	3.27	2.91	2.20	2.50	2.80	3.32	2.84
	Difference	**2.10**	**1.90**	**2.66**	**2.01**	**2.20**	**2.64**	**2.00**	**1.72**	**2.13**	**2.64**	**2.24**
Big ideas	Before	1.30	1.50	1.00	0.95	1.93	1.68	0.67	1.13	1.00	1.11	1.29
	After	2.60	2.70	2.33	2.76	3.13	3.00	1.90	2.50	3.20	3.06	2.79
	Difference	**1.30**	**1.20**	**1.33**	**1.81**	**1.20**	**1.32**	**1.23**	**1.37**	**2.20**	**1.95**	**1.50**
Indigenous contexts	Before	0.90	1.60	1.00	0.90	1.60	1.27	1.20	1.70	1.20	1.11	1.25
	After	1.90	2.60	2.00	2.33	2.87	2.59	2.30	2.50	3.20	2.26	2.50
	Difference	**1.00**	**1.00**	**1.00**	**1.43**	**1.27**	**1.32**	**1.10**	**0.80**	**2.00**	**1.15**	**1.25**
Hands-on activities	Before	1.70	2.70	2.33	2.29	3.27	2.68	2.00	2.40	2.40	2.74	2.53
	After	3.00	3.60	4.00	3.38	3.80	3.50	3.40	3.40	3.40	3.63	3.50
	Difference	**1.30**	**0.90**	**1.67**	**1.09**	**0.53**	**0.82**	**1.40**	**1.00**	**1.00**	**0.89**	**0.97**
Pre/post tests	Before	1.40	2.10	1.67	2.38	1.67	2.41	1.78	2.70	2.40	2.53	2.19
	After	2.10	3.20	2.33	3.00	2.20	2.59	2.56	2.90	3.20	2.74	2.69
	Difference	**0.70**	**1.10**	**0.66**	**0.62**	**0.53**	**0.18**	**0.78**	**0.20**	**0.80**	**0.21**	**0.50**
Textbooks/ worksheets	Before	1.70	2.60	3.00	2.24	1.53	2.09	2.80	3.10	2.80	2.68	2.34
	After	1.90	2.00	3.00	1.62	1.20	1.38	2.60	2.60	2.80	2.05	1.89
	Difference	**0.20**	**-0.60**	**0.00**	**-0.62**	**-0.33**	**-0.71**	**-0.20**	**-0.50**	**0.00**	**-0.63**	**-0.45**

Note. Rating scale: 0=not at all; 1= very little; 2=somewhat; 3=moderately; 4=extensively.

Table 2.16 and Table 2.17 are derived from the exit surveys. By the end of the program, more than half the teachers (53%) reported use of the YDM approach in most or all lessons, with only 9% reporting very limited use of YDM (see Table 2.16).

The exit survey of teachers showed the greatest average change in teaching approaches for the use of RAMR, big ideas and Indigenous contexts (see Table 2.17 and Figure 2.3). The use of hands-on activities and pre/post tests also increased, although to a lesser extent and starting from a higher base. In the biannual surveys, 44% of responses reported reduced use of textbooks/worksheets (see Table 2.14), as would be expected when using the YDM approach. This result is supported by the exit survey, which showed a small decrease in their use on average.

Teacher reflective journals

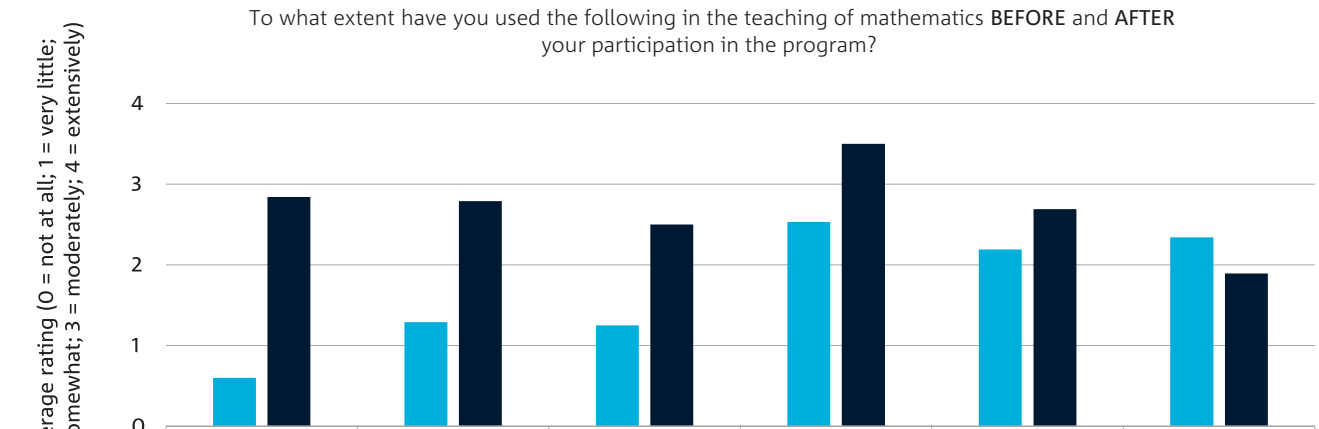
Teacher reflective journal entries documented the journeys of many teachers in using YDM in their own classrooms. They provided many examples of YDM application in the classroom and insights into the implementation challenges experienced by teachers. This section summarises those issues thematically, supported by excerpts from some teacher reflective journals relating to YDM implementation and challenges.

YDM implementation

Many teachers started by experimenting with parts of the RAMR framework. This gave them insights into how the framework could be applied and the confidence to go further.

Some teachers used YDM activities as a way of creating initial interest for students:

- *Students reflected on how this knowledge [of decimals] could be applied back to money and gave each other a 'test' question to check their understanding. … I had a small chat with some of my higher students about the size of thousandths and ten thousandths, and we cut up a tile to model this. … I have been using the Reality aspect of the cycle as my 'Hook' and prior knowledge 'Activate' activity.* [Teacher 98, School 7A]
- *Prep … (sequencing days of the week): Students [were] given the days of the week and asked to place the days of the week in order. Lots of questioning was used to help guide student thinking e.g., Why do you think that day goes there? How do you know? This activity was engaging and a good way to 'hook' in the students' interests from the beginning.* [Teacher 103, School 7A]



	RAMR	Big ideas	Indigenous contexts	Hands-on activities	Pre/post tests	Textbooks/ worksheets
BEFORE	0.60	1.29	1.25	2.53	2.19	2.34
AFTER	2.84	2.79	2.50	3.50	2.69	1.89

Figure 2.3 Teacher perceptions of change in their teaching approaches (exit survey; n = 125)

- *We have been learning about patterns so we took them on a local walk to find patterns in our environment. We then recorded and discussed our findings. From then on students are constantly finding new patterns in their environment that they haven't noticed before. Making the introduction into pattern such a real-life experience has allowed them to see how we would use patterns in our everyday life and valuing the importance of them.* [Teacher 75, School 5E]
- *A lesson on stats and averages where students measured all the students in the class height and arm span then used the data to create the average Yr 9 student. Discussion naturally progressed to outliers as there was both a very short and tall student in the class.* [Teacher 129, School 4H]
- *Yr 8 Algebra teaching distributive law. Initially taught using ppt … which was developed from ideas in YuMi Algebra book (How many arms and legs? How many jerseys?). Students became very bored and disengaged with the lesson even though I was following a RAMR approach. I retaught the lesson but used the area method for developing the distributive law. … Kids were actively engaged in making the areas which meant the activity worked much better.* [Teacher 134, School 8D]
- *Maths now follows the RAMR cycle, with the reality and abstraction activities used as hooks in [the] 'maths' [part of the cycle].* [Teacher 7, School 2B]
- *I began trialling the RAMR model in the classroom … by incorporating Body activities with the Hand and Mind activities I already used and made a conscious effort to relate mathematics to Reality.* [Teacher 126, School 10D]
- *It makes me think about including more body activities.* [Teacher 7, School 2B]

Some teachers used informal pre-post testing methods to learn what their students already knew (retesting) or had learned (posttesting):

- *The pre-lesson involved showing a cartoon clip about fractions, asking students what they knew about fractions and asking them to answer a worksheet about fractions at Yr 3 and Yr 6 levels. Note: Many were unsure of the mathematical representation of a fraction and struggled with completing the worksheet.* [Teacher 139, School 9A]
- *Verbal and board work pretesting showed that students did not understand or recognise like terms in algebra. Using the reality of grouping fruit and extending this to numbers and then letters, students moved around the classroom and explained the reasons for their groupings. … Exit pass (posttest) to sort a variety of algebraic terms indicated that all students were able to determine like terms.* [Teacher 5, School 2A]
- *Reality and finding what they know for measurement and their understanding of the different attributes … discovered very little knowledge and many misconceptions.* [Teacher 122, School 5C]
- *I wind my lessons back more after I have assessed where they [students] are at. I discover many gaps in knowledge.* [Teacher 122, School 5C]
- *What surprised me the first time we did the [fraction] walk back is that the children said '3 quarters' when we reached the 1 quarter mark because it had been 3 quarters on the first journey. It should have been 1 quarter on the return journey, so this presented some challenges and misconceptions that needed addressing and clarification.* [Teacher 118, School 9E]

Many teachers have tried to apply the YDM RAMR cycle, with varying degrees of success:

- *For every lesson I write down the RAMR cycle and try to implement each step where I can. I will continue to do this but may not use it in every lesson.* [Teacher 35, School 3A]
- *Using YDM as an idea, making reference to real-life situations and use hands-on activities where possible.* [Teacher 89, School 3B]
- *Introducing number/finding out where the class is at. I began this lesson having the class work together to construct a number line, I then modified it and got different students to collect all the green cards (ending in 5,0) and make a new number line only using the green cards. We then discussed the patterns they could see with the 5 and 0 before taking away the cards ending in 5 and discussed the pattern students could see in the tens. … The reflection at the end was the most powerful moment as it reinforced the role of patterns in skip counting.* [Teacher 66, School 6D]
- *Hit a roadblock—to sum it up I've found that I'm an indoctrinated teacher trying to change my ways towards indoctrinated students. I am going to persist with Reality in all lessons, or reference to past realities at least.* [Teacher 119, School 10C]

The reflective journals detailed the trialling by teachers of RAMR as a basis for designing lessons. It included checking students' prior knowledge, using real-life contexts and kinaesthetic activities/materials, and including reflection time. Many teachers shared their lessons based on RAMR and body–hand–mind. A few examples are quoted here, and many more are listed in Appendix F.

- *Students worked in small groups to divide a rope into line segments using pegs (halves, quarters, eights). … Shared collections into halves and quarters using marbles, counters, pictures. … What do you already know—real-life connections (what do you call the break during a football game/ basketball game, discuss the halfway/ try line positions; describe this glass using mathematical language). … Reversing, if this is ¾ show me a whole etc. … Students position themselves on a number line to show fractions. … Maths mat used to give and follow directions—fantastic for low level students. … Used clocks to support clockwise/anti-clockwise direction.* [Teacher 127, School 8B]
- *Students were asked to compare the weights of each other's school bags … we then went back into the classroom and discussed the connections they made that if bag A is heavier than bag B and bag B is heavier than bag C, then C is lightest and we don't need to measure that against bag A.* [Teacher 112, School 5D]
- *Year 2 Measurement—Capacity … I had a range of different materials i.e., pasta, rice, sand. … I had a range of different containers in different shapes and sizes. … The children experimented with filling containers with different materials. The objective was for them to discover that a container's capacity involved the container being completely full with no gaps or spaces. … They also discovered that some containers were different shapes but had the same capacity. They hypothesised that water would be great for determining capacity.* [Teacher 38, School 4G]

Some teachers commented on how the RAMR framework fits with frameworks and pedagogies mandated by their education authorities:

- *The RAMR framework easily fitted within the current TfEL frame. I made changes to some learning experiences ensuring that the concept of body, hand and mind were evident.* [Teacher 43, School 5B]
- *The process of body, hand and mind works well with explicit teaching.* [Teacher 127, School 8B]
- *I love it—I find it easy to incorporate into any C2C lesson, or as a review lesson. We do YDM as warm-ups, as group work and as reflections.* [Teacher 13, School 1A]
- *The move towards explicit teaching cut short a lot of these opportunities and encouraged rote learning which made Maths very boring and turned a lot of students off Maths. I'm glad to be able to return to using a more active/activity-based teaching/ learning approach.* [Teacher 134, School 8D]

Challenges to the successful implementation of YDM

In their reflective journals, teachers identified a number of challenges:

- finding a suitable reality/context, especially for secondary topics
- student behaviour
- student differentiation
- resources needed for YDM
- time required in class and for preparation
- inspiring other teachers to try YDM
- evidence of learning and link to assessment.

Examples of comments made in each of these areas follow.

Finding a suitable reality. Many teachers identified the difficulty of finding a suitable reality context and/or constructing a RAMR cycle that was suitable for the students. This was mentioned particularly by secondary teachers:

- *The reality aspect is not always so easy to find.* [Teacher 63, School 6B]
- *I do think however that it [YDM/RAMR] is much more based in primary school and I have trouble working out how to incorporate it into a secondary school.* [Teacher 81, School 4H]

- *My challenge was identifying reality that was suitable for addition, to overcome this I found a book … I have since furthered this through identifying other texts that I could use.* [Teacher 64, School 6C]
- *Challenges include subjects that I find have limited ideas for reality and abstraction stages. These topics I find more challenging to fit into the RAMR framework, as I like to ensure I have engaging reality/abstraction to begin my lessons.* [Teacher 103, School 7A]
- *Teaching students about equivalence … started out briefly discussing reality, but then [the] only thing I could think of to relate this to is their prior knowledge of equations: the straightforward 1 + 2 = 3.* [Teacher 24, School 4B]
- *The challenge was to explain how to use an algebraic expression instead of a number length to describe the length of a box which can expand and contract … The challenge still exists to find situations in reality that require an expanding box. Using a model for this was essential and must again be used for future classes … I would like to discover more ways to demonstrate concepts using the RAMR approach that encourages students to have a go and not give up at the first sign of confusion.* [Teacher 5, School 2A]
- *If I was to teach this lesson again I would like to be able to relate binomial expansion to the real world, and use manipulatives for students to see what is going on.* [Teacher 9, School 2A]
- *I still find it hard to come up with Abstraction ideas for some of the topics covered in the high school section.* [Teacher 35, School 3A]
- *As the unit progresses, I find less opportunity to incorporate body and hand. It becomes just mind activities.* [Teacher 127, School 8B]
- *When writing the RAMR, I found the Reality section most challenging to find a link to prior knowledge related to their (Year 1) experiences … I made the assumption that my students had the basic understanding of what simple fractions look like. We made a number line and placed fractions on the number line with [the] use of fractions in digits only. It was a disaster, even my stronger maths students struggled.* [Teacher 19, School 4A]

Student behaviour. Many teachers reported that student behaviour was challenging at times, particularly in secondary schools. Although many of the YDM activities were interesting and enjoyable, teachers found that it was sometimes difficult to overcome entrenched attitudes and keep behaviour under control or to maintain the students' focus throughout the lesson.

- *Students' attitudes are very hard to change. In very difficult classes with challenging behaviour some students will still complain a hands-on activity is boring, even though you can see them engaged and enjoying themselves.* [Teacher 52, School 1C]
- *I still have trouble getting all children involved in the whole body activities as some think it is better to fight over who holds the elastic rather than concentrate on the activity … I would like to experiment with small groups.* [Teacher 68, School 3A]
- *I would like to learn more about reaching students who refuse to engage in whole-body activities or have listening/attention issues … I would also like to be able to divide my attention between groups appropriately and effectively for maximum engagement and feedback … Getting students trained to get involved in whole-body activities in ways that promote learning.* [Teacher 83, School 3A]
- *Challenges: Students failing to engage with 'body' activities. Retaught expectations. Getting to the point where students are happy to take risks with their learning. Helping the classroom teacher to develop an environment where they feel safe to take risks.* [Teacher 55, School 2D]
- *This group of students still are not enthralled with maths and it is even difficult some days to get them up and involved in hands-on activities as they seem to prefer to sit and do nothing.* [Teacher 35, School 3A]
- *Some students were a little silly with this at first but other students' comments indicating why they are incorrect soon corrected the behaviour. What I would do differently next time is not include toy animals as one of the items to be grouped. Students distracted themselves easily here and needed to be supervised at this activity.* [Teacher 5, School 2A]
- *Working with a Year 8 Maths Foundation Class … I am finding it really difficult due to my clientele. Firstly, there is a bit of a lack of interest and secondly, there are some behaviour concerns where students just go really silly and miss the whole point of the activities … I try to find activities that will engage them but does not always work.* [Teacher 15, School 4B]

- *It was hard to keep the kids focused … Many of the students who have not performed well in maths have been disengaged and have a great deal of other issues … These students are predominantly demotivated and have significant behaviour problems … We have focused on providing a safe environment that they feel comfortable entering and staying in. This has been a huge task for me and has utilised a vast amount of resources to simply build rapport with these kids. They require one-to-one support and rarely work independently.* [Teacher 24, School 4B]
- *Keeping behaviour under control … found it challenging to catch up students who are away when I teach YuMi math as there are no worksheets or textbooks … The challenge I currently have is taking the students' understanding expressed when using hands-on resources to problem-solving with a word problem on a page.* [Teacher 30, School 4F]
- *The behaviour of the class as a whole wasn't good and a lot of students were just doing the activity and not getting anything from it. [Teacher 81, School 4H]*
- *Found it difficult to get students to attend to the [weight] activity. Had to individually complete the activity with all students.* [Teacher 115, School 5G]
- *The reality part of the lesson though interesting and physical for the children struggled to relate back to the main focus … Initially, they were more engaged but lost interest as the lesson dragged.* [Teacher 14, School 4A]
- *Even though all students were involved in the outside activity may need to ensure that the quieter kids voices are being heard. As students do not normally work together this also provided a challenge and unfamiliarity amongst groups.* [Teacher 60, School 6A]
- *Some students are not always engaged (use the time to daydream, fidget) … Discussions meant that some non-participants were distracted/not involved … Trialled seating students in groups to support discussions—ineffective for focus and behaviour management … [Students] lost interest in maths games quickly—need a wider assortment.* [Teacher 127, School 8B]
- *Disengaged students, students with behaviour issues. These students are difficult to 'catch' and engage in YuMi or any type of maths lessons. They are often disruptive and tend to sabotage these lessons.* [Teacher 134, School 8D]

Student differentiation. Managing different student needs in terms of participation and differentiation were also mentioned as challenges by some teachers. However, others considered that YDM assisted with differentiation:

- *Challenges: Engaging more able students.* [Teacher 122, School 5C]
- *Students working individually were not able to follow instructions at the same rate therefore made it hard to address some of the presumed understanding we (the teacher) had of the student. e.g., Reducing to lowest common factor.* [Teacher 59, School 6A]
- *Constructing RAMR cycles using the YuMi resources have been difficult for the 5/6 class. The students are working at and above year level and we have had difficulty with concept descriptors. [Teacher 99, School 7A]*
- *Whole class participation and differentiation for the different year levels … my challenge was … the wide range of needs in my class around number.* [Teacher 73, School 6E]
- *Reversing worked well—challenged higher students … Worked really well with differentiation—in some maths lessons, students completing General Capabilities, Foundation, Year 1 and Year 2, Year level and above mathematics and all were engaged.* [Teacher 127, School 8B]

Resources needed for YDM. Many teachers commented about the resource demands of YDM and the time and/or money needed to acquire them:

- *Making resources is also very time-consuming.* [Teacher 42, School 5A]
- *Creating resources for a lesson takes LOTS of time.* [Teacher 134, School 8D]
- *YDM is heavily resource-based and getting this set up is my biggest challenge.* [Teacher 41, School 3B]
- *My challenges all relate to resources. Time to make the resources.* [Teacher 24, School 4B]
- *The challenges of YuMi … are to collect all the materials to make it a great lesson. I have to carry mine to each class as I do not have my own classroom.* [Teacher 25, School 4A]
- *Materials and also time is very much a challenge for some activities.* [Teacher 14, School 4A]
- *Money to purchase materials.* [Teacher 68, School 3A]

- *It would also be great if our school had enough of them [mats] for each teacher—I don't have one so to use it I need to borrow it from a teacher who has not already planned on using it. Our school only has 5 mats and elastic sets to share between 18 classrooms.* [Teacher 13, School 1A]
- *Preparation of resources and time constraints are the main challenges … However, with the support of the leadership along with SSO support time, we were able to overcome some of these issues. We have been developing resources that can be used by everyone in the faculty …. We are hoping that everyone will have a go once we have developed more resources.* [Teacher 60, School 6A]
- *A challenge I face is the students' respect for the resources provided. Many students in the class do not have any respect for the resources provided to them often destroying parts of them and not managing them correctly. What I did to mitigate this issue was to allocate each student their own resource that they had to look after. The students that kept the resources in good condition were rewarded and the students who purposely caused damage to it were given consequences for their actions.* [Teacher 104, School 7C]
- *Resources. Time. I have used different methods like getting them to draw the shapes if I was not able to have the hands-on multi-link blocks. This made it a little more difficult but most students were still able to complete the task on grid paper.* [Teacher 54, School 2D]
- *I would like to have one mat for every 4 students so that I don't have those students who will just sit back and not get involved.* [Teacher 35, School 3A]

Time. Some teachers commented on the time needed to prepare lessons and/or the class time needed for the YDM approach:

- *Although engaging I find they [YDM lessons] take a long time.* [Teacher 122, School 5C]
- *I also found that some of the topics were very time consuming … it took time to plan resources, ensure the resources were appropriate to the YuMi lessons rather than using things I already had planned.* [Teacher 103, School 7A]
- *Time management can be a challenge. We get so engaged in what we are doing that we spend longer on some activities although it results in deeper learning.* [Teacher 36, School 4F]
- *Using the RAMR planning takes time to do it fully. It takes time to teach. You still need to do revision.* [Teacher 68, School 3A]
- *There is never enough time for the students to explore each maths concept within the loaded curriculum. In my planning I am very conscious to link other maths concepts where relevant. I am still playing with this as the year goes on.* [Teacher 106, School 10A]
- *At the moment the only great change is in my thinking which has not translated to much practice, unfortunately, mainly due to being time poor and easier to revert back to the norm.* [Teacher 119, School 10C]
- *Challenges now are having awesome activities is good but time in the term to run them can sometimes be hard especially when other activities outside your control continually mean you lose maths lessons and yet you have the same amount of content to get through.* [Teacher 15, School 4B]
- *Being able to meet all the topics set by ACARA in the time frames of the term … Time management will be key!* [Teacher 83, School 3A]
- *Time! I find it difficult to find time to write out lesson plans. I used bits from already created YuMi lessons and added parts to fit the context in which I was teaching. I need to be more proactive and smarter with my time management. Once again I enjoyed abstraction activities, but they do often take a while to do in class.* [Teacher 71, School 5D]
- *Not to make a big lesson out of the whole body activities. I can easily spend an hour on the whole body each time we do it and not get time for other activities. I should plan in smaller steps.* [Teacher 68, School 3A]
- *Small challenges trying to fit RAMR lessons in with tight curriculum constraints.* [Teacher 13, School 1A]
- *Time constraints and deadlines.* [Teacher 52, School 1C]
- *My main challenge is trying to fit it in with the many other hats I wear in the school.* [Teacher 28, School 4A]
- *We came back from the PD wanting to do this and that and you just lose momentum with everything else that is happening.* [Teacher 37, School 4G]

Inspiring other teachers. A small number of teachers commented on the challenges of trying to inspire other teachers to implement the YDM approach and the importance of support from management:

- *It has been challenging to get staff on board but with examples and assistance they are coming around.* [Teacher 42, School 5A]
- *… having other staff … on board to have a go.* [Teacher 31, School 3D]
- *Getting teachers to transfer this [YDM] to the classroom.* [Teacher 73, School 6E]
- *Inspiring other teachers to be committed to teaching YuMi style … to get these teachers to continue teaching YuMi style independently is not always successful. Why—time to prepare, creating ideas, lack of resources, being convinced that this is a worthwhile way to deliver lessons, + it's easier to have students sit at desks and teach than try to create resources/run activities/manage behaviour … I also feel that the drive for YuMi needs to come from 'above' me and needs more of a commitment to encouraging teachers to try it out.* [Teacher 134, School 8D]
- *Supporting staff to implement and trial YuMi pedagogy in their classrooms … I have found it challenging [to] find the time to check in and support other teachers to implement YuMi into their math programming and teaching cycles … The main challenge is having the time to check in with everybody but also for people to find resources … Challenges still existing include having time to go and model/watch/ provide feedback to colleagues with their teaching.* [Teacher 66, School 6D]
- *Trying to adapt YDM to … [our] context. Attempting to overcome the perception of some staff that it wouldn't work for their context. We did a whole staff demonstration of the RAMR cycle. This inspired some staff to have a go and alleviated some concerns. The challenge that exists is keeping it at the forefront of people's minds in planning for the RAMR cycle and keep YDM on the agenda.* [Teacher 57, School 3C]
- *Ensuring furthering our journey gets the air time it needs (and deserves)!* [Teacher 46, School 5C]
- *There is only so much I can do as we don't get extra time to teach other teachers about YuMi. With the maths itself I found no challenges as YuMi is easy to implement and use.* [Teacher 26, School 4E]
- *Breaking down traditional ways of doing things as teachers poses new challenges, persevere I will though.* [Teacher 97, School 7B]

Evidence and assessment. A lack of hard evidence of student learning was seen as a challenge by a small number of teachers. Meeting school and parental expectations for assessment was a challenge for secondary teachers:

- *Teachers across the year met the challenge of having nothing written down or in students' maths books as evidence of learning after a rigorous maths lesson. They are much more at ease with this and are in the developing stages of creating simple and manageable systems which capture what students can do, know and understand. (photos, quick anecdotal notes, post-it scribbles which are sometimes student managed) This is also an area in development but a challenge teachers faced and 'let go!' as they saw that the time spent recording was not the intent of the lesson but the discussion and problem-solving was.* [Teacher 121, School 5C]
- *The stress of ensuring you teach the mathematics so that students can achieve well on assessment, while still trying to engage students. Schools and parents see assessment results, however in secondary school they don't really get to see student understanding through 'hands-on activities'.* [Teacher 52, School 1C]

2.4.2 Whole-school implementation

After teachers have become confident in their own use of YDM, they are ready to begin the process of sharing YDM with their colleagues, supporting them in adopting the pedagogy and acquiring the necessary resources. This leads to whole-school implementation of YDM where all teachers are using the pedagogy and school documentation explicitly refers to YDM use. This process may not begin to produce results until the second year of the program.

Evidence of whole-school implementation has been collected from surveys of teachers and principals, teacher reflective journals and YDC practitioner reports of their school visits.

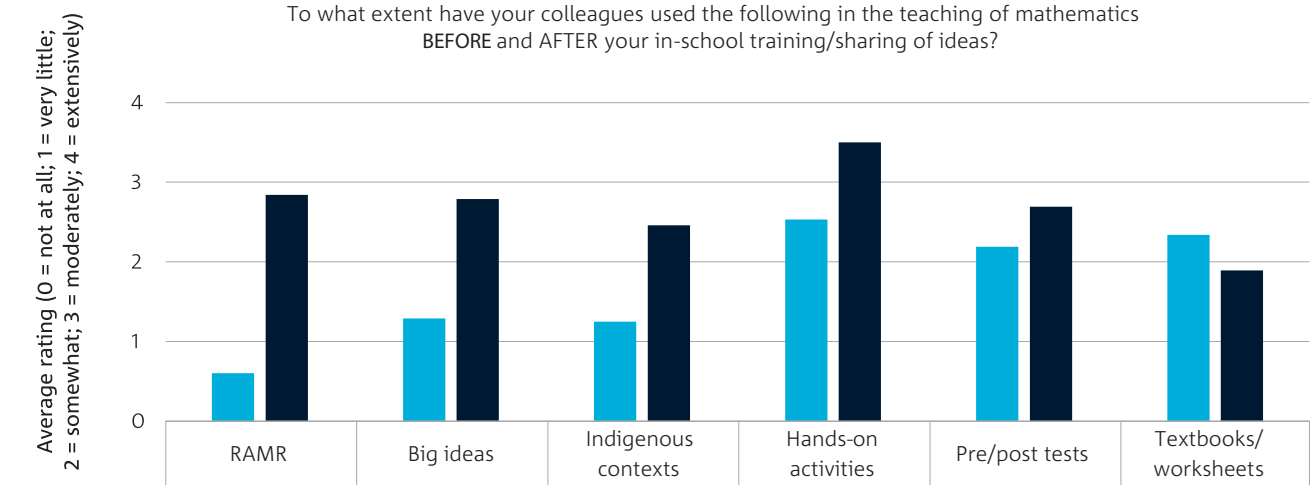
Teacher surveys

Table 2.18 shows that the teacher-trainers in almost every school have provided some in-school training to at least one of their colleagues, with 97% of survey responses reporting the training of one or more colleagues. It is possible that the 3% of teachers who had not shared YDM with any colleagues were those who attended PD workshops later in the program and may not have been sufficiently advanced in their own YDM journey to share with other teachers.

The most prominent methods of in-school training were sharing of ideas/strategies (80%) and informal conversations (78%). The majority of responses rated the train-the-trainer approach as 'sometimes effective' (52%), and the most common feedback from colleagues about the YDM approach to teaching mathematics was positive, with colleagues wanting to try more YDM (61%) and/or learn more about YDM (60%). However, many colleagues were also concerned about the lesson preparation work needed (37%). A lack of time for both the teacher-trainers (44%) and their colleagues (45%) was the leading challenge for in-school training.

Table 2.18 also shows that according to the biannual teacher surveys, their colleagues had used 'one or more activities' most commonly (76%), followed by 'YDM lesson plan(s) developed by someone else' (33%) and the use of 'some Indigenous contexts' (26%).

Results from the teacher exit survey (see Figure 2.4) show substantial increases from the beginning to the end of the program for their colleagues' use of RAMR, big ideas, Indigenous contexts and hands-on activities, and a small decrease in the use of textbooks/worksheets by colleagues, as would be expected when using the YDM approach.



	RAMR	Big ideas	Indigenous contexts	Hands-on activities	Pre/post tests	Textbooks/ worksheets
BEFORE	0.60	1.29	1.25	2.53	2.19	2.34
AFTER	2.84	2.79	2.46	3.50	2.69	1.89

Figure 2.4 Teacher perceptions of change in their colleagues' teaching approaches (exit survey, n = 125)

Table 2.18 In-school training by YDM teacher-trainers (biannual and exit surveys)

ASPECT OF IN-SCHOOL TRAINING	% OF RESPONSES (N = 569)
How many colleagues have you shared YuMi Deadly ideas with?	
• none	3%
• 1–2	23%
• 3–5	28%
• 6–10	11%
• all teachers in the school/department	35%
How have you shared the YDM approach with your colleagues?	
• sharing ideas and strategies	80%
• informal conversations	78%
• short presentation(s) at staff meeting(s)	53%
• sharing of YuMi Deadly Maths books	46%
• mentoring other teachers	42%
• presentation(s) to meeting of school managers	17%
• extended training session(s) for colleagues	16%
• no opportunity to share with colleagues	3%
• other	8%
How effective do you think the 'train-the-trainer' approach has been in your school?	
• very effective	7%
• mostly effective	22%
• sometimes effective	52%
• not very effective	4%
• the 'train-the-trainer' approach is not working in my school	4%
• can't say because we have not yet tried the YDM approach	11%
What feedback have you received from your colleagues who have tried the YDM approach?	
• want to try more YDM	61%
• want to learn more about YDM	60%
• concerned about the lesson preparation work needed	37%
• not very different from what they have already been doing	29%
• very keen to adopt YDM approaches	24%
• pre/post tests allow them to focus their teaching on areas of need	10%
• does not suit their style of, or beliefs about, teaching mathematics	8%
• not very useful for them	4%
• too many tests	1%
How have your colleagues applied the YDM approach in their mathematics classrooms? (surveys 1–3 only, n = 432)	
• they have used one or more activities	76%
• they have used a YDM lesson plan developed by someone else	33%
• they have used some Indigenous contexts	26%
• they have used their own YDM lesson plans	21%
• they have reduced their use of textbooks/worksheets	20%
• they have used pre/post tests	19%
• they have changed to a RAMR pedagogical approach in most/all lessons	6%
What obstacles have you encountered in sharing the YDM approach with colleagues?	
• some colleagues are too busy/not enough time	45%
• I am too busy/not enough time	44%
• conflicting school priorities	33%
• some colleagues resist new ideas/methods	27%
• some colleagues are unwilling to take on the extra work	26%
• some colleagues do not accept the need for change	25%
• some colleagues are not interested	24%
• some colleagues lack information about the local Indigenous culture and community	21%
• there is a lack of suitable classroom resources	19%
• trained teachers have left the school	12%
• there is little support from HoD/HoC/Principal	8%
• the school's mathematics program is not suited to the YDM approach	8%

Principal surveys

Table 2.19 shows survey data on the use of YDM methods in schools as perceived by principals. On average, principals perceived an 'occasional' to 'moderate' use of YDM methods across their schools. Although implementation of YDM methods was noticeably lower in the primary years in Clusters 7 and 8 (located in Brisbane South and Far North Queensland, respectively), these clusters included only one and two primary schools, respectively, meaning most responses would have been from secondary school principals.

Table 2.19 Principal perceptions of the use of YDM methods in their schools (biannual and exit surveys)

	CLUSTER										AVERAGE
YEAR LEVEL	1 (N=31)	2 (N=29)	3 (N=13)	4 (N=20)	5 (N=25)	6 (N=17)	7 (N=15)	8 (N=23)	9 (N=17)	10 (N=28)	1–10 (N=200)
Prep to Year 3	2.40	2.40	2.33	2.38	3.06	2.83	1.33	1.30	2.45	2.71	2.49
Years 4 to 6	2.30	2.50	2.33	2.50	3.07	2.92	1.33	1.30	2.55	3.26	2.61
Years 7 to 9	2.80	2.60	3.00	1.70	2.63	2.08	2.71	2.13	1.31	1.80	2.25
Whole school	2.40	2.30	2.86	2.10	2.93	1.40	2.00	1.00	1.80	2.73	2.23

Note. Rating scale: 0 = none; 1 = rare; 2 = occasional; 3 = moderate; 4 = extensive. Four biannual surveys and one exit survey in Clusters 1–4; three biannual surveys and one exit survey in Clusters 5–10. For consistency, the Clusters 1–10 column excludes the fourth biannual survey results from Clusters 1–4 (n = 18 responses).

Teacher reflective journals

The journals showed that in-school training and implementation was occurring through a variety of strategies ranging from formal or faculty training to informal sharing with other staff, modelling YDM lessons, providing all staff resources and lesson plans, and embedding YDM practices such as the use of reality contexts across the school. This section summarises the comments by teacher-trainers about extending YDM to the whole school.

- *At every second staff meeting, we have implemented a warm-up activity to the staff … We have introduced YuMi Deadly to the whole staff at a staff meeting … and how the project will be slowly introduced into our school … We have shared many of the ideas from there [workshops] with our staff. [Name] and I have timetabled time together each week/fortnight to focus on the implementation of YuMi into our school. [Teacher 28, School 4A]We ran a PD for the whole of Junior Maths faculty in the student-free days and generated some good conversations about what we can do to incorporate more physical activities into classes. At least one classroom teacher now has a number line taped on the floor.* [Teacher 80, School 4H]
- *… were given the opportunity to have a whole half day of a pupil free day to share YuMi activities! Such a different training for them all, being up on their feet. Got the teachers thinking about how they could incorporate this in their maths and teachers even found they could use this in other subject areas … Also got share what worked for us and some of the stories about how we got certain students engaged. We shared the RAMR model and a few examples to help give ideas. Teachers could see this being used in other learning areas.* [Teacher 73, School 6E]
- *I am running Maths Staff PDs to share lesson and activity ideas and inspire others to deliver engaging lessons using YuMi and the RAMR approach.* [Teacher 97, School 7B]
- *Presentation to all staff at the staff meeting … demonstrated/practised a measurement lesson with a Year 6 class … work with a Year 4 class once a week to model for the teacher.* [Teacher 25, School 4A]
- *I modelled a class … about graphs and reading graphs as they have done a unit on data collection … It was good to show this teacher some different ways to make connections in Maths 'through storytelling' … We [teachers] plan together and frequently reflect on our teaching together … Our site are [sic] happy to trial and play around with the YuMi approach to teaching … I organised a working bee for all staff to help make math mats with 100s charts, tens frames*

and number ladders … this was a good opportunity to get all hands on deck to make more resources readily available to the staff. [Teacher 66, School 6D]

- *Modelled a fraction lesson to start the unit for a colleague … We brainstormed what students knew about fractions—discussions linking to their reality etc. … Moved on using bread to create a number line using fractions … Walked the line and had discussions about the patterns etc. I gave the teacher some activities and examples of where to move to continue this lesson and unit on fractions. The following day she came to me and told me … the number line was good to reinforce learning with the class—they were more engaged and understood. She said students really benefited from walking the line and moving etc (more willing to get on board and up and moving than previously—getting used to the WHOLE BODY activities).* [Teacher 66, School 6D]
- *I demonstrated a YuMi lesson … on fractions of a quantity to … teachers at my school … They were amazed to see YuMi in action … The teachers were so enthusiastic about using the YuMi approach when teaching maths as they could see how engaged everyone was and how the students understood the concept.* [Teacher 30, School 4F]
- *I have been working with another teacher who is eager to learn about YuMi … My co-teacher has been very receptive to all the learning, trials and triumphs and even had a go at teaching a lesson on her own.* [Teacher 64, School 6C]
- *I am looking forward to facilitating staff learning as the term progresses on multiplication so some teachers have the confidence and capacity to move beyond just speed and accuracy testing and rote learning.* [Teacher 56, School 5C]
- *I have been supporting the teachers with weekly visits in the classroom. We are tackling the RAMR together and identifying useful strategies for reality and abstraction. Each week we are co-building a concept planner that covers RAMR suggestions that we will be able to attach to our curriculum planning documents. Feedback has been positive from Prep and Year 1 … In terms of whole-school rollout, I have aligned the RAMR with our Explicit Instruction Framework as staff need to see how they complement each other rather than replace each other. The teachers had positive feedback on the alignment. I also created our RAMR visuals so the students can make connections with their learning.* [Teacher 99, School 7A]
- *Trying to adapt YDM to … [our] context. Attempting to overcome the perception of some staff that it wouldn't work for their context. We did a whole staff demonstration of the RAMR cycle. This inspired some staff to have a go and alleviated some concerns. The challenge that exists is keeping it at the forefront of people's minds in planning for the RAMR cycle and keep YDM on the agenda.* [Teacher 57, School 3C]
- *We revised the YuMi 'way' and brainstormed Reality in year level groups … asked all staff to try to introduce Reality into some of their lessons … asked for volunteer staff to work with us on YuMi and had a good response—someone from each year level at this stage except for Year 5. Two of us are doing demonstration lessons with these teachers … We took our staff through some examples of RAMR lessons on angles … We also provided some resources that they could use to introduce the lesson (Indigenous pictures).* [Teacher 25, School 4A]
- *To enable our staff to communicate and collaborate effectively, I have developed a YuMi OneNote that we are all contributing to. I … regularly communicate with the teachers at our school to reflect on our progress … 91% of staff surveyed said they wanted YuMi training. This speaks well for the program and how the YuMi trained staff at school are sharing their passion. After a very successful staff opt-in YuMi Deadly PD, staff have increased their awareness of YuMi and how this thinking can be applied to their work … We showcased several 'YuMi-fied' math concepts in our school library and allowed teachers to roam so that they could pick and choose what piqued their interest … The principal is encouraging of the YuMi focus and looks for opportunities to allow our YuMi facilitators to share.* [Teacher 34, School 4F]
- *I have managed to get the Head of Curriculum to upload onto our School Site a lot of YuMi Deadly Resources for all to share; I have almost moved all the Maths equipment in the school into one location so that staff can find Maths Resources for their lessons.* [Teacher 18, School 4C]
- *I have worked with the YuMi school leaders team to begin to develop RAMRs for their specific class needs.* [Teacher 22, School 4D]
- *The reality aspect is not always so easy to find and I feel that lots of teachers skip this part. We know from YuMi how important this is. My YuMi team … is meeting this week and one of the agenda items will be helping teachers link maths to real life … The RAMR planning tool … is certainly a planning tool I will begin to use with my team at school.* [Teacher 63, School 6B]

- *The teachers loved the ideas so much. One teacher was so keen to try the activities with her prep class the next day that I gave her my resources! … I demonstrated a YuMi lesson … on fractions of a quantity to … teachers at my school; I've been having a fantastic time playing with grade 3 and grade 4 and the teachers have been able to see that YuMi does indeed work for their kids too. I've taught fractions of a quantity, graphs, properties of 3D shapes, angles and division. Each time I've followed a RAMR approach … share my YuMi knowledge with staff through a YuMi Maths Fiesta in Term 2 and sharing with my cohort how I effectively teach angles the YuMi way … Initiated a meeting with HOC about installing tens grid and hundreds board plus place value houses and a large circle in several locations around the school.* [Teacher 30, School 4F]

- *We have started our whole-school implementation. Teachers have reacted positively to the PD and have started implementing the philosophies of a RAMR in their lessons … Enthusiasm has developed in some lower school teachers who are seeing transferability of skills to other curriculum areas based on the idea of abstract concepts … Feedback cycles are occurring with teachers and interactions are positive … we have started accessing more of the online material which has been extremely helpful in providing our teachers with RAMR examples. We have incorporated these with our own concept planners we have designed to now have a good bank of resources that cover most concept descriptors.* [Teacher 99, School 7A]

- *Once we felt more confident with … the RAMR cycle, we aligned the Achievement Standards with the Content Descriptors. Our intention was to build our knowledge of the Math curriculum and our purpose was to choose the guarantees for each level and base them on the YuMi Big Ideas. We created benchmark tests. … Once we could see where our students needed to improve we trialled learning stations in our classrooms. If the whole class needed to work on a concept we start the RAMR cycle.* [Teacher 62, School 2B]

- *As a whole school we have committed to using YD maths as our 'how to teach mathematics'. … trying to ensure that all staff understand the RAMR cycle. … I am increasingly trying different ways to support staff to implement YDM.* [Teacher 57, School 3C]

- *The teachers have been trialling different aspects of YuMi lessons and testing RAMR versions.* [Teacher 34, School 4F]

- *Having a different team this year has allowed me a chance to work with non-YuMi trained teachers and share ideas, knowledge and collaborate to build in the links to student reality and whole-body learning. I planned with my year level team in the holidays and they have been trialling different activities and seem happy with it so far.* [Teacher 66, School 6D]

- *Using the RAMR planning involves another way of lesson planning that will take years to compile and replace current plans, but hopefully well worth it in the end. … Dividing up all the components equally and making time for reflection is essential as is revision of topics at all stages of RAMR.* [Teacher 83, School 3A]

- *Teachers are starting to realise the need to make students' learning more realistic. They will get more learning happening as well as more engagement from their students. … We printed out a lesson plan for each of the grades to implement with their classes this term and they will report back at a staff meeting next term.* [Teacher 28, School 4A]

- *Unit on patterning to my Year 2 class. I collaborated with the other 3 Year 2 teachers to co-plan using the RAMR unit. … The cyclic framework used when planning within a YuMi mindset is more effective. … It has changed the teaching approach across the year level.* [Teacher 77, School 5E]

- *I would like to learn more about pre and post testing as I feel ill-equipped in this area. I want the testing to reflect the YuMi philosophy and pedagogy. I plan to work with colleagues in small group planning and staff meetings to improve in this area.* [Teacher 77, School 5E]

- *We are now looking at how to 'YuMify' other subjects.* [Teacher 7, School 2B]

- *I am using/considering YuMi pedagogy across the curriculum. Helping students (Aboriginal too) to see the whole before the small parts e.g., pre-teaching vocab, to then deconstruct a text, prior to students attempting to construct their own, coding sentence writing, manipulating words/phrases to have students physically make sentences, moving around. You could say, an 'AHA' moment! … This way of teaching can be transferred across the curriculum, and sits alongside our TfEL design tool with ease. In fact, it value adds to it by ensuring teachers consider how they will assist with student understanding by bringing in the hand, body and mind, and then checking for and consolidating learning using reflection.* [Teacher 46, School 5C]

Some teacher-trainers described the establishment of professional learning communities with teachers from other schools:

- *Partnership presentations … I have conducted two YuMi Maths presentations for teachers of our partnership. In each session I highlighted the importance of the RAMR model and how it relates to … Natural Maths strategies that schools have already implemented. It was a great chance for me to share my journey and resources and get ideas from other teachers of the middle primary years. I definitely had more content and greater experience to talk to in the second presentation. This valuable experience enabled me to be a leader and advocate for the YuMi Deadly Maths strategy. … I have enjoyed the implementation. It has been encouraging to witness other teachers using the resources and creating their own lessons. I feel like I'm leading our staff and staff from other sites in YuMi Maths.* [Teacher 71, School 5D]
- *[Teacher] organised and facilitated network meetings to keep us all accountable and provide teachers [with] a chance to network, reflect and share ideas. These meetings were so valuable and I loved having a chance to work with other teachers from different sites. … It was great to begin the term with a YuMi Network meeting I organised to have at our site. Teachers were positive and seemed to enjoy this opportunity. … I also put the invite out to staff at my site to join in these year level groups so they could hear from someone other than me about the activities and learning other sites are involved in. The feedback seemed positive.* [Teacher 66, School 6D]
- *From the YDM workshops we have furthered our own learning and now have a professional learning community. … We meet together to share what we have been doing and to discuss any problems we may have encountered … discuss the planning of lessons, share resources and ideas. … Through this [school partnerships] we were able to work together and support each other with planning and queries. I found this fantastic to work alongside other teachers and see what they have been doing within their site. … It also gave me time to reflect on my practice as a teacher, further build and develop my ideas and gain ideas from another teacher that will support me into the future.* [Teacher 64, School 6C]

There was evidence of schools supporting kinaesthetic learning by providing the necessary resources:

- *Our school recently had a blank 100 square marked into our courtyard.* [Teacher 73, School 6E]
- *Grid mats developed … Areas painted (handball courts already existing).* [Teacher 127, School 8B]
- *Changed layout of room for more floor space. … Furniture is moved to the side to create space for maths lessons. … 100 square painted on concrete. 100 square mats being made and delivered to classrooms. Made place value cup stacks.* [Teacher 94, School 8B]
- *I bought shade cloth and tape to create Number Mats to gain teachers' attention on YuMi. Teachers made their own mats during a 'Make and Take' afternoon.* [Teacher 18, School 4C]
- *Gathered all the Maths equipment into one place, organised the cupboards into Number/Length/ Mass etc. Created an inventory of all the resources and placed them onto the teacher drive in the folder titled MATHS.* [Teacher 68, School 3A]

YDC cluster coordinator reports

School visits

Reports from YDC cluster coordinators showed that the extent of school engagement with the PRIME Futures program varied considerably. School engagement and commitment to the program can be summarised into three broad categories:

- **School-wide**: A commitment from the outset to embed YDM as the preferred mathematics pedagogy across all levels of the school (mainly primary schools).
- **Faculty-wide**: A commitment to embed YDM as the preferred mathematics pedagogy across all classes in Years 7–9 (mainly secondary schools).
- **Key teachers only**: YDM strategies being used by the key teachers only to a greater or lesser extent within their own classes (both sectors).

Some schools progressed from involving key teachers only to whole-school/faculty involvement during the program and some variation existed within such broad categories. One school in Cluster 2 displayed the greatest commitment from the outset by employing an additional staff member using additional school funds to coordinate and support teachers. Many schools almost immediately introduced PD for all staff.

A school in Cluster 4 arranged an additional full day of training from YDC for the entire staff of the school, including paraprofessionals and the leadership team. This was conducted at their school at an additional cost to the school, as they felt that it was important for all teaching staff to have access to this program and an understanding of the program. This was delivered at the start of the second year of the program and was well received by all staff.

Other evidence of commitment came in the provision of classroom resources, storage space for additional resources and, in the case of one school, a room to both store/manage resources and use those resources in a space with Indigenous cultural artefacts and practices evident (see Figure 2.5).

Those schools with the highest engagement also had clear implementation strategies incorporated in the school annual operational plan (see Figure 2.6) and/or references in teaching programs (e.g., secondary schools 8C, 8G and 8H made substantial changes to their teaching programs).

At the other extreme, some schools restricted the program to key teachers only, adopting a wait-and-see attitude before making decisions about which aspects of YDM to adopt and implement.

Figure 2.5 Dedicated YDM resource room including yarning circle

YUMI Deadly Maths

Action Plan (2016)

Key priority: **Initiate the Yumi Deadly Maths pedagogical approach**

	GOALS	SCHOOL STRATEGIES	ACTIONS
Successful learners	Students demonstrate significant, measurable growth and achievement in Numeracy (LoA, NAPLAN).	Further develop the systematic, whole school processes for the planning and delivery of differentiated teaching for student learning across the school.	Analyse student data regularly to inform improvement and guide teaching practices. Implement and monitor 'action-research project'.
		Support Indigenous students with differentiated teaching practices.	Create a culture of engaging learning that improves achievement for all students.
Great	To have staff with high levels of	Identify consistent and effective	Coach and mentor teachers in Yumi Deadly Maths.

Figure 2.6 Extract from a school annual operational plan

Implementation

YDC practitioners agree that it often takes time for the outcomes of the YDM pedagogy to come to fruition. In the first one or two PD workshops, teachers are just coming to grips with the concepts and have yet to see the difference it makes. After two years of formal training, the seeds that have been planted throughout the PDs generally begin to produce good results. By the end of the PRIME Futures program and the final PD, many participants who were initially doubtful expressed glowing comments and shared discussion and/or demonstrations of effective implementation. This highlights that a two- or three-year term for a project, while demanding a strong commitment from schools in terms of staff attendance at PDs, is barely sufficient to cement new practices, and may not be long enough for effective train-the-trainer practices to be established within the school.

Initially, the teachers involved focused on their own professional growth. Individual implementation levels by teachers varied both within and between schools. Classroom observations during school visits confirmed survey evidence that all teachers were trialling some YDM strategies. Indirect evidence (such as students' familiarity with the strategies, routine procedures for movement around the room and enquiries about YDM resources) suggested that most teachers were genuine in their attempts to develop strategies and practices in line with YDM pedagogy.

After teachers became more confident in the use of YDM they then progressed to sharing with other teachers of the same year level. This often occurred towards the end of the first year of the program. Some Queensland schools had exposure to earlier YDM projects and already had some elements of YDM embedded in practice from the outset.

It is interesting to note that some 'second generation' YuMi teachers (i.e., those who have been trained by the trainers who attended the PD) have contributed to the implementation of YDM. For example, in Cluster 1, the Emerald Educators' Conference has been a biennial fixture in this district. Each time they have invited a YDC presenter to work with local teachers to enthuse more teachers.

Two schools in Cluster 4 held YuMi Fiesta Days at their schools, which involved the entire school participating in YuMi-style activities throughout one or more sessions of the school day. One of the schools also invited parents along to participate, with a good response. The other school held YuMi Fiesta Days for the upper and lower school on two separate occasions, during which every child and teacher in the school participated, and held a combined Fiesta Day with the local high school as part of the Year 7 transition program.

A school in Cluster 9 conducted a Maths Activity Day (MAD) across the whole school using activities largely supplied by the PRIME Futures teachers. This led to requests for the teacher-trainers to share more information about the PRIME Futures program and the YDM approach with the rest of the school.

School change

School changes observed during this program were very much dependent on the input from the leadership team within the school. Most schools sought to embed some YDM strategies and practices into existing instruction programs, although some schools took longer to decide on how YDM would be used within the school and to identify the necessary resources. Implementation within these schools did not progress much beyond the teachers attending the PD workshops.

In some clusters, schools were used to forming partnerships with other schools. This led to many examples of schools working together to support the implementation of YDM.

The schools that showed the highest level of uptake and change within their schools were those that supported one another, meeting regularly and training each other as well as their peers.

Three schools in Cluster 6 that were geographically close to one another formed a partnership, which supported the implementation of the PRIME Futures program and training of other staff in their schools and region. Teachers from this group of schools had a very high uptake of YDM, both in their own classrooms and across the schools. The trainees became YuMi Champions and were expected to take on a leadership role. Staff from these three schools also delivered PD outside of their schools at conferences and workshops and at the YDC Sharing Summit. These schools have a strong ongoing commitment to YDM and have embedded the philosophy in their school documents.

The coordinator of Cluster 10 (Albany, Western Australia) considered the cluster one of the most successful and cohesive of all the clusters. This was attributed to several factors:

- The isolated location probably meant there were fewer PD opportunities for these schools than elsewhere, so participants were more engaged and committed.
- The cluster was relatively close geographically and drawn from schools that were keen to be involved.
- All principals or deputies attended at least one workshop, with some deputies continuing to attend as part of the team, showing commitment and support.
- The participants from each school were well chosen, being ready to learn, committed and very stable. Very few teacher changes meant that each teacher benefited from the whole course, which was a good base for continuity in schools.
- The involvement of seven different YDC practitioners in the delivery of the program to this cluster (PD and school visits) appeared to be a positive factor, enabling participants to experience different styles of presentation and a wide variety of ideas for implementation.
- Indigenous perspectives seem to be more clearly part of the Western Australian educational landscape and local culture than in other states.
- There was a wide range of participants, who taught students from Prep to Year 12.
- The local network coordinator was a strong driver of the program.

To achieve effective ongoing change and continuous refinement requires a considerable investment of time and money to support staff from within the school resources. While the PRIME Futures program may be the catalyst to spark change, the greatest investment comes from within the school. Thus, the greatest evidence of implementation occurred in schools where the leadership team was actively involved in the implementation. In these circumstances, the teacher-trainers were active in changing their own practices but also in spreading concepts to other teachers. YDC practitioners agreed that there are four essential requirements for a school to implement and maintain a pedagogy such as YDM across the school:

- support and high expectations from the leadership team
- key personnel to drive the change and being retained in this role
- systemic and regional focus supporting the change
- time and money to support staff in making the change.

Without this involvement and leadership, teachers largely confined practices to their own classroom.

Within the schools that did make significant changes, there was considerable variation in the way it was achieved. The primary message evident in reports from YDC cluster coordinators was that 'every school does it differently'.

Challenges

Cluster coordinators reported on challenges that were encountered by schools and teachers. These were mostly unavoidable and reflected the reality of implementing a program such as PRIME Futures in a school setting. Although unavoidable, these challenges did have an impact on the outcomes.

Some schools experienced high levels of staff turnover. Frequent changes in the leadership teams of some schools over the duration of the program made it harder to sustain the process of school change. Where the incoming managers had little idea of the purpose and processes of the PRIME Futures program, the YDC practitioner used the school visit to provide the required information.

In some cases, leadership changes and systemic requirements impinged on the schools' ability to fully support implementation. These schools, while supporting their teachers and staff in attending the PD workshops and implementing the program in certain school areas or classes, were unable to commit to whole-school change. In most instances, it was changes to or the loss of key drivers of implementation in the schools that led to the lessening of the effectiveness and therefore the uptake of YDM across the school.

> In Cluster 1, only one out of the original seven school principals remained at the end of the program, and some schools had three or four different principals over that time.

> At one secondary school in Cluster 3, discussions were held during the initial visit with a view to providing PD for teachers in that school in addition to that offered by the PRIME Futures program. However, a change in the HoD position at the school resulted in a significant reduction in commitment. Subsequent staffing changes further reduced involvement, leading to the school withdrawing from the program.

The nature of the schools in the PRIME Futures program, serving low-SES and remote communities, was that many teachers took the opportunity to move to a less challenging, or more geographically desirable, school if it became available. Changes to the teachers attending the PDs were caused by those teachers leaving the school. This contributed to the large number of teachers attending only one or two PD workshops, as noted in Section 2.1.

In some cases, the remoteness of the cluster might have been a challenge. For example, in Cluster 5 (Port Lincoln) teachers did not have any prior experience of YDM nor were they able to visit any schools that were already using YDM practices. However, teachers overcame this by totally immersing themselves in the PD and taking every opportunity to gain more training and experience. The willingness of schools and the South Australian Department for Education to spend their own money to fly teachers to Queensland on more than one occasion to undertake further training opportunities, their willingness to turn over large amounts of their partnership time to developing YDM resources and programs, and their total dedication to implementing the training into their schools overcame the challenges of distance and access to trainers. This cluster, with its already established partnership, was exemplary in the way it was able to meet any challenges and implement this program.

In both Cluster 6 (Adelaide) and Cluster 9 (Geraldton), schools were undergoing restructures at the time of the PRIME Futures program. These restructures changed the year levels that the schools catered for. This impacted on teachers' opportunities to trial activities. However, the participants are to be commended for their commitment to implementing YDM concepts in their forward planning.

It is unfortunate that the PRIME Futures program coincided with the implementation phase of the Australian Senior Mathematics Curriculum and the associated changes to assessment methods, particularly in Queensland. This impacted particularly on secondary schools. Although PRIME Futures in those schools focused on Years 7–9, secondary school teachers were typically involved at many different year levels within the school. Therefore, teachers had the additional workload of coming to grips with the new assessment requirements and writing programs for the new curriculum as well as engaging with the changes to teaching pedagogy encouraged by the PRIME Futures program. Combined with six days of PRIME Futures training per year, the need to attend meetings and PD relating to curriculum and assessment changes meant that teachers' time away from class was impacting student learning and the school principals or deputies started to limit teacher time away from class. Workshops relating to assessment were considered to be essential, so PRIME Futures participation suffered, although the teachers concerned were still enthusiastic supporters of PRIME Futures and YDM.

A significant challenge for Queensland schools in implementing YDM pedagogy, both across the school and in an ongoing capacity, was the lack of Queensland Department of Education support for such programs. While the YDM program is accepted by the Department, it is not seen as essential content. With the recent move to Curriculum into the Classroom (C2C) in Queensland schools, many schools are being mandated to follow C2C lessons. Schools are required to report using test items included in C2C and if these lessons are not taught, the students are disadvantaged. While some teachers and schools have been able to interweave YDM and C2C, in many cases YDM was not viewed as core and therefore was seen as additional work, which time-poor teachers did not view as necessary.

Similarly, a directive in some Queensland Department of Education regions to use EDI caused concern for some Queensland schools, particularly those in Clusters 1 and 8. Some teachers initially refused to consider the YDM pedagogy, despite YDC staff adapting the RAMR framework to include or parallel EDI pedagogy. This resistance was overcome through the efforts of YDC staff. For example, in a Cluster 1 school, the principal asked to observe a YDM lesson delivered by the YDC cluster coordinator. After doing so, the principal decided, and convinced her staff, that the two approaches were compatible and they should continue to implement YDM.

In South Australia, Department for Education mandates and changes to key personnel at critical junctures influenced the effectiveness of the program, particularly in Cluster 6 (Adelaide). There was a change of focus in a number of the schools as a direct response to school reviews and/or regional directives that mandated English and reading as priority curriculum areas. This meant that PRIME Futures and mathematics programs or projects were seen as non-essential and not core business. This led to a decrease in participation and, for some participants and schools, an inability to enact or continue the changes recommended by the PRIME Futures program. Consequently, the PRIME Futures program resulted in minimal changes for some schools.

Further, during the course of the program there were changes in key personnel, impacting on the take-up of the PRIME Futures program. The amalgamation of a primary school and a secondary school in Cluster 6 meant that the newly appointed head of the primary section had not agreed to the use of the PRIME Futures YDM pedagogy in her school and did not support or continue to allow her teachers to be involved in PRIME Futures training. Changes in senior staff (e.g., Principal, HoC, Deputy Principal and Head of Mathematics) at three schools in Cluster 6 led to a lessening of support for the program and its implementation in those schools.

Changes of key personnel in the South Australian Department for Education also meant that the initial overwhelming support for the PRIME Futures program diminished over time and the participating schools no longer felt as supported by the Department in making changes.

In Cluster 9 (Geraldton) some other teaching programs were in use when the PRIME Futures program commenced. One school sought to use YDM in a manner for which it was not designed to supplement a commercially available package. Consequently, their staff participation diminished, and ultimately the school withdrew from the program. Four other schools in this cluster also withdrew from the PRIME Futures program because of overlap with other programs already operating in those schools. Other schools took from YDM what was needed to transform their teaching programs. Thus, YDM strategies were used in conjunction with other school and systemic initiatives.

2.4.3 Summary

Many of the teacher-trainers started applying YDM by experimenting with parts of the RAMR framework, initially experiencing varying degrees of success. The biannual surveys, conducted progressively throughout the program's implementation, showed that approximately two-thirds of the teacher-trainers had tried some YDM activities and/or developed their own lesson plans based on YDM methods. However, by the end of the program, more than half the teacher-trainers (53%) reported use of the YDM approach in most or all lessons. Almost all reflective journal responses contained accounts of lessons based on RAMR and body–hand–mind.

However, teacher-trainers also reported on challenges in implementing YDM in their own classrooms:

- finding a suitable reality/context, especially for secondary topics
- student behaviour
- resources needed for YDM
- time required in class and for preparation
- obtaining evidence of learning and link to assessment
- limited knowledge about Indigenous contexts.

YDM teacher-trainers in almost every school have provided some in-school training to at least one of their colleagues. The most common methods of in-school training were sharing of ideas/strategies and informal conversations. Some schools established in-school professional learning communities and others formed professional learning communities with other schools. The majority of responses rated the train-the-trainer approach as 'sometimes effective', with most teacher-trainers reporting that their colleagues wanted to do more with YDM. Results from the teacher exit survey showed substantial increases from the beginning to the end of the program for their colleagues' use of RAMR, big ideas, Indigenous contexts and hands-on activities.

According to the teacher-trainers, the main challenges in extending YDM to the whole school were the difficulty in inspiring other teachers to try YDM and the lack of time for both the teacher-trainers and their colleagues. YDC cluster coordinators reported that conflict with mandated teaching approaches and/or other school programs sometimes impacted on the whole-school implementation of YDM.

These general conclusions are discussed in more detail in Section 3.4.

2.5 Student outcomes

Chapter 1 outlined the nature and objectives of the PRIME Futures program. The program focused on students in Foundation (F) to Year 9, with the objectives of increasing participation and achievement of Indigenous students in mathematics. This was to be achieved by:

- **Improvements in student engagement**. Mathematics is a compulsory subject for students in Years F–9. It follows that the PRIME Futures program cannot lead to increased participation in mathematics at the school level. However, it can influence the nature of that participation. Accordingly, the PRIME Futures program sought to improve student engagement in mathematics. Engagement is defined to be the extent of the 'attention, curiosity, interest, optimism, and passion that students show when they are learning or being taught,' including their 'motivation … to learn and progress in their education' (Great Schools Partnership, 2016, para. 1).
- **Improvements in student achievement.** In education, achievement is defined to be the attainment by students of the desired learning objectives or standards that their schools and teachers want them to achieve.

The program aimed to achieve these improvements in student outcomes by training teachers in pedagogical approaches that are effective for Indigenous and low-SES students. Since the focus was on good pedagogy, it was expected that the program would also result in similar improvements for all students. The Indigenous focus was achieved by targeting those schools with higher than average Indigenous enrolments.

It has already been explained that the requirement to obtain informed consent from caregivers before data can be collected about students, and the practical difficulties in obtaining that consent in relation to every student in a class, effectively prevented the collection of data about student outcomes directly from students. However, teachers were encouraged to share de-identified and aggregated information about outcomes in their classes in some survey questions and in their reflective journals. This has resulted in a compromise between data quality and availability and a focus on qualitative data.

This section reports on the impact of the PRIME Futures program on both student engagement and student achievement. The results presented in this section were collected through online biannual and exit surveys of teachers and school principals, teacher reflective journals and reports from the YDC cluster coordinators.

2.5.1 Teacher and principal surveys

In the biannual teacher surveys, 86% of responses reported increased student engagement and 71% reported improved student learning/understanding (see Table 2.20). About one-fifth (22%) of responses reported better test results. There was least reporting of increased STEM interest (9%).

Table 2.20 Percentage of responses reporting improved student outcomes (biannual teacher surveys)

WHAT STUDENT OUTCOMES HAVE YOU OBSERVED WHEN USING THE YDM APPROACH?											
	CLUSTER										AVERAGE
	1 (N=61)	2 (N=68)	3 (N=30)	4 (N=87)	5 (N=54)	6 (N=51)	7 (N=43)	8 (N=35)	9 (N=21)	10 (N=43)	1–10 (N=443)
Increased student engagement	93%	84%	80%	91%	89%	84%	91%	80%	67%	88%	86%
Improved learning/ understanding	85%	65%	67%	75%	65%	63%	88%	74%	48%	79%	71%
Better test results	26%	32%	17%	32%	13%	14%	21%	23%	10%	21%	22%
Increased interest in STEM subjects/ pathways/careers	11%	16%	7%	9%	11%	8%	16%	6%	5%	2%	9%

Note. Four biannual surveys in Clusters 1–4; three biannual surveys in Clusters 5–10. For consistency, the Clusters 1–10 column excludes the fourth biannual survey results from Clusters 1–4 (n = 50 responses).

The exit survey of teachers, as presented in Table 2.21 and Figure 2.7, confirms that teachers have observed an increase in all student outcomes, but particularly in student engagement, describing it as improving from 'satisfactory' to 'good' on average. However, the increased student engagement did not appear to have resulted in a similar increase in attendance at school.

Teachers were also asked about the engagement of different groups of students in mathematics. Table 2.22 shows that, on average, teachers observed slightly less than a 'moderate' increase in student in engagement. Of more interest is the fact that the increase in student engagement was observed in all types of students.

Table 2.21 Teacher perceptions of improved student outcomes in mathematics before and after using the YDM approach (exit survey)

BEFORE AND AFTER HAVING USED YDM – GIVE YOUR OPINION OF YOUR STUDENTS' OUTCOMES IN RELATION TO MATHEMATICS IN THE FOLLOWING AREAS:												
		CLUSTER										AVERAGE
		1 (N=9)	2 (N=11)	3 (N=3)	4 (N=20)	5 (N=14)	6 (N=22)	7 (N=10)	8 (N=10)	9 (N=5)	10 (N=19)	1–10 (N=123)
Student engagement	Before	2.20	2.40	2.33	2.30	2.64	1.76	1.70	2.20	1.60	2.32	2.16
	After	3.30	3.50	3.33	3.45	3.36	3.25	2.70	3.10	3.20	3.32	3.27
	Difference	**1.10**	**1.10**	**1.00**	**1.15**	**0.72**	**1.49**	**1.00**	**0.90**	**1.60**	**1.00**	**1.11**
Learning/ understanding	Before	2.20	2.30	2.67	2.40	2.36	1.80	1.80	2.00	1.60	2.21	2.13
	After	2.70	3.30	3.33	3.05	3.14	2.79	2.60	2.90	3.00	3.21	2.99
	Difference	**0.50**	**1.00**	**0.66**	**0.65**	**0.78**	**0.99**	**0.80**	**0.90**	**1.40**	**1.00**	**0.86**
Test results	Before	2.10	2.30	2.00	2.15	2.17	1.61	2.13	1.60	0.75	2.18	1.97
	After	2.40	3.10	3.00	2.80	2.75	2.41	2.57	2.50	2.50	2.76	2.68
	Difference	**0.30**	**0.80**	**1.00**	**0.65**	**0.58**	**0.80**	**0.44**	**0.90**	**1.75**	**0.58**	**0.71**
Interest in STEM subjects/ pathways/ careers	Before	1.40	1.90	3.00	1.63	2.00	1.67	2.25	1.00	1.25	2.07	1.75
	After	2.30	2.70	3.00	2.60	2.43	2.62	3.00	1.60	2.25	3.00	2.58
	Difference	**0.90**	**0.80**	**0.00**	**0.97**	**0.43**	**0.95**	**0.75**	**0.60**	**1.00**	**0.93**	**0.83**
Attendance	Before	2.60	2.30	2.67	2.20	2.92	2.05	1.90	2.67	1.60	3.00	2.42
	After	2.90	3.00	3.00	2.75	3.00	2.44	2.30	3.00	2.40	3.21	2.81
	Difference	**0.30**	**0.70**	**0.33**	**0.55**	**0.08**	**0.39**	**0.40**	**0.33**	**0.80**	**0.21**	**0.39**

Note. Rating scale 0 = very poor; 1 = poor; 2 = satisfactory; 3 = good; 4 = excellent.

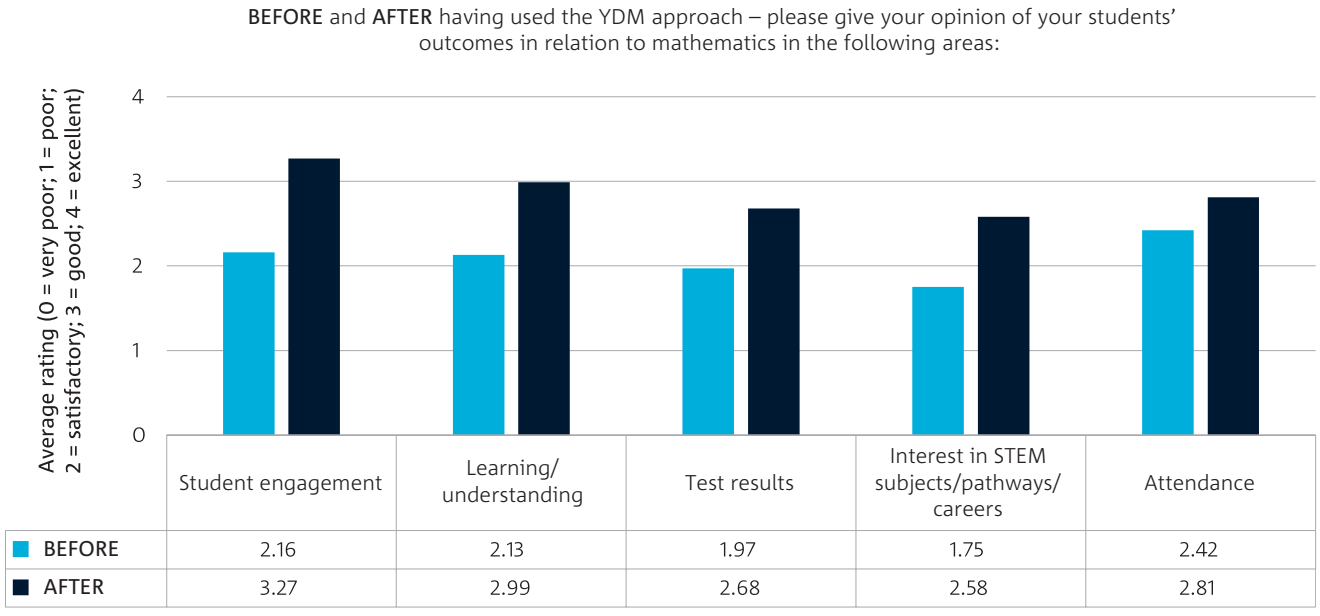


Figure 2.7 Teacher perceptions of improved student outcomes in mathematics before and after using the YDM approach (exit survey; n = 123)

Table 2.22 Teacher perceptions of increased engagement of different student groups in mathematics (biannual surveys)

HOW HAVE DIFFERENT GROUPS IN YOUR CLASS(ES) INCREASED THEIR ENGAGEMENT IN MATHEMATICS?											
	CLUSTER										AVERAGE
	1 (N=61)	2 (N=68)	3 (N=30)	4 (N=83)	5 (N=51)	6 (N=50)	7 (N=43)	8 (N=34)	9 (N=20)	10 (N=43)	1–10 (N=443)
Indigenous	2.50	2.60	2.52	2.68	2.52	3.03	2.55	2.68	2.56	2.66	2.64
Boys	2.80	2.60	2.46	2.92	2.79	3.07	2.83	2.64	2.50	2.77	2.78
Girls	2.60	2.70	2.73	2.77	2.57	3.15	2.70	2.59	2.53	3.03	2.75
Upper ability range	2.70	2.60	2.69	2.93	2.62	3.26	2.67	2.38	2.47	2.83	2.74
Lower ability range	2.80	2.70	2.50	2.85	2.84	3.33	2.86	2.76	2.25	3.15	2.85

Note. Rating scale: 0 = not at all; 1 = very little; 2 = somewhat; 3 = moderately; 4 = extensively. Four biannual surveys in Clusters 1–4; three biannual surveys in Clusters 5–10. For consistency, the Clusters 1–10 column excludes the fourth biannual survey results from Clusters 1–4 (n = 50 responses).

The exit survey confirmed these results from the biannual surveys, showing that teachers perceived improved engagement for all groups of students, with the highest improvement for students in the lower ability range and Indigenous students (see Table 2.23 and Figure 2.8).

Table 2.23 Teacher perceptions of increased engagement of different student groups in mathematics (exit survey)

BEFORE AND ***AFTER*** HAVING USED THE YDM APPROACH – TO WHAT EXTENT HAVE DIFFERENT GROUPS IN YOUR CLASS(ES) SHOWN ENGAGEMENT IN MATHEMATICS?												
		CLUSTER										AVERAGE
		1 (N=9)	2 (N=11)	3 (N=3)	4 (N=20)	5 (N=14)	6 (N=21)	7 (N=10)	8 (N=10)	9 (N=5)	10 (N=19)	1–10 (N=122)
Indigenous students	Before	1.20	1.50	1.33	1.67	2.29	1.37	1.67	2.00	2.20	1.76	1.71
	After	2.30	3.10	2.33	2.61	3.21	3.00	2.67	2.78	3.60	2.88	2.88
	Difference	**1.10**	**1.60**	**1.00**	**0.94**	**0.92**	**1.63**	**1.00**	**0.78**	**1.40**	**1.12**	**1.17**
Boys	Before	1.80	1.60	2.67	2.05	2.57	1.89	1.78	2.00	2.20	2.58	2.11
	After	2.70	2.90	2.67	3.05	3.29	3.35	2.89	2.78	3.60	3.26	3.10
	Difference	**0.90**	**1.30**	**0.00**	**1.00**	**0.72**	**1.46**	**1.11**	**0.78**	**1.40**	**0.68**	**0.99**
Girls	Before	2.20	2.10	2.67	2.22	2.77	1.95	2.33	2.11	2.20	2.47	2.28
	After	2.90	3.20	3.00	3.17	3.29	3.11	3.11	3.22	3.60	3.21	3.17
	Difference	**0.70**	**1.10**	**0.33**	**0.95**	**0.52**	**1.16**	**0.78**	**1.11**	**1.40**	**0.74**	**0.89**
Students in the upper ability range	Before	2.90	3.30	4.00	3.06	3.36	2.76	2.67	2.38	3.00	3.47	3.07
	After	3.10	3.90	4.00	3.35	3.71	3.56	3.22	3.38	4.00	3.79	3.57
	Difference	**0.20**	**0.60**	**0.00**	**0.29**	**0.35**	**0.80**	**0.55**	**1.00**	**1.00**	**0.32**	**0.50**
Students in the lower ability range	Before	1.70	1.60	1.33	1.47	2.00	1.50	1.33	1.80	1.8	1.47	1.60
	After	2.80	3.20	2.33	2.74	3.00	2.95	2.67	2.70	3.40	3.16	2.92
	Difference	**1.10**	**1.60**	**1.00**	**1.27**	**1.00**	**1.45**	**1.34**	**0.90**	**1.60**	**1.69**	**1.32**

Note. Rating scale: 0 = not at all; 1 = very little; 2 = somewhat; 3 = moderately; 4 = extensively.

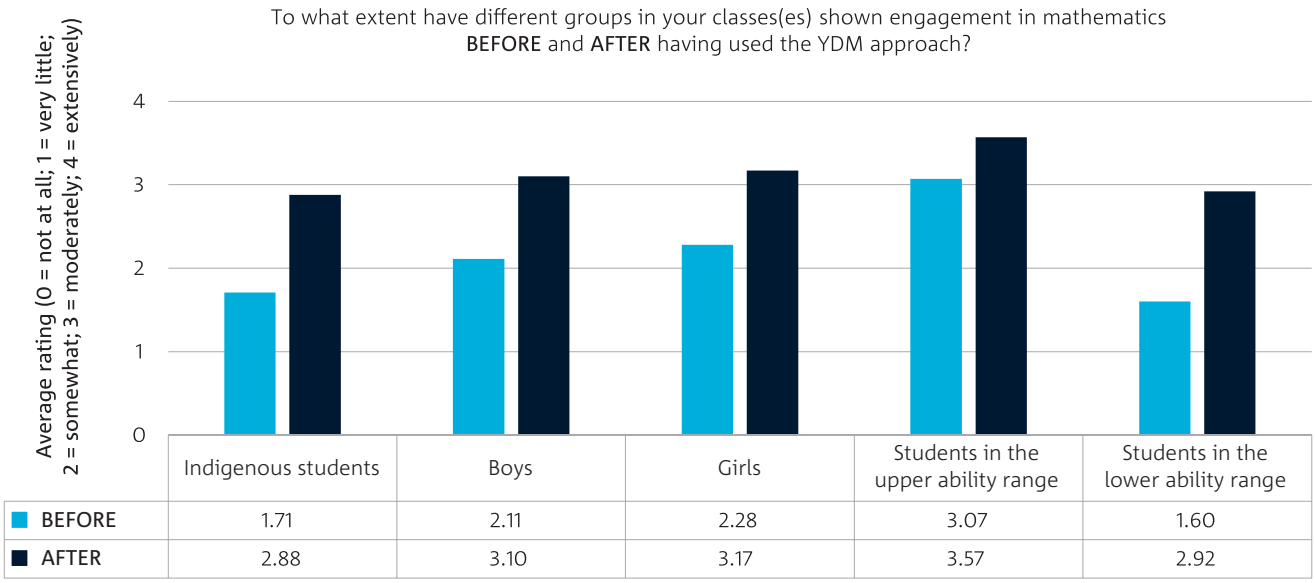


Figure 2.8 Teacher perceptions of improved engagement in mathematics of different groups of students before and after using the YDM approach (exit survey; n = 122)

Finally, Table 2.24 was presented earlier (Table 2.11 in Section 2.2.5) in the context of reporting on Indigenous student outcomes but is reproduced here to ensure a full accounting of all student outcomes. The exit survey of principals supports the teachers' perceptions of increased Indigenous student engagement (see Table 2.24 and Figure 2.9).

Table 2.24 Principal perceptions of improved Indigenous student engagement/achievement in mathematics (exit survey)

PLEASE GIVE YOUR OPINION ON THE EXTENT OF INDIGENOUS STUDENT ENGAGEMENT/ACHIEVEMENT IN MATHEMATICS **BEFORE** AND **AFTER** YOUR SCHOOL'S PARTICIPATION IN THE PROGRAM.												
		CLUSTER										AVERAGE
		1 (N=6)	2 (N=5)	3 (N=1)	4 (N=4)	5 (N=6)	6 (N=2)	7 (N=4)	8 (N=5)	9 (N=2)	10 (N=7)	1–10 (N=42)
Indigenous student engagement in mathematics	Before	1.80	1.80	2.00	2.00	1.83	1.50	1.00	1.40	2.00	1.86	1.71
	After	3.00	2.60	3.00	2.75	3.00	2.00	2.50	1.80	3.00	2.71	2.64
	Difference	**1.20**	**0.80**	**1.00**	**0.75**	**1.17**	**0.50**	**1.50**	**0.40**	**1.00**	**0.85**	**0.93**
Indigenous student achievement in mathematics	Before	1.60	1.40	2.00	1.50	1.67	1.00	1.00	1.60	1.50	1.29	1.40
	After	2.80	2.00	3.00	2.25	2.50	2.00	1.75	2.00	2.00	2.14	2.19
	Difference	**1.20**	**0.60**	**1.00**	**0.75**	**0.83**	**1.00**	**0.75**	**0.40**	**0.50**	**0.85**	**0.79**

Note. Rating scale 0 = very poor; 1 = poor; 2 = satisfactory; 3 = good; 4 = excellent.

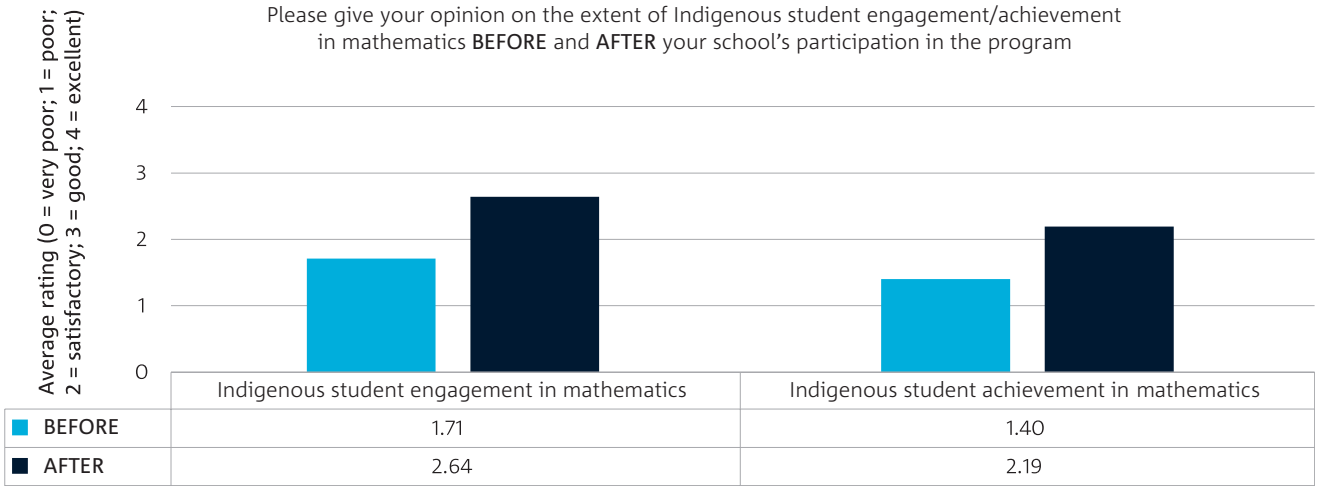


Figure 2.9 Principal perceptions of improved Indigenous student engagement/achievement in mathematics (exit survey; n = 42)

2.5.2 Teacher reflective journals

This section summarises common themes with excerpts from teacher reflective journals relating to improved student outcomes, especially in student engagement and achievement.

Student engagement

Teachers overwhelmingly commented on improvements in student engagement. In many cases they attributed this to the use of a pedagogy and activities that allowed students to act out situations using their bodies, hands and, eventually, minds:

- *My students engage when I provide them with hands-on experiences.* [Teacher 40, School 4E]
- *Students definitely engage more with hands-on learning.* [Teacher 54, School 2D]
- *I noticed how much the students enjoyed the opportunity to explore the mathematical concept through movement/body. I think already this provided more engagement from some children who would normally become distracted when sitting in at a seat or on the carpet. Many students were eager to have a turn on the number mat. … We tried out the physical movement of multiplying by 10 and dividing by 10 how the place value moves along. … it really supported the students' learning of this concept how a number becomes 10 times larger or smaller. … The students enjoyed the moving on the map. The body movement enabled the students to really think about quarter turns, turn left, right etc. … Learning maths concepts with real-life learning and hands-on experiences really provides students [with] an understanding of why they are learning it. Knowing the purpose increases engagement. … The students enjoy this method of learning and their attitudes show more positivity towards learning concepts they've previously thought were challenging.* [Teacher 19, School 4A]
- *The children love being able to move around, touch, experiment, discuss, hypothesise, test and reach conclusions.* [Teacher 37, School 4G]
- *I am trying to incorporate a lot more practical activities that are allowing students to move in my lessons before the working out of a textbook content. Students on the whole enjoy it.* [Teacher 15, School 4B]
- *Students were highly engaged and were not distracted … the kids love going outside and using hands-on materials.* [Teacher 36, School 4F]
- *By using active participation activities, the level of engagement within my students has greatly increased.* [Teacher 104, School 7C]
- *Students are always excited [about] doing some hands-on type activities.* [Teacher 60, School 6A]

- *Reintroducing models and manipulatives has had a huge positive impact on my class not only with engagement but also in positive attitudes towards maths.* [Teacher 5, School 2A]
- *Most of my students have enjoyed using their bodies.* [Teacher 73, School 6E]
- *Students loved the moving around the classroom, hands-on activities which put them in charge. They always love using the grid mat to do activities and engagement is always exceptional! … Every time I get the grid out for activities the students are immediately engaged.* [Teacher 13, School 1A]
- *The Aboriginal student in my class really enjoys hands-on activities as she is able to clearly demonstrate her understanding of concepts due to her low literacy skills. … Students are able to make links back to the activities they have done.* [Teacher 52, School 1C]
- *Engaging for most students. … Using body, hand, mind in consolidations increased engagement. … Prior knowledge/ why are we learning this connected to real-life experience more effectively. … Maths games worked well very engaging.* [Teacher 127, School 8B]
- *Year 1, Topic—Skip Counting … Students were engaged and really loved the movement.* [Teacher 96, School 7A]
- *Used [stairs] as an analogy with moving forwards and backwards with counting … It was great. The children were engaged, counting, laughing.* [Teacher 37, School 4G]
- *A very interactive and enjoyable lesson. Lots of laughing. … So much laughter with a fraction circles game that class next door wanted to know what we were doing!!! … It was a real buzz to see and hear students who don't normally participate in math be collaborative and contribute their ideas. The class certainly loved the hands-on nature of the lesson and that there was no math books or worksheets. Everyone was engaged.* [Teacher 30, School 4F]
- *The body and hands aspects have really assisted the students in building their understanding of maths concepts and the level of engagement was high.* [Teacher 64, School 6C]
- *The movement not only keeps people engaged but adds to the learning something tangible. An experience to call on in later learning.* [Teacher 42, School 5A]
- *The movement and active involvement has dramatically changed the way my children engage with their learning and has had a big impact on behaviour. … giving them natural object i.e., stones, sand, open space to learn in is very engaging for them.* [Teacher 38, School 4G]
- *Students were asked to compare the weights of each other's school bags. … The engagement of the students was fantastic and they all discussed which bags should be next to weigh.* [Teacher 112, School 5D]
- *By using hands-on activities and the RAMR strategy it allows my students to relate the new concepts being taught, back to their previous knowledge. This has started the students becoming more engaged in mathematics as they can see where this maths relates to their everyday lives. The activities also allow for active engagement in the class and clears up most misconceptions before they go deeper into the content.* [Teacher 104, School 7C]
- *During hands-on activities such as moving their bodies or moving cards or being active (even right down to answer the questions verbally) they could easily answer all of the questions … once we moved to a piece of paper the students couldn't or wouldn't try to answer.* [Teacher 18, School 4C]
- *Class groups work well when they are a good class. I have had plenty of good experiences with my Year 7 classes to hands-on YuMi type work. With my Year 8 foundation however it is a struggle as they are disinterested a lot. Though I did make a hands-on assignment for them and they have done well.* [Teacher 15, School 4B]
- *We have been learning about coordinates … before an excursion we had to … Zoo. Students were engaged as I used the animals from the Zoo along with pictures of the school to draw them in when we put the map together and looked at how to read coordinates. I also created little tables that students working on the floor could continue with while I could focus in on select students. This was a great way to increase engagement without losing the students.* [Teacher 66, School 6D]

The use of real-life contexts was also mentioned as an important way of engaging students:

- *Linking to reality is certainly engaging the class more.* [Teacher 63, School 6B]
- *Having the students use real-life experiences reinforced their application to the real world.* [Teacher 54, School 2D]
- *YuMi engages the students! … My students are now more engaged and it is easier to interest students now with reality and abstraction activities. … Maths now follows the RAMR cycle, with the reality and abstraction activities used as hooks in [the] 'maths' [part of the cycle]. … The 'YuMi' ideas and examples have made maths engaging and have demonstrated improvements in student learning.* [Teacher 7, School 2B]
- *I now approach most mathematical concepts with the question 'What reality is this concept based on?' Most times I can find simple ideas (usually straight from the school environment) that the students can connect with. This approach has enabled more 'buy-in' from the students and the concept is worked through in a much more in-depth way. … The incidental learning through their peers is amazing as well. … The children have been enjoying our Monday maths sessions because whatever content is being taught directly relates to them. … Also, those students who struggle have found ways to participate and be successful in their maths learning.* [Teacher 14, School 4A]
- *Found that providing meaning and purpose for their learning at the outset makes it relevant for them and doesn't make them feel as though they are alienated from the curriculum. Their attitude towards maths has changed. They love it because they can experience it. … I have seen a massive change in attitude, enthusiasm and confidence in my students. I believe that this could be the start of a really positive learning journey for them.* [Teacher 38, School 4G]
- *RAMR for a unit on angles … students had increased 'buy-in' after the reality phase. The students enjoyed the abstraction activity and identified that they were learning, and began making connections between these activities and their reality. During the mathematics phase, the students at first struggled … But after a couple [of] lessons, everything quickly fell into place for them.* [Teacher 87, School 4E]

Teachers commented on the improvement in engagement as a consequence of the pedagogy allowing the students to experience success in mathematics:

- *I have learned that students' attitude towards maths is very poor because they feel they are not able to solve questions or understand concepts. It is all 'too hard'. Showing them how easy it is gives them joy and empowerment and makes them want to show off what they have learned, both at school and at home.* [Teacher 5, School 2A]
- *Most were engaged and achieved success, some going beyond the lesson expectations. I think they were successful firstly because it was something different, secondly as it was well scaffolded and thirdly everyone supported each other and tried their hardest.* [Teacher 59, School 6A]
- *I have had very positive responses from the children I am teaching, many who struggle mathematically. Very few children are disengaged and I am seeing children who are saying, 'Now I get it'.* [Teacher 128, School 10D]
- *It was fantastic to see the engagement and buzz when they were successful.* [Teacher 64, School 6C]
- *Students estimating the same fractions on a rope with pegs. … With all the estimates of a rope of 10 metres, the maximum error was 7 cm for the 1/2 by one of the students and all the others were within 4 cm. This gave a sense of achievement for all participants. … One of the students was keen to learn about 'hard fraction addition, using the cross way', something they had seen in the past. … The next lesson I used clip-on cross multiplication and a couple of examples before the students were, some with assistance, getting it right. I started the next lesson with an interactive timed challenge on adding fractions with the same denominator, which got all but one of the students keen to beat each other's time.* [Teacher 139, School 9A]
- *My students are enjoying maths, for some it is their 'favourite subject'!* [Teacher 71, School 5D]

Many teachers described the improvements in students' attitude, enthusiasm, interest, enjoyment, confidence and motivation as a result of using YDM methods. While some teachers were still experiencing problems with student behaviour, many observed that it had improved:

- *The class I teach is working at Foundation to Year 3 level so if I don't YuMi lessons there are major behaviour management issues.* [Teacher 80, School 4H]
- *The lesson went really well. The most notable feature was the engagement of the whole class (a challenging class) in all the lesson's activities.* [Teacher 25, School 4A]
- *My students love it when I do 'YuMi'. They request it often and when I do a YuMi lesson behaviour for the class is always positive and behaviour for learning. Win-Win for all involved.* [Teacher 97, School 7B]
- *I have found that by utilising YuMi structures, specifically the reality and abstraction stages, my lessons are more engaging and students are more excited/willing to participate in maths lessons.* [Teacher 103, School 7A]
- *When learning the concept of time the children enjoy using craft to make Maths resources. They made a paper plate clock, drawing clocks on the quadrangle with chalk, making a wristwatch to play a game, laminated game packs and writing about what they do at a specific time.* [Teacher 106, School 10A]
- *YuMi has been excellent for my Aboriginal and Torres Strait Islander students but the program is also very beneficial for all the students in my class. … I noticed a massive difference in my students' engagement and their willingness to learn. … When they come back from second lunch they didn't want to do any learning, whereas now that is the highlight of our day. … It's just been fantastic for my teaching and for the students being so much more engaged and willing to do the activity.* [Teacher 10, School 1B]
- *This [activity] adds a lot more variety to the lessons and students seem to enjoy Maths a lot more than they were. A large number of behaviour issues seem to have dissipated as a result of these changes. … students in my class are more engaged and enjoy Maths.* [Teacher 134, School 8D]
- *Students were engaged and showing leadership within the classroom when normally this a rare occurrence. … My students race into my classroom when I tell them I am doing YuMi. Almost unheard of. Behaviour from the students like this is rare. I love YuMi and my students love YuMi. Engaging and learning is undoubtedly happening.* [Teacher 97, School 7B]
- *The students were engaged and on task … The teachers next door are asking why that class is having all the fun. … This level of engagement by students is highly sought after.* [Teacher 34, School 4F]
- *Teachers have really enjoyed the process and have seen the increase in motivation and engagement in maths lessons. … Our students are more engaged and loving learning.* [Teacher 28, School 4A]
- *My students were always engaged and the lesson flow always provided those opportunities to ask questions about their thinking. It was particularly engaging for my chatty NEP Aboriginal Year 5 boy and my dyslexic, ADHD non-Aboriginal Year 5 boy who can't read or write. The hands-on (Abstraction) activities provided entry points and they loved manipulating materials and being able to hold their own in participating with their peers and answering questions. … Didn't find any negative 'I hate maths' expressed during hands-on lessons. Kids also asked when were we doing it again.* [Teacher 122, School 5C]
- *My students are engaged and so far ahead of most students in the class and they are now willing to attempt tasks without one on one support.* [Teacher 29, School 4B]
- *Her confidence in telling the time, calculating elapsed time and enthusiasm for engaging in activities is heavily linked to the relationship I have developed with her in Maths. It has given her confidence to have a go at other subjects too. She trusts me to teach her, she believes she can learn from me. YuMi did that.* [Teacher 24, School 4B]
- *Area and perimeter of triangles activity: I was most impressed with the students who became very determined to prove me wrong and how they were surprised by their own findings, they were very forthcoming with their results and were proud to show me their efforts with each new triangle formed.* [Teacher 105, School 7C]
- *Introduce[d] the basic fact strategies to my Year 5/6. … Some of the strategies were a real aha moment for my students. … My students loved them and they felt really successful. … I even had a parent ring to say that his daughter had shared some of the strategies at home and he was amazed as he had never been good at times tables and rote learning didn't help him!* [Teacher 56, School 5C]

- *Throughout the year it has been amazing to see the engagement of all the students within my class. … My students' attitude towards maths and learning has greatly changed. My students who used to struggle to stay engaged within a lesson are now engaged for extended periods of time (almost 100 minutes). … I have a few students who are reluctant to be a part of maths lessons, and at the mention of maths they will often run/escape or undertake work avoidance behaviours. I have noticed that as we introduce more of the YuMi methodologies into the maths lessons there are less [sic] disruptions and more engagement from these children.* [Teacher 64, School 6C]

- *My students do enjoy the Abstraction part of the lesson but still are not overjoyed with doing the Maths examples. The Year 8 class who are a fairly low-level class I believe are understanding the concepts better. … This group of students still are not enthralled with maths and it is even difficult some days to get them up and involved in hands-on activities as they seem to prefer to sit and do nothing.* [Teacher 35, School 3A]

- *These students are very reluctant to be involved in the physical acting out of maths problems, but have been more likely to 'play' with the concrete/tactile learning objects and materials. … I think the YDM program has enabled me to provide the supportive environment that these students need, and working with hands-on materials has allowed some success for these students and this has led to positive interactions, leading to building rapport. It's slow going, but progress is being made.* [Teacher 24, School 4B]

- *Students were engaged and enjoyed the hands-on activities. They seemed to understand the concepts well. As all students were involved there were no students who didn't have a role to play. … RATES: … The whole-body section … was also enjoyed by all and all participated. … When doing the body part of the abstraction not all students were involved and so this left some students disinterested and not paying attention.* [Teacher 35, School 3A]

Student achievement

It could be argued that a weakness of this case study is the paucity of quantitative student achievement data. However, this is compensated for by the many teachers who reported improvements in student thinking and understanding. Some teachers also provided qualitative information about student achievement in their reflective journals.

Many teachers commented on improvements in student thinking, evidenced by the students' questions, discussion, linking to prior learning, problem-solving and creativity:

- *We played with various objects and the students really loved trying to work out the easiest way to count. Without providing them the answer … it was quite fascinating to me that they decided (whilst keeping my role as a facilitator) that counting in 10s was better with larger amounts and smaller amounts of objects 2s and 5s were best. The students had a ball and so did I as it was interesting to watch their thoughts being verbalised and their discussion amongst themselves. Behavioural problems were non-existent.* [Teacher 18, School 4C]

- *Students remained on task for the entire time and were keen (and demanding) the next challenge/question.* [Teacher 59, School 6A]

- *Students are significantly more engaged when involved in hands-on and full-body activities. The flow of discussion becomes a lot more in-depth about the concepts explored and links are created to the real world, previous knowledge as well as how the math concept can be further developed/applied. I believe the learning is a lot more 'real' rather than abstract unlinked concepts.* [Teacher 129, School 4H]

- *I got students to use their bodies to make shapes. … I was amazed at the conversations, the problem-solving and the language they were using without much guidance from me. … it was great again to see the discussions and problem-solving skills. … The students have been really engaged in all of the measuring activities. The discoveries they have made have been fantastic and it has been due to their own exploring—not me telling them.* [Teacher 73, School 6E]

- *We used elastics to make four-sided shapes and it was great again to see the discussions and problem-solving skills.* [Teacher 73, School 6E]

- *Reflection … this often is where students have their AHA moments/ make deeper connections with what we have done and why. … I have found that the YuMi approach to teaching has REALLY increased the discussion around mathematics in the classroom! Confidence of students is higher and engagement is also up as they are loving it!!!!!!* [Teacher 66, School 6D]
- *I found that students who did previously understand this concept go 'ohhhhh, that's why' during the abstraction phase. They knew how to complete these questions mathematically, I didn't realise that they didn't have a firm understanding of why the concept worked this way.* [Teacher 98, School 7A]
- *There was obvious enjoyment from the students and I noticed a huge increase in the use of mathematical language as they discussed with each other where their fractions belonged on the number line. Students who understood were explaining to those who didn't and I could literally see the thinking going on.* [Teacher 78, School 5F]
- *Children loved seeing how different children counted and strategies such as piling the coins into one-dollar groups saved time. They liked finding out for themselves what worked for them and looking at what strategies everyone used. Sharing ideas and talking during the learning process!!!!* [Teacher 18, School 4C]
- *Students appeared to be engaged by being allowed to be as creative as possible.* [Teacher 52, School 1C]
- *Very high energy level/discussions.* [Teacher 59, School 6A]
- *Students are significantly more engaged when involved in hands-on and full-body activities. The flow of discussion becomes a lot more in-depth about the concepts explored and links are created to the real world, previous knowledge as well as how the math concept can be further developed/applied. I believe the learning is a lot more 'real' rather than abstract unlinked concepts.* [Teacher 129, School 4H]
- *Island excursion: loads of discussions amongst students, with hands-on galore. The learning was commenced prior to going, so provided a great and genuine source of motivation, while the continuation of learning after, provided the opportunity for students to reflect on what we had physically experienced.* [Teacher 46, School 5C]
- *Used the concept of Part + Part = Total to teach my Year 11 Maths A students how to find the missing sides of shapes in area, perimeter and volume calculations. The students who have struggled to visualise shapes have found success in thinking of a missing side as either a part of a total or the total. … This means that these students can then actually complete the question rather than just writing down the formula because they know the rule.* [Teacher 80, School 4H]
- *At [the] end of [the] lesson I asked them to walk 5/4 with interest to see what they would do. … Interestingly some walked the whole and continued beyond the court another 1/4 measurement and others stopped at the whole and turned and counted another 1/4. Had discussion re who was correct … they agreed that both could be as we still had a whole and 1/4 which is same as 5/4. I was surprised and pleased!* [Teacher 43, school 5B]
- *This was so successful giving students two ways to solve the same problem. … We did not encourage one over the other and left it up to the students as a choice. The students loved this and were happy to see it worked out both ways each time. … It worked wonderfully and this surprised us.* [Teacher 9, School 2A]
- *There are groups that don't do anything and other groups that have great productive questions and work really efficiently.* [Teacher 81, School 4H]

Improvements in student thinking led to a deeper understanding of mathematics. Deep understanding made it easier to develop later concepts:

- *Students were engaged, cooperating, working well in groups to solve solutions. … Through teaching multiplication and related division facts this [YDM] way I believe the students grasped a deeper understanding of multiplication and division, whilst learning their desired number facts.* [Teacher 71, School 5D]
- *Students really enjoy the activities and get a deeper understanding of concepts.* [Teacher 30, School 4F]

- *In the past my students have struggled with the partitioning (place value) and then later on understanding place value to 100. … We spent time making teen numbers with hands, toes, tens frames, bundles, and MAB blocks. I found this saved me time later in the Maths stage because the students had developed a solid understanding of place value. This has now progressed to numbers beyond teen numbers with very little teaching required.* [Teacher 41, School 3B]

Some teachers were able to share the outcomes of student assessment. However, some teachers described a disconnect between the student understanding demonstrated in activities and the same understanding shown in an exam:

- *I had quite a bright class last year but this year's class have understood fractions much better. … Students progressed from C–B result for Mathematics. Within that, higher scaled C and B scores were noted. Some D–C movement.* [Teacher 127, School 8B]
- *Comparing pre and post test data shows that the students all had considerable improvement. … I know my maths teaching has improved and my students' learning has improved because of it.* [Teacher 87, School 4E]
- *Conducted pre and post testing for this unit of work … when I compared their results from the start of the term … I saw that they all had made progress—and some made some very impressive gains. … I have been pleasantly surprised at the results from my Year 8 Maths class.* [Teacher 24, School 4B]
- *They LOVED this activity. My class is a particularly rowdy bunch and I had no issues with behaviour throughout this lesson. Every child was engaged and participating, using mathematical language, reasoning, estimating, justifying and calculating. Their formative and summative assessment in measurement showed that every child had met their learning goals in this area. … providing meaning and purpose for their learning at the outset makes it relevant for them and doesn't make them feel as though they are alienated from the curriculum.* [Teacher 38, School 4G]
- *I was surprised with how well the class did with this activity and was able to clearly see the growth in their learning.* [Teacher 63, School 6B]
- *Students are much more engaged in mathematics and are showing improvements in results due to the use of YuMi Maths.* [Teacher 10, School 1B]
- *We have even been so successful that we have even achieved almost 100% (in that all children even our Learning Support children were able to pass). … created a simplified fun yet abstract test to determine if we were successful in improving understanding. Children really enjoyed the approach we took and even the test seemed fun to them. We make sure that we tell children that we just want to see how they are travelling with the ideas so we can help them out and they respond well to this. They love knowing what the goal is and why they are doing it. They like to know if they have reached the goal as well. … Students really love and have loved seeing that they can all achieve and that all students function differently.* [Teacher 18, School 4C]
- *I think the use of these activities lifted their understanding to another level. I used the I can do Maths test this year and tested in Term 1 and Term 4. Every student who was retested showed some growth which was amazing to see!! … I have students who had consolidated their numbers 1–10 who within weeks were skip counting by 10s to 100, looking at combinations to 100, recognising numbers to 100. It has been amazing to see the rapid growth by just taking a different approach.* [Teacher 73, School 6E]
- *The initial lesson involved students using paper strips to demonstrate 1/2, 1/4, 1/3, 1/5 and 1/7. This became a challenge to some, including a support teacher. However, one of the students became a peer support to others and they all achieved constructing and labelling the fractions.* [Teacher 139, School 9A]
- *I am very aware that my assessments need to change. I usually use a worksheet style assessment to keep as a record, however if the children do not do many worksheets they often do not do so well in a test. This may be something to cover and learn more about/ how to assess maths effectively in relation to the style of teaching.* [Teacher 106, School 10A]
- *I retaught the lesson but used the area method for developing the distributive law. … Kids were actively engaged in making the areas which meant the activity worked much better. Most students gained a stronger understanding of the distributive law and were able to transfer these skills to exercises on the topic. Some students did not do well in expanding/ factorising on their exams.* [Teacher 134, School 8D]

2.5.3 YDC cluster coordinator reports

YDC cluster coordinators reported that, on the whole, teachers involved in the PD program indicated that students were more engaged and they had fewer behaviour management issues to deal with when the RAMR structure (or at least parts of it) was implemented in classes.

Teachers in a school in Cluster 3 enthusiastically commented on using the RAMR structure in planning lessons. Using a reality both familiar and of interest to students (in this case fishing and legal size requirements for different species) resulted in higher quality output from students. Attention to detail and accuracy of measurement by the students were attributed to the use of a reality that was significant and relevant to the student group.

Hard information about student achievement was limited, with only a few schools able to provide concrete conclusions. Two examples are described below.

One school in Cluster 2 used quantitative data extensively. The principal tracked semester result data for cohorts of students across year levels. Variation in student results could be correlated with the strategies teachers were using in class. Teachers using YuMi strategies obtained much better success rates for the same group of students. For example, one cohort of students had a success rate of 63% (i.e., 63% obtained a rating of C or above) at the end of one year and in semester one the following year obtained 80% success with a teacher using YDM strategies. The Indigenous students within that cohort moved from 50% to 86% success rate.

Two schools in Cluster 8 provided documented evidence (either through NAPLAN data or internal school data) of gains in student performance. In one of the schools, students on individual education programs working at the Year 5 level at the start of the PRIME Futures program were capable of being assessed using the Year 10 core standards for assessment by the end of the program.

Despite a general lack of student achievement data, many teachers made observations and related anecdotes about the impact of YDM in their classes during school visits. Information of a global nature relating to student outcomes was often cited by HoDs and members of the school leadership team. There were many reports of increased teacher and student satisfaction levels. Teachers reported student comments that they enjoyed mathematics and believed they had a better understanding of the subject. Teachers described their students' willingness to become 'risk-takers', to not merely wait for the answer to arrive but to engage in discovering the answer and the why behind it. Teachers stated that their students were wanting to be active and actively involved in mathematics and now saw mathematics as something about them, not just something in a book.

The teachers in a school in Cluster 2 enthusiastically commented on experiences where teachers team-taught combined classes to spread YDM skills to other teachers and observed that in a 1.5-hour session there were only four minor pauses to instruction for behaviour management correction.

A teacher from a school in Cluster 4 reported that they had initially moved their maths lesson from the middle of the day to the beginning of the day because students who habitually arrived late were then arriving on time as they did not want to 'miss out on maths'. The same teacher later reported that they were now considering moving maths to the end of the day as some students were absconding after the maths lesson.

Some issues were encountered with older students in secondary schools where the students had become accustomed to traditional lesson structures and were resistant to change. Seeing other students experience successful outcomes eventually provided a motivation for a change of attitudes. Teachers in some secondary schools were reluctant to apply the YDM approach to classes they considered to be working at year level standard or above but reported that they had delivered YDM lessons and

modified the programs for classes that were considered to be working below year level or disengaged with the curriculum. A teacher aide from a secondary school who undertook the training reported using YDM strategies and activities in many classes and groups and that the previously reluctant students had responded positively and shown a greater willingness to engage in the learning.

Participants from a Cluster 3 secondary school all made efforts to implement YDM in their classrooms with varying levels of success. Teachers reported that they found it harder in the upper grades as students had entrenched ideas about how maths should be taught. Teachers persisted and reported that they could see a difference near the end of the program as students who had experienced YDM in lower grades moved through to the upper year levels.

2.5.4 NAPLAN data

ACARA's My School website (https://www.myschool.edu.au) lists the National Assessment Program—Literacy and Numeracy (NAPLAN) results for all Australian schools, including those participating in the PRIME Futures program. We had intended to present an analysis of the NAPLAN numeracy data of those schools in this report as a means of measuring student achievement.

The data published on the My School website shows the 'mean scaled score' of each cohort in each domain (including numeracy) of Year 3, 5, 7 and 9 students since 2009. The value of this score conveys little useful information, other than showing that most schools in the program have mean scaled scores below the averages for the nation and their state. However, it cannot show whether these results are reasonable in the circumstances of each school. Of more use is the 'average gain', which is the difference in the mean scaled score for the same cohort of students over a two-year period (e.g., Year 3 to Year 5). This measure is a better indicator as it is less likely to be influenced by external factors such as the school's SES, remoteness and resource levels. It indicates how the school and its teachers have been able to improve the students' outcomes over the two-year period. It can be compared to the same measure for the schools that are considered by ACARA to be 'similar' to the school under consideration.

However, calculating the average gain for several schools requires taking an average of an average—a questionable procedure that gives the same weight to the data from a large school as it does to a small school. The My School website does not provide sufficient data in a usable form for those averages to be weighted for the size of the school.

A further problem with using average gain is that it requires data from two NAPLAN tests executed two years apart. The data must be consistent at those two points in time. Factors that might affect this consistency include:

- students changing school, particularly as they move from primary to secondary schooling; in South Australia, for example, this changeover occurs at the end of Year 7, so no South Australian secondary school has NAPLAN data at two points in time
- school closures, restructures and amalgamations, all of which occurred to at least one school in the PRIME Futures program
- no students in some cohorts in some schools—a feature of several very small participating primary schools.

Allowance must also be made for the time lag in collecting meaningful data. This includes the time required for teachers to be trained in YDM (a two-year program), implement YDM in the school and make a difference for students sufficient for it to be reflected in the NAPLAN test results. Finally, it takes almost a year for ACARA to conduct, mark and publish the results of the tests. Thus, it is doubtful that the effects of the PRIME Futures program would be evident in the test conducted in May 2018 (the most recent published data), especially for the Cluster 7–10 schools that commenced in the program in Term 2 of 2017.

It was possible to remove from the data set those schools where the data was contaminated by a lack of consistency, missing test results and recency of the NAPLAN test. However, after these excisions were made, only 18 primary schools and five secondary schools remained in the data sets. They were considered to be too small to produce meaningful results, especially when some of the methods of analysis were unreliable. For this reason, analysis of the NAPLAN data has been omitted from this report.

2.5.5 Summary

In summary, the data on student outcomes pointed to improved student engagement and achievement in mathematics.

Almost all teachers and principals reported increased student engagement and nearly three-quarters reported improved student learning/understanding. The comments in the teacher reflective journals overwhelmingly supported the quantitative data. The increase in student engagement was observed in all types of students.

However, only a small percentage of survey responses from teachers and principals considered that the increases in student engagement had translated to increases in student achievement. Despite this, many teachers commented in their reflective journals on their classroom observations of improvements in student thinking and understanding.

These general conclusions are discussed in more detail in Section 3.5.

3 DISCUSSION

This chapter discusses the outcomes of the program, synthesising the data to develop the conclusions in Chapter 4. The discussion is structured into five key areas:

- effectiveness of the PD workshops
- Indigenous perspectives and community engagement
- teacher capacity
- program implementation
- student outcomes.

The original specification for the PRIME Futures program required that, as a minimum, it involve 60 schools, training 120 teachers and reaching 1500 Indigenous students before the end of Term 2 in the 2019 school year. These targets were exceeded, with 62 schools completing the full program, training 379 teachers (or 332 teachers excluding 47 who only attended PD 5) and potentially reaching 32,317 students of whom 6975 (22%) were from Indigenous backgrounds (see Appendix E).

The substance of the YDC cluster coordinators' reports has already been presented. In some instances, cluster coordinators included in their reports their opinions about aspects of the program and made suggestions for improvement. These have been reported in Chapter 2 as part of the data collected. However, as these issues are also relevant to the discussion, they may reappear in this chapter.

3.1 Effectiveness of the PD workshops

This section discusses the effectiveness of the PD workshops based on both quantitative and qualitative data from the participants. It then examines some challenges relating to the PD workshops and factors that influenced their effectiveness.

3.1.1 Participants' evaluations of PD workshops

The data presented in Section 2.1 shows that 425 teachers and 39 principals/deputy principals from 75 schools attended the PD workshops. Participants rated the PD sessions highly: on a five-point scale (*1 = not useful; 5 = very useful*), the mean rating was 4.22.

Participants were also given the opportunity on the PD evaluation forms to comment on the sessions. Many participants noted that their confidence in the teaching of maths had grown. In addition to the numerical ratings, many participants chose to add favourable comments about the effectiveness of the PD workshops.

Some teachers made additional comments about the workshops in their reflective journals. For example:

Totally inspired. Makes me a better teacher. Makes me enjoy teaching again. Gives me a purpose. Allows me to better provide lessons. [Teacher 97, School 7B]

The three different forms of data all supported an overall conclusion that the PD workshops were very successful and highly valued by the teachers attending.

3.1.2 Challenges and success factors relating to the PD workshops

Notwithstanding the favourable comments and ratings, there were some challenges in conducting the PD workshops and factors that influenced their effectiveness.

Level of the mathematics content

Consistent with the usual practice when training teachers in YDM, the workshops included teachers from Years F–9; that is, both primary and secondary teachers. Some participants felt that the program should have been delivered as separate primary and secondary workshops so they could focus on the issues that related directly to their teaching.

Component 3 of the underlying philosophy of the YDM teaching approach, as detailed in Section 1.2.3, requires that teachers have a broad appreciation of the cultural capital embodied in mathematics (Claussen & Osborne, 2012). It is essential that their students can understand and engage in mathematics discourse relevant to their future cultural, academic and professional lives. There are two types of mathematical knowledge that we believe should be systematically provided to Indigenous and low-SES students to better prepare them to handle formal abstractions and more complex mathematics in later years of schooling and life. They are the big ideas *of* mathematics and the big ideas *about* mathematics (Chalmers et al., 2017). Part of the rationale for this focus on big ideas is to show teachers how a concept can be developed at many different levels[14] and how it can apply to other areas of mathematics. Accordingly, we argue that teachers of the early years should understand how the content knowledge they teach is developed with their students in future years. Similarly, teachers of secondary content benefit from knowing how the students' prior mathematical knowledge was learned. One teacher, in particular, liked this approach, stating "I have enjoyed … learning how we can actually confuse students with the 'compromises' we make to just get students to understand the level of maths we are teaching for that grade/year" [Teacher 24, School 4B]. An appreciation of early and later mathematical understandings is also useful for teachers when differentiating their lessons for a range of student abilities. Accordingly, in the YDM approach teachers are encouraged to look forward to future concepts to ensure early concepts are presented in a way that promotes successful future learning.

When the YDM philosophy was explained, most (but not all) teachers accepted the approach and appreciated the content and strategies presented. However, because each workshop was delivered by a team of YDC practitioners with a range of skills, it was possible to accommodate the teachers' preferences by splitting some sessions into 'early understandings' and 'later understandings'. In some cases, primary teachers chose to attend the later understandings sessions and vice versa, to see mathematics from a different perspective.

With the benefit of hindsight, it might have been possible to anticipate this issue earlier. Providing an early explanation of how and why the YDM philosophy aims to give teachers a broad appreciation of school mathematics (perhaps in the context of a session about 'big ideas') might have prevented the issue from arising later.

Duration of the PD

The PRIME Futures program provided for five 3-day PD workshops, conducted over two years at approximately six-monthly intervals. However, the Western Australia Department of Education directed that teachers in government schools could not be released for more than two days at a time. Accordingly, the PD sessions in the two Western Australia clusters (Clusters 9 and 10) were shortened to two days by increasing the length of attendance at each day. Further, a 'catch-up' PD 1 workshop in Cluster 1 was also presented in early 2016 over two days.

In Section 1.2 we explained how YDM and the associated PD program has been developed and refined by researchers and teaching practitioners employed by QUT over a period of ten years. That process revealed that teachers needed time to develop the required deep understanding of pedagogy and content. Substantial periods in between the PD workshops were useful in allowing teachers to consolidate and trial the ideas presented in the PD sessions. Accordingly, presenting the PD in 15 days over two years was a deliberate decision. However, the need to release teachers for this amount of time caused problems for many schools, especially the smaller remote schools.

Teacher turnover in schools was another challenge that arose as a consequence of the extended duration of the program. Teachers leave schools for many reasons. First, many of the teachers employed in government schools were on fixed-term contracts that may not have been renewed or extended. Second, for some teachers, the remote and low-SES schools in the program were seen as being less desirable places to live and/or work, leading them to seek transfers to other schools when possible. Finally, transfers of family members to other locations, resignations, retirements and extended leave all added to the loss of teachers from a school. The impact of losing a teacher involved in the YDM program is twofold:

- If the departure of the teacher occurs before the PD is completed then they will be unable to complete the program, diminishing the potential benefit for that teacher.
- If the departure of the teacher occurs after the PD is completed while the school is trying to implement YDM, then the other teachers in the schools lose their in-school trainer and mentor, diminishing the potential benefit for the school.

14 For example, the process of addition is 'adding like things'. This process applies to any context: place value in whole numbers, place value in decimal fractions, common fractions, algebraic terms, Cartesian coordinates, surds, complex numbers and vectors. Thus, the process introduced in Year 1 will be regularly revisited in increasingly more complex contexts.

The extended duration of YDM training makes it more likely that teachers will leave a school before the PD and/or whole-school implementation has been completed. From a school manager's perspective, it must be disheartening to lose a teacher when scarce resources, often diverted from other areas of need, have been invested in that teacher's PD.

Selection of schools in the program

Schools were identified for participation in the program through a consultative process involving YDC and CSIRO. It took into account the geographic location of the schools, the number of Indigenous students attending the schools, the areas of Australia of interest to the BHP Foundation and the existence of other CSIRO programs that might have been occurring in the same region. Schools identified through this process were invited to join the program. There was no formal process that allowed a school to apply to join the program, although on a few occasions if YDC practitioners became aware of a school's interest in the program and the school appeared to meet the selection criteria, they may have arranged for the school to be considered for participation against those established criteria.

Ideally, when contemplating PD, it is preferable that the initiative is taken by the school managers or the relevant education authority. This ensures that the program has the full support and commitment of the school management and/or educational authorities. As later discussion will show, this management support is vital to ensure the program fits with the school philosophy and priorities and is compatible with existing school programs. A lack of management commitment was one of the main reasons for the withdrawal of the 12 schools that left the program before its completion.

In the circumstances of the PRIME Futures program, the proposal for a school to participate initially came from YDC. It is likely that some school principals would have been ambivalent about the offer but accepted because they did not want to miss the opportunity for free PD (especially for inexperienced teachers) or because other local schools were going to be involved. These are not circumstances that lead to wholehearted management support.

However, given the nature of the program and the way it was implemented as part of a larger project, there was little choice about the way schools were invited to participate. A longer lead time that permitted a general advertisement for schools to apply for the program may well have resulted in schools with a greater management commitment but would probably not have resulted in viable geographic clusters or compliance with the other conditions of the BHP Foundation funding. There is no clear solution to this dilemma, but it nonetheless is an issue that similar programs should consider in the future.

Selection of teachers attending the PD workshops

Component 6 of the underlying philosophy of YDM relates to the training of teachers in YDM based on the cycle of school change and leadership illustrated in Figure 1.3 (YuMi Deadly Centre, 2014). A methodology for facilitating school change was developed, where selected teachers were trained in all aspects of YDM. These teachers became teacher-trainers who returned to their schools and then trained their colleagues in YDM. In the case of the PRIME Futures program, it was agreed that four staff members (teachers, teacher aides and/or school leaders) from each school would be offered the opportunity to become teacher-trainers.

The PD planning was done on the basis that the four teacher-trainers would be able to attend all five PD workshops. Additionally, to fulfil their roles as teacher-trainers successfully, they needed to have the influence, enthusiasm and willingness to encourage other teachers to change their pedagogical approach. This did not always occur.

Table 2.1 shows that only 16% of teachers at the 62 completing schools attended all five PD workshops. This affected the continuity of the PD program and left the new participants feeling they had missed out on the basics (e.g., the detail of the RAMR framework). As each PD workshop was intended to build on the previous one, participation was harder for those teachers who had missed earlier PD workshops. In the opinion of one YDC cluster coordinator, it takes at least two workshops to become familiar with the YDM approach.

Conflicting priorities within schools influenced the choice of teachers to send to a PD workshop. For example:

- Schools needed to consider the impact of a particular teacher's absence on their normal teaching duties; if the teacher had many recent absences from class, the school (or the teacher concerned) may have been reluctant to agree to anything that would lead to further absences.

- Some schools chose teachers with low levels of contact teaching time on a particular day to attend PD sessions held on that day—this could result in a different teacher attending the workshops on each day.
- Some schools, striving for equity, chose to share the PD opportunities among their teachers by nominating a different teacher to attend each workshop.

As discussed earlier in this section, teacher turnover was another cause of a lack of continuity of attendance at the PD workshops.

When YDC cluster coordinators realised there was a lack of continuity in the teachers attending the PD workshops, they adjusted the content of some sessions. This affected what could be achieved during the workshops and, consequently, was a sub-optimal solution.

In some cases, the selection of the teacher-trainers by schools was unfortunate. If a teacher is required to persuade their colleagues to change their pedagogical approach, then their judgement must be respected by their colleagues. This would occur if a teacher was well regarded for their effectiveness as a teacher, experience, maturity and/or seniority in the school. Yet often the teachers directed towards the PD by school managers were those considered to be in need of assistance in overcoming problems with teaching. Other teachers attending the PD may not have been willing to devote the time and energy needed to act as teacher-trainers. One of the YDC cluster coordinators noted the challenge of working with teachers who attended the PD workshops only for themselves.

Cost of PD attendance to schools

In Chapter 1 it was noted that the PRIME Futures program involved extensive cost and time commitments by schools and teachers. Although YDC's costs were met by the BHP Foundation, schools and teachers were asked to contribute significant resources towards their participation in the program.

Each school was asked to bear the cost of their employees' attendance at the PD workshops. This could be for up to four teachers. The highest cost was in employing replacement teachers to undertake the teachers' duties while they were absent. This possibly amounted to more than $24,000 for the four teachers over the two-year duration of the program. In small towns, there may not have been enough casual teachers to meet the demand for replacements of teachers attending the PD workshops. Additional costs included travel and/or overnight accommodation for teachers who lived some distance from the PD venue.

Schools were not given a lot of prior notice about the rollout of the PRIME Futures program in their area (particularly the Phase One schools), preventing them from seeking additional funding for the program in the cyclical school budgeting process. The South Australian Government was the only educational authority to assist some schools with the cost of participation in the program. In all other cases, the necessary funding had to be found from within the existing school budget, usually by reallocating funds. While this might be possible in large schools, the limited budgets of small schools made it almost impossible. The cost of replacing teachers attending the PDs prevented some schools from accepting the invitation to join the program and contributed to the decision of other schools to withdraw from the program. In South Australia, it was agreed that if small schools could not use all four places allocated to them in the program, then the larger schools could take up these places.

Organisations funding PD for teachers need to be aware that delivery of the program represents only part of the cost and many schools will need assistance in managing the cost burden imposed on them.

YDC staffing and expert practitioners

The PD program was implemented by YDC very quickly—the first PD workshops in Clusters 1 and 2 commenced less than three months after the start of the contract between QUT and CSIRO. The rollout of the PD program, ultimately keeping 10 clusters operating smoothly, was a major undertaking for the small group of staff that made up YDC. It involved some practitioners in extensive travel, long hours of work and deferred leave. In several cases, it was necessary to work around staff absences due to illness or other unavoidable personal circumstances. YDC was fortunate to have access to such high-quality practitioners able to deliver the PD as and when required. The expertise of the practitioners ameliorated some of the difficulties associated with the procedural aspects of the program's implementation.

3.1.3 Summary

The results presented in Chapter 2 and discussed in this section show that the PRIME Futures YDM PD workshops were, overall, very successful. The three sources of data—numerical ratings for each PD session, comments on evaluation forms and comments in reflective journals—all support the conclusion that most teachers appreciated the high quality of the PD and were inspired to change their teaching approach.

Factors that impacted the effectiveness of the PD workshops included the need for teachers to develop an appreciation of early and later mathematical understandings through early emphasis on the big ideas; the extended duration of the training with consequent turnover of participants; the suitability of both schools and teachers selected to participate in the program; the high cost to schools of the teacher attendance at PDs; and the ability of YDC to provide expert practitioners despite some staffing difficulties. These factors are summarised in Figure 3.1.

3.2 Indigenous perspectives and community engagement

While schools were selected for the PRIME Futures program on the basis of high numbers of Indigenous enrolments, the teacher-trainers were not chosen based on the number of Indigenous students in their classes. The YDM pedagogy was not delivered in a way either to exclude non-Indigenous students or favour Indigenous students. Some of the schools are from differing socio-economic areas, and in many instances, the students within these schools were more likely to be homogenous through social disadvantage than through culture or race.

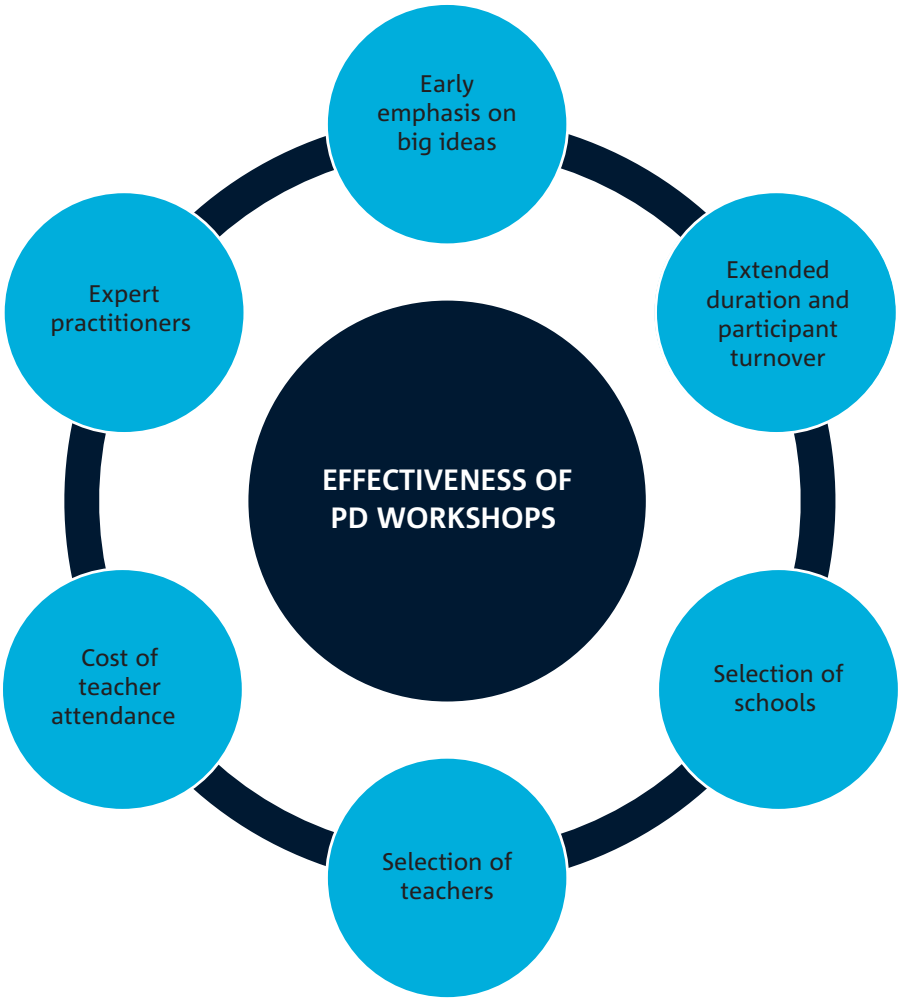


Figure 3.1 Factors influencing the effectiveness of PRIME Futures YDM PD workshops

The data presented in Section 2.2 revealed that:

- Indigenous enrolments in the schools of the program averaged 22%, compared to an average of 5.6% nationally.
- The teacher-trainers generally appreciated the PD sessions on Indigenous perspectives and found them enjoyable, useful and informative.
- Many of the schools had access to Indigenous community engagement officers to assist in areas such as local Indigenous knowledge, working with Indigenous students and classroom support, as needed. Of those officers interviewed, most had heard of the PRIME Futures program, but few had been actively involved in the program.
- Principals and teacher-trainers generally believed that their schools did not receive meaningful support from the local Indigenous community. Further, while the PRIME Futures program had resulted in an increase in the level of that support, the change was minimal.
- The PRIME Futures program did result in an increase in teachers' knowledge of local Indigenous culture and community. However, the improvement was small and started from a low base. Most teacher-trainers had tried to increase their use of Indigenous contexts in mathematics lessons, but many of them wanted to learn more in this area.
- According to the school principals, the PRIME Futures program had led to some improvement in the engagement and achievement of Indigenous students.

This section discusses three aspects of these results:

- school actions that supported Indigenous perspectives
- teachers' knowledge of Indigenous culture
- community support.

3.2.1 School actions that supported Indigenous perspectives

While the surveys and reflective journals did not seek information about the actions of the various schools to promote Indigenous perspectives and engagement, some information was provided by teachers in the 'who we are' sections of the charts prepared during the Engoori session of the PD. Teachers from 34 of the 53 schools commented on the diverse cultures in their schools, with 30 of them stating that their school culture incorporated Indigenous culture. Almost half the schools mentioned that they had access to Indigenous teachers, aides and/or liaison officers and were supported by Indigenous community leaders, parents and other role models. Seventy per cent of the schools had specialised school programs for Indigenous students and just under half of the schools celebrated Indigenous culture through ceremonies, excursions and other activities. These statistics demonstrated that most schools in the program had the personnel, programs and activities in place to support Indigenous perspectives. When asked to identify 'what we need to change', the teachers mentioned embedding Indigenous perspectives better or more consistently (21 schools), cultural inclusivity (15 schools), more leadership roles for Indigenous students (17 schools), and more.

Given that all the schools had relatively high levels of Indigenous enrolments (averaging 22%), it is suggested that the 'who we are' figures should have been higher, and the 'what we need to change' figures could desirably be lower.

While many schools had programs to link the school with its local Indigenous community, YDC practitioners visiting the schools reported that in some schools there was still scope to strengthen those relationships, especially by linking YDM to these programs. However, some teachers saw the existing whole-school programs as sufficient and did not accept that there was a need to develop classroom activities that incorporated the local Indigenous culture. Consequently, there was little connection between school programs and classroom activities in their schools. In a small number of cases, teachers were resistant to YDM initiatives to forge links with local communities, most commonly justifying their actions by stating that they did not have any Indigenous students in their class.

The evidence presented in this section shows that some schools had worthwhile programs to foster links with the local community and promote Indigenous students and their culture. However, the evidence collected in this study suggests there was room for improvement in the

way other schools recognised and supported Indigenous students and their culture. The three sources of data (surveys of teachers, teacher reflective journals and PD evaluation forms) permitted triangulation of this data and strengthened the credibility of the conclusion that there is potential for improvement in the way that schools support and empower their Indigenous students and that teachers are generally keen to learn how to do this well.

3.2.2 Teachers' knowledge of Indigenous culture

Participants' responses to the Indigenous content within the PRIME Futures YDM training were positive, with some participants rating the sessions on Indigenous perspectives as the highlight of the day. In comments in the reflective journals and PD evaluation sheets, many teachers stated they appreciated the sessions that added to their knowledge of Indigenous culture and history. For example:

Loved the Indigenous presenter's info, knowledge and real-life experiences could have listened to her all day. [Anonymous comment on PD evaluation form from a teacher in Cluster 2]

As a group, the teacher-trainers did not rate their knowledge of local Indigenous culture highly, averaging 1.9 (the 'poor' end of 'satisfactory') before participating in PRIME Futures and 2.65 (between 'satisfactory' and 'good') on completion of the program (see Table 2.6). However, as these overall ratings were not high, there appears to be potential for teachers to continue to learn more. Probably because of the aforementioned lack of teacher knowledge about Indigenous contexts, most teacher-trainers rated their use of Indigenous contexts in their mathematics classroom as 'very little' to 'moderate' (see Table 2.8). These quantitative results are confirmed by responses to another survey question, in which an average of 18% of teacher-trainers identified a lack of information about the local Indigenous culture and community as one of the obstacles to adopting YDM methods (see Table 2.7). In the Engoori charts (see Figure 2.1), teachers in nine schools proposed that school should do more to embed sustainable programs that support Indigenous students and their culture.

These responses suggest there is scope to increase the use of Indigenous contexts in mathematics lessons. Almost all teachers seemed to be willing to do this, but many felt they lacked information about Indigenous contexts and needed more support in embedding them in their mathematics lessons. For example:

The Indigenous session provided knowledge and understanding to apply perspective in the classroom, interested in doing further PD on this. [Anonymous comment on PD evaluation form from a teacher in Cluster 4]

When teachers are planning lessons, it is difficult to incorporate Indigenous perspectives without strong links to, and knowledge of, the culture of the local community. Indigenous students are a readily available source of such knowledge within the classroom. YDC practitioners observed teachers' commendable willingness to capitalise when issues were raised by the Indigenous students in their class.

Given that linking teaching and learning to the students' lived reality is good pedagogy in any subject, it is possible there is scope to increase the use of Indigenous contexts and cultural knowledge in schools across the board, not just in mathematics. The PRIME Futures program included at least three sessions (five to six hours in total) on Indigenous perspectives, yet for many this was insufficient. However, considering the other objectives of the program, it was probably not realistic to do more in the available time. This is, perhaps, an issue that needs to be taken up more strongly by schools, education authorities and even pre-service teacher training providers. Further, given the transient nature of teachers in many regional, remote and low-SES schools (see Section 3.1.2), it requires constant reinforcement.

3.2.3 Community support

The biannual principal surveys showed that, on average, school principals perceived that PRIME Futures had minimal impact on the level of support for their school's activities from the local Indigenous community. Average levels of influence were rated between 'very little' and 'somewhat' (see Table 2.4). The biannual survey results are supported by the exit survey, which used retrospective pre-post methods to show that, in general, school principals observed only a small increase in support for their school's activities from the local Indigenous community since the PRIME Futures program commenced. The small increase is on a very low base, representing a change in support from 'very little' to 'somewhat' (see Table 2.5 and Figure 2.2).

These results should be interpreted in the context of the activities of the PRIME Futures program. Contact between YDC staff and the school's local Indigenous community occurred only at the start of the program and, in some cases, during an interview with a small number of local Indigenous representatives. Having assisted the school in contacting their local Indigenous community, where necessary, further contact was at the discretion of the school and the community. These results suggest that either follow-up at the school level was limited, or schools did not adequately promote the excellent inclusive activities observed in some YDM teacher-trainers' classrooms.

As noted in Section 2.2.6, an important factor influencing local Indigenous community support in Cluster 10 was withdrawal of government funding for Indigenous community engagement officers employed across the state, which affected the previously strong connection between the community and the schools achieved through the efforts of the local engagement officer. This meant that the second half of the program in this cluster struggled to find that community link for Indigenous perspectives and support, thereby increasing the schools' perceived need to gain insights into Indigenous perspectives from the YDM PD workshops and resources.

During the Engoori process conducted in PD 3 or PD 4, teachers in 14 schools identified 'increased ownership and involvement of Indigenous students and the community in school programs and activities' as one of the things they would change in their schools (see Figure 2.1). This, and other data, suggests there were missed opportunities for engagement between the school and community. Interviews conducted with 13 Indigenous community members in eight clusters shows that, although able to talk in detail of the programs that they directly worked in, they had little detailed knowledge of the YDM program. YDC cluster coordinators reported that Indigenous parents could be reluctant to talk to teachers to offer help in putting their culture upfront and helping teachers to understand why their students see things from a different perspective. Similarly, most teachers could visit cultural or significant celebrations but chose not to. Improved efforts to strengthen the relationship between schools (managers and teachers) and the local community, and funding to support this, would yield benefits for all parties.

3.2.4 Summary

This section discussed three aspects of Indigenous perspectives and community engagement:

- school actions that supported Indigenous perspectives
- teachers' knowledge of Indigenous culture
- community support.

It concluded that there was scope for improvement. Schools could do more to recognise and support Indigenous students and their culture. Teachers generally wanted to improve their pedagogy to reflect the local Indigenous culture but felt they needed to learn more about the culture. Finally, both schools and their local communities should seek out more opportunities to strengthen their relationship.

3.3 Teacher capacity

The data presented in Section 2.3 demonstrated considerable improvements in teacher capacity as a result of the PRIME Futures program. Thematic analysis suggested that the improvements were due to changes in pedagogy (the use of the RAMR pedagogy that included real-life contexts and kinaesthetic activities), improved teacher knowledge and understanding of mathematics, and enhanced enjoyment of teaching. This section examines the extent of the improvements in teacher capacity, factors that are important for promoting teacher change and challenges affecting teacher change.

3.3.1 Improvements in teacher capacity

Unlike the reflective journals that rely on anecdotal evidence, surveys of teachers and principals, involving response rates of 57% and 73%, respectively, provide more comprehensive data. The survey data shows evidence of, on average, 'moderate' improvements in teacher capacity (see Table 2.12 and Table 2.13). Although this is encouraging, it is perhaps not as much as YDC practitioners might have hoped. One possible explanation is that survey respondents may have been thinking of all mathematics teachers in the school when answering questions about improved teacher capacity. Perhaps a question that focused only on the YDM PD participants would have yielded higher ratings.

Another possible explanation is that it takes time for YDM training to come to fruition. In the early stages, teachers are coming to grips with the pedagogy and trialling new approaches with their own classes. It is likely that the data may have been collected before the full effects of YDM training were evident.

However, the anecdotal evidence from YDC cluster coordinator reports and teacher reflective journals shows considerable improvements in teaching capacity for some teachers. One reason for including so many quotes from teachers in this case study is to demonstrate the extent of this anecdotal evidence.

3.3.2 Promoting teacher change

Many teachers attended the PRIME Futures YDM PD at the instigation of their school management, not because it was their personal choice. This was a reflection of the rapid manner in which the program was introduced to schools. Where PD participants were less than enthusiastic, it was essential to engage their interest from the outset. To achieve this, the PD workshops included many hands-on activities intended to capture the interest of teachers quickly. YDC practitioners aimed to show teachers new and effective ways to engage students in lessons; for example, using the body–hand–mind approach. Desirably, some of these activities should be novel; for example, the maths mat.

Further, the activities needed to be immediately useful and fit with the curriculum. Therefore, it was desirable to achieve congruence between what teachers wanted to know and what was offered in the PD. Since initiating change requires time and effort, teachers needed to be persuaded that expending that time and effort would be worthwhile.

Experienced YDC practitioners considered that the PD needed to present teachers with high-interest activities that are effective in teaching the important mathematics ideas and harness sufficient enthusiasm to induce teachers to make changes in their practice. For this reason, all the workshops actively involved teachers, requiring them to play the part of their students.

The success of the PD workshops in inspiring change is demonstrated by teacher comments such as the following:

The YDM [workshops] are fabulous. Every time I participate in one I feel my understandings of mathematical concepts deepening. I am finding better ways to teach my students and therefore feel like they are making greater gains in their learning. They have been instrumental in changing the way I teach each mathematical concept. [Teacher 14, School 4A]

For some teachers, YDM represented a new approach to teaching:

I have changed the way I think about planning my maths lessons. … I have enjoyed how the students can verbalise their thinking processes while completing the hands-on activity at the beginning. … I have changed the way I structure my lessons to ensure that I have relevant reality and abstraction activities at the beginning to engage students in the learning process. I find that this is a great way to develop prior knowledge and thinking, as well as discover any misconceptions, prior to the 'maths' stage. [Teacher 103, School 7A]

For others, the YDM training reminded teachers of what they already knew:

I knew that maths was best taught using, not just concrete materials, but the children themselves, and I have tried to incorporate that into daily teaching but it was not always possible. It was how I was taught at Teacher's College. There was a very big emphasis on that particular pedagogy but over the years some of that has slipped away, usually with the encroachment of other programs that schools have invested in … I will remind myself that we start with the real world, move onto the concrete, then the abstract … then reflect … every time where possible. [Teacher 118, School 9E]

However, there is a danger with focusing on activities that teachers will simply use those activities without adopting the underlying pedagogical approach. Component 6 of the underlying philosophy of YDM relates to the teacher as a learner, as described in Section 1.2.6. Teachers are presented with a structured instructional sequence called the RAMR framework (see Figure 1.5). RAMR is part of the overall YDM planning and teaching cycle (see Figure 1.6). To maximise learning outcomes the pedagogical approach includes supporting classroom activities, many of which were provided to participants as exemplars in the YDM resource books and presented at PD workshops. When first introduced to the YDM pedagogy, teachers are usually keen to adopt the links to students' reality and the activities (i.e., the reality and abstraction phases), but find the mathematics and reflection phases of the RAMR cycle harder to incorporate in their teaching and planning. This is reflected in the vast majority of teacher reflective journal comments that focused on reality and/or body–hand–mind activities but said little about the later phases. However, to gain the maximum benefit of YDM it is important to eventually adopt the entire approach. This takes longer to develop, often requiring attendance at several PDs or demonstration lessons.

3.3.3 Challenges for teacher change

Some teachers experienced challenges in changing their pedagogical approaches.

Demands on teacher time

Teachers have commented on the demands that the YDM approach makes on teacher and classroom time. There are several aspects of this problem.

First, in the implementation phase, YDM requires considerable teacher preparation time to revise lesson plans and develop new teaching programs. However, we suggest that this is a problem experienced with any new pedagogical program and is not unique to YDM.

Second, YDM lessons involving many classroom activities can take longer to deliver. However, we argue that time spent at the beginning of the lesson/topic to establish a solid base of knowledge and understanding is often recouped later because later concepts can be taught more quickly, as illustrated in this journal extract:

We spent time making teen numbers with hands, toes, tens frames, bundles, and MAB blocks. I found this saved me time later in the Maths stage because the students had developed a solid understanding of place value. This has now progressed to numbers beyond teen numbers with very little teaching required. [Teacher 41, School 3B]

Further, there is little point in teaching a concept quickly if the methods used do not result in deep understanding.

Third, for some teachers, acting as a teacher-trainer and mentor takes time they do not have. Teacher-trainers do need a time allocation to train and mentor other teachers. This is a matter of school resource allocation and is one of the reasons that management support for YDM is critical. YDC practitioners accept that implementing YDM does require time and effort, at least initially. The challenge for teacher-trainers is to persuade others in their schools that it is worth the effort.

Finding a suitable reality context

Component 2 of the underlying philosophy of YDM challenges teachers to recognise their students' cultural capital by linking mathematics to their existing repertoires of knowledge and experience; that is, the reality of the students' world. Many teachers identified the difficulty of finding a suitable reality context and/or constructing a RAMR lesson that was suitable for their students. This was mentioned particularly by secondary teachers. It should be possible to find a suitable reality context for most

mathematics topics in the primary years. Similarly, many secondary mathematics courses that are not prerequisites for university studies in mathematics and science (e.g., Essential Mathematics and General Mathematics) focus on the mathematics needed for life (e.g., financial mathematics); therefore, it should not be hard to find reality contexts for the topics in these life-related courses.

However, YDC practitioners acknowledge that it is harder to find contexts for the content of courses leading to higher mathematical studies, which often involve extensive algebra and other abstract concepts. Nevertheless, if it is accepted that abstraction in higher mathematics is the generalisation of concepts first encountered in arithmetic, patterning and geometry (to name a few), then a re-imagining of these early understandings can provide a context for abstraction.

The difficulty in providing a suitable reality context is possibly a greater challenge for teachers new to the YDM pedagogy. Potential solutions include collaboration with more experienced colleagues within the school or in other schools; the accumulation of experience in using YDM; and accessing resources within the school (such as Indigenous community engagement officers) or developed by YDC practitioners (such as exemplar lesson plans).

3.3.4 Summary

The evidence presented in Chapter 2 and discussed in this section demonstrated considerable improvements in teacher capacity as a result of the PRIME Futures program. To successfully promote teacher change, it is important for PD workshops to include engaging activities to harness interest from teachers and develop their motivation to change their teaching practice. When first trialling the YDM approach, teachers often enthusiastically adopted this aspect of the YDM pedagogy; that is, links to students' reality and the kinaesthetic activities. However, they sometimes overlooked the later components of the RAMR framework, particularly the reflection phase. To obtain the maximum benefit from YDM, it is important for teachers to eventually adopt the entire pedagogy.

Teachers identified two challenges in successfully changing their practices. First, using the YDM approach can add to the time needed for the preparation and teaching of some concepts. However, the evidence of more experienced YDM teachers is that this is a temporary effect. Second, teachers sometimes struggled to find suitable reality contexts, especially in the secondary years.

These factors are summarised in Figure 3.2.

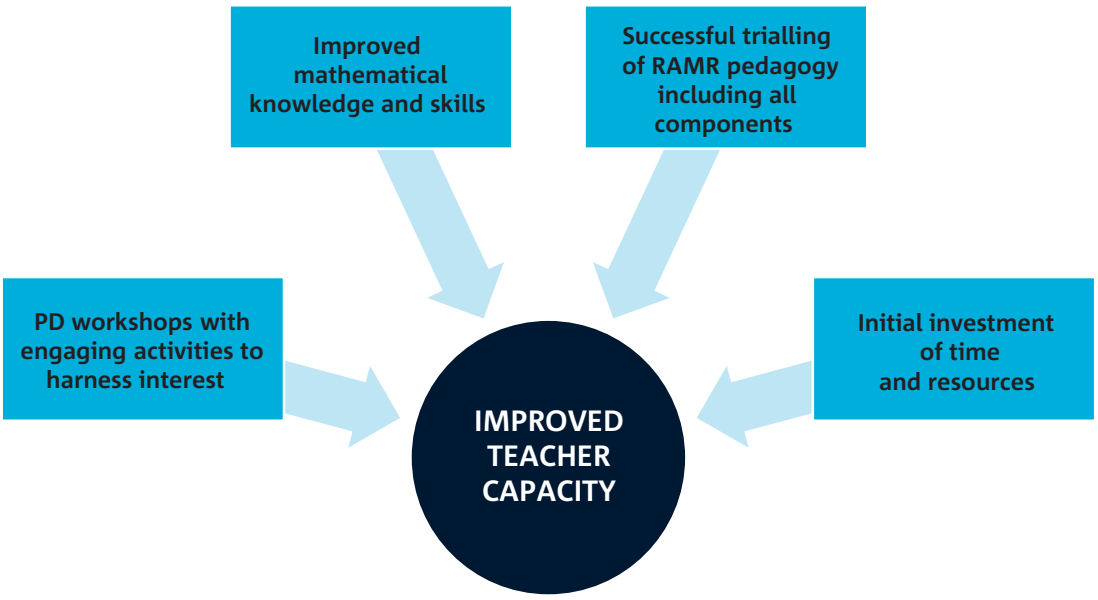


Figure 3.2 Factors influencing teacher capacity

3.4 Program implementation

The train-the-trainer approach used in the PRIME Futures program required teachers attending the PD workshops to train the other mathematics teachers in their school in YDM methods. The cost of this for the school could include releasing the teacher-trainers from their usual duties to observe lessons by other teachers and/or engage in team teaching, and the provision of time in staff meetings or on student-free days for training in YDM methods. Teacher-trainers also required time to prepare for meetings and/or demonstration lessons and to assist teachers in developing lesson plans.

This section discusses the extent of implementation of the program in the participating schools in terms of management commitment, professional learning communities and challenges that affected successful implementation.

3.4.1 Management commitment to the program

It takes time for YDM training to come to fruition. YDC practitioners have observed that in the first few PD workshops teachers are learning the process and have yet to see the difference it makes in their own teaching. After two years of formal training, the seeds that have been planted throughout the PDs generally begin to produce good results so that by the final PD, many participants who may have been doubtful initially express glowing comments and share discussion and/or demonstrations of effective implementation. This highlights that a two- or three-year term for a project is barely sufficient to cement new practices and may not be long enough for effective train-the-trainer processes to be established within a school. This also suggests that many schools in the PRIME Futures program have not yet had sufficient time to fully implement YDM. To that extent, this case study may be premature.

Evidence of school commitment to the PRIME Futures program was obtained from the following sources:

- PD records that showed management support through attendance by principals or deputies at one or more workshops, with some school managers continuing to attend as part of the school's team
- survey data that showed the extent of YDM implementation in the schools (see Section 2.4.2)
- YDC cluster coordinators' observations, both in person and through telephone and email conversations
- teacher reflective journals that provided examples of management support:
  As a whole school we have committed to using YD maths as our 'how to teach mathematics'. … trying to ensure that all staff understand the RAMR cycle. … I am increasingly trying different ways to support staff to implement YDM. [Teacher 57, School 3C]
- evidence of the provision of physical resources needed for YDM and the modification of learning spaces and outdoor areas to accommodate the kinaesthetic approach to teaching
- school planning documents that included explicit reference to YDM.

The extent of school engagement with the PRIME Futures program varied considerably. School engagement and commitment can be summarised into three broad categories:

- **School-wide**: A commitment from the outset to embed YDM as the preferred mathematics pedagogy across all levels of the school (mainly primary schools).
- **Faculty-wide**: A commitment to embed YDM as the preferred mathematics pedagogy across all classes in Years 7–9 (mainly secondary schools).
- **Key teachers only**: YDM strategies being used by the key teachers only to a greater or lesser extent within their own classes (both sectors).

In these circumstances, the teacher-trainers were active in changing their own practices but also in spreading concepts to other teachers.

The best results occurred in schools where the leadership team was actively involved in the implementation. One school in Cluster 2 displayed the greatest commitment from the outset by using school funds to employ an additional staff member to coordinate and support teachers in YDM implementation.

YDC cluster coordinators agree that there are four essential requirements for a school to implement and maintain a pedagogy such as YDM across the school:

- support and high expectations from the leadership team
- key personnel to drive the change and being retained in this role
- systemic and regional focus supporting the change
- time and money to support staff in making the change.

School changes observed during the program depended on the input from the leadership team within the school.

Most schools sought to embed some YDM strategies and practices into existing instruction programs. However, some schools took longer to decide how to use YDM within the school and to acquire the necessary resources (in time, funding and physical resources). At the time of writing this report, implementation within these schools had not progressed much beyond the individual teacher.

In some cases, changes to leadership teams impacted on the schools' ability to fully support implementation. They led to a diminution of the effectiveness, and therefore the uptake, of YDM across the school. They made it harder to sustain the process of school change. In a few schools, there were frequent changes to the school leadership team. For example, in Cluster 1, only one out of the original seven school principals remained at the end of the program, and some schools experienced three or four different principals in that time. Where the incoming managers had little idea of the purpose and processes of the PRIME Futures program, obtaining management support for YDM was difficult. In most instances, it was changes to or the loss of key drivers of implementation in the schools that led to the lessening of the effectiveness of YDM across the school or withdrawal from the program. For example, at one secondary school in Cluster 3, discussions were held during the initial visit with a view to arranging additional PD for mathematics teachers in the school. However, a subsequent change in the HoD position resulted in a significant reduction in commitment, eventually leading to the school withdrawing from the program. Frequent changes in a school's strategic direction are wasteful of school resources and frustrating to teachers who have been trying to implement the previous managers' vision for the school.

3.4.2 Professional learning communities

The YDM theoretical framework outlined in Section 1.2 includes types of scaffolding that can be used to effectively facilitate teacher learning. One of these is the establishment and maintenance of professional knowledge-building communities of practice. Many schools have established professional learning communities of practice. Some were YDM committees within a school that enabled teachers to communicate regularly, provide PD in YDM for other teachers, and mentor other teachers through team teaching and classroom visits.

To enable our staff to communicate and collaborate effectively, I have developed a YuMi OneNote that we are all contributing to. I … regularly communicate with the teachers at our school to reflect on our progress. … 91% of staff surveyed said they wanted YuMi training. This speaks well for the program and how the YuMi trained staff at school are sharing their passion. After a very successful staff opt-in YuMi Deadly PD, staff have increased their awareness of YuMi and how this thinking can be applied to their work. … We showcased several 'YuMi-fied' math concepts in our school library and allowed teachers to roam so that they could pick and choose what piqued their interest. [Teacher 34, School 4F]

Other schools partnered or networked with neighbouring schools to share training and experiences. Some partnerships were pre-existing arrangements between schools, often fostered by the relevant education authority, while others were established as a result of contacts made at the YDM PD workshops:

From the YDM workshops we have furthered our own learning and now have a professional learning community. … We meet together to share what we have been doing and to discuss any problems we may have encountered … discuss the planning of lessons, share resources and ideas. … Through this [school partnerships] we were able to work together and support each other with planning and queries. I found this fantastic to work alongside other teachers and see what they have been doing within their site. [Teacher 64, School 6C]

Best results occurred when these communities had strong management support.

3.4.3 Challenges

School-wide adoption of YDM is a key aspect of the school change process but occurs towards the end of a chain of events that commenced with the PRIME Futures program. It is beyond the direct control of YDC practitioners. Perhaps it was not surprising that some schools and teacher-trainers experienced challenges.

Inspiring other teachers to try YDM

A small number of teacher-trainers commented on the difficulty of trying to inspire other teachers to implement YDM. There are several possible reasons for this:

- **Colleagues' willingness to change**. As one teacher explained: "Inspiring other teachers to be committed to teaching YuMi style ... to get these teachers to continue teaching YuMi style independently is not always successful. Why—time to prepare, creating ideas, lack of resources, being convinced that this is a worthwhile way to deliver lessons, + it's easier to have students sit at desks and teach than try to create resources/ run activities/ manage behaviour" [Teacher 134, School 8D]. One possible solution to this problem is to focus the initial implementation efforts on those teachers who want to give YDM a go. If it is possible to develop a critical mass of teachers who are enthusiastic about YDM, it is more difficult for teachers who are resistant to change to ignore its benefits.
- **Extent of management support**. Without committed and visible support from management, it can be very difficult to persuade some teachers to implement YDM. The teacher quoted in the previous point concluded their comments by saying, "I also feel that the drive for YuMi needs to come from 'above' me and needs more of a commitment to encouraging teachers to try it out" [Teacher 134, School 8D]. Inclusion of explicit expectations about YDM in school teaching programs can also be persuasive.
- **Choice of teachers to be trainers**. As discussed in Section 3.1.2, the school may not have chosen the best people to attend the PD workshops. Successful teacher-trainers need to be able to demonstrate through their own practice that YDM is effective and then enthuse other teachers to give it a go. In the absence of clear statements of support for YDM from management, teacher-trainers need sufficient seniority within the school to be able to speak on behalf of management.

Conflicting school programs and priorities

Where schools are already undergoing a lot of change, the inclusion of yet another change by introducing YDM is likely to be counter-productive. The impact of the change depends on the type of school. For example, if in a secondary school the English teachers are focusing on a new literacy program, then the impact of a new mathematics program is likely to be minimal as there is little overlap between teachers of each subject. However, in a primary school where English and mathematics are usually taught by the same teacher, the impact could be insurmountable.

In several clusters, the schools were required to comply with education authority directives about school priorities that conflicted with the implementation of YDM. In Queensland, with the recent move to C2C, many schools were mandated to follow C2C lessons. Schools were required to assess and report using test items provided to them and if the related lessons are not taught, the students are disadvantaged. While some teachers and schools have been able to interweave YDM and C2C, in many cases YDM was viewed as a lower priority than C2C. Similarly, a Queensland Department of Education imperative to use EDI caused concern for some Queensland schools. Teachers initially considered that the inquiry-based nature of YDM was incompatible with EDI, despite YDC staff adapting the RAMR framework to include or parallel EDI pedagogy. The perceived incompatibility with EDI was also a barrier to recruiting schools for the program in Cluster 8 (Far North Queensland).

In South Australia, Department for Education mandates and changes to key personnel at critical junctures influenced the effectiveness of the program, especially in Cluster 6 (Adelaide). Further, some schools in that cluster and in Cluster 9 (Geraldton, Western Australia) were undergoing restructures at the time of the PRIME Futures program. These restructures changed the year levels that the schools catered for and distracted teachers in those schools from implementing YDM as effectively as they might otherwise have done.

Another challenge in Cluster 9 was that some other teaching programs were in use when the PRIME Futures program commenced. One school sought to use YDM in a manner for which it was not designed, supplementing a commercially available package. Consequently, their staff participation diminished and ultimately the school withdrew from the program. Four other schools in this cluster also withdrew from the PRIME Futures program because of overlap with other programs already operating in those schools.

Other schools took from YDM only what was needed to transform their teaching programs. Thus, YDM strategies were used in conjunction with other school and systemic initiatives.

With the benefit of hindsight, it was asking a lot of those schools undergoing restructures to simultaneously implement a pedagogy that promoted further school change. Similarly, the inclusion of schools in PRIME Futures that had existing programs that conflicted with or paralleled YDM required more thought. Where the program was mandated throughout the state or region, such as C2C or EDI in Queensland, excluding schools on the basis that YDM was incompatible with these initiatives would have had the effect of excluding the entire state. The solution adopted was to demonstrate how YDM was compatible with these other initiatives.

Figure 3.3 Factors influencing successful whole-school implementation of YDM

Resources needed for YDM

YDC practitioners accept that YDM is an active and practical pedagogy that encourages teachers to use particular classroom teaching resources; for example, the maths mat. Some of these resources are available commercially, others can be made by teachers and students: "The resources are cheap and easy and ideal for our context" [Teacher 99, School 7A]. In most cases, once developed and/or acquired, the classroom resources can be re-used. Single-use resources can often be developed and saved as a computer file so they can be reprinted as needed. Edible resources need replenishing each time the lesson is repeated.

Some schools dedicated sections of their grounds to facilitate YDM activities, incorporating grids painted on the ground and Indigenous artwork. Schools with several classes in each year level needed to acquire several class sets of resources. As some of the resources are bulky (e.g., the maths mat), there is a need for a suitable storage area after the resources have been acquired.

It is evident that the acquisition of the resources needed to support the implementation of YDM is one of the hidden costs for a school in adopting the YDM pedagogical approach.

Remoteness of the schools

In some cases, the remoteness of the cluster posed challenges. For example, Cluster 1 (Emerald region) had difficulty in selecting a venue for PD that all teachers could attend easily. However, in Clusters 5 (Port Lincoln) and 10 (Albany) the remoteness contributed to the existence of already stable partnerships among the schools that became an asset in implementing YDM.

3.4.4 Summary

The most successful examples of YDM implementation occurred in schools where the leadership team was actively involved in supporting the program. In these circumstances, the teacher-trainers were able to change their own practice and then spread the concepts to other teachers. Many schools established professional learning communities, either within the school or in conjunction with neighbouring schools. However, challenges to successful implementation of YDM in schools were the difficulty of inspiring teachers to change their teaching methods; conflicting programs and priorities within the school (the counterfoil of strong management support) that made implementing YDM more difficult; and the cost of acquiring and storing the resources needed to support YDM. These factors are summarised in Figure 3.3.

3.5 Student outcomes

Section 2.5 presented the data on student outcomes, which showed that almost all teachers and principals reported increased student engagement and nearly three-quarters reported improved student learning/understanding. The comments in the teacher reflective journals overwhelmingly supported the quantitative data. The increase in student engagement was observed in all types of students.

Despite these positive results, only a small percentage of survey responses from teachers and principals considered that the increases in student engagement had translated to increases in student achievement. However, in their reflective journals, many teachers commented on their classroom observations of improvements in student thinking and understanding. This section discusses four aspects relating to student outcomes from the PRIME Futures program: engagement, behaviour, achievement and assessment.

3.5.1 Student engagement

As explained in Section 2.5, a key objective of the PRIME Futures program was to improve student engagement in mathematics; that is, the extent of the students' attention, curiosity, interest, optimism and passion for learning (Great Schools Partnership, 2016). This includes the motivation to learn. In the biannual teacher surveys, 86% of responses reported increased student engagement and 71% reported improved student learning/understanding (see Table 2.20). About one-fifth (22%) of responses reported better test results. There was least reporting of increased STEM interest (9%). Given that many of the schools involved in the program are primary schools, perhaps it is too early to expect students to be thinking of careers in a way that is evident to teachers.

The biannual and exit surveys all demonstrated that teachers observed improvements in engagement for all groups of students, with marginally higher improvements for students in the lower ability range and Indigenous students (see Figure 2.8). Given the deliberate focus of YDM on effective teaching for all students in a class, not just Indigenous students, the data about the engagement of different groups of students in mathematics is interesting (see Tables 2.22 and 2.23). While it shows that, on average, teachers observed slightly less than a 'moderate' increase in student engagement, of more interest is that the increase in student engagement was observed in all categories of students. This supports the belief of YDC practitioners

that good pedagogy, focusing on real-life contexts (including Indigenous contexts) is effective for all students. To use a cliché, 'a rising tide floats all boats'.

Confirming the trend of the quantitative data was the anecdotal evidence from teachers' reflective journals. Teachers overwhelmingly commented on improvements in student engagement. In many cases, they attributed this to the use of an approach that allowed students to act out situations using their bodies, hands and, eventually, minds. The use of real-life contexts was also mentioned as an important way of engaging students. Teachers also considered the improvement in engagement as a consequence of the pedagogy was because it allowed the students to experience success in mathematics. Many teachers described the improvements in students' attitude, enthusiasm, interest, enjoyment, confidence and motivation as a result of using YDM methods.

Supporting the first-hand information in the teacher reflective journals were the secondary observations of the YDC cluster coordinators. They reported that, on the whole, teachers involved in the PD program indicated that students were more engaged and they had fewer behaviour management issues to deal with when the RAMR structure (or at least parts of it) was implemented in classes.

3.5.2 Student behaviour

One significant aspect of student engagement is student (mis)behaviour. Students exhibit challenging behaviours in the classroom for many reasons, but high on the list would be boredom, inability to see a use for the concepts being taught, a lack of understanding (often due to a lack of the essential prerequisite knowledge), or to distract from poor achievement. Use of the YDM approach, with its links to reality, focus on folding back so that students develop the required prerequisite knowledge, high expectations and engaging activities, should remove many of the causes of challenging behaviours.

Component 5 of the underlying philosophy of YDM identifies the need for whole-school policies to address challenging student behaviour. A common school behavioural management program used consistently in each classroom is required to prevent unacceptable behaviour from interfering with mathematics instructional activities. As predicted, many teachers reported that after introducing YDM, student behaviour improved, lessening the need to access the school behavioural management policies: "My students race into my classroom when I tell them I am doing YuMi. Almost unheard of. Behaviour from the students like this is rare" [Teacher 97, School 7B]. However, it may be a gradual process: "I have noticed that as we introduce more of the YuMi methodologies into the maths lessons there are less [sic] disruptions and more engagement from these children" [Teacher 64, School 6C]. Several teachers described how mathematics has become their students' favourite lesson. The teachers in a school in Cluster 2 enthusiastically commented on experiences where teachers team-taught combined classes to spread YDM skills to other teachers and observed that in a 1.5-hour session there were only four minor pauses to instruction for behaviour management correction.

However, a smaller number of teachers found that problems with student behaviour continued, or even increased, after introducing YDM. This was more likely to occur with older students in secondary schools, where students had become accustomed to traditional lesson structures and were resistant to change. In most classes, YDM leads to changes in classroom routines and procedures. It could take time for some students to become accustomed to these changes, with a consequent short-term deterioration in student behaviour. It may be necessary to re-negotiate the classroom expectations with those students.[15] The high expectations philosophy that accompanies the YDM approach should also assist in reversing this trend.

A more active and engaging pedagogy should eventually lead to improved student behaviours, as many YDM teachers have found. However, from a teacher's perspective, a lesson in which students leave their desks, move about the room (or the school grounds) and make decisions for themselves potentially represents a loss of control that might exacerbate student behaviour problems. It creates a paradox for those teachers for whom the way to improve student behaviour is to give students more opportunities to be active. It requires a determination to persevere even though things may get worse before they get better. It also requires understanding and support from school managers.

15 A participant in an earlier YDM program described how it took him several lessons to teach students how to behave when conducting a mathematics lesson outside the classroom, while another joked that 'YuMi' was an acronym for 'you unleash mayhem in [class]'.

An interesting anecdote shared by one teacher highlighted an unanticipated behavioural bonus from using Indigenous contexts:

When I use Indigenous perspectives and students become mildly disruptive, other students and Indigenous students have made the firm statement 'Respect the culture' as a way of saying listen up, be respectful. I believe the idea of respecting culture resonates with other cultures in the classroom and students pull themselves into line. Master stroke! [Teacher 97, School 7B]

While YDM is not a panacea for all classroom behavioural issues, we contend that, on balance, YDM leads to improvements in student behaviour.

3.5.3 Student achievement

Student achievement is the attainment of desired learning objectives or standards. It could be argued that a weakness of this case study is the paucity of quantitative student achievement data. However, we contend that this is compensated for by the many teachers who reported improvements in student thinking and understanding, evidenced by the students' questions, discussion, linking to prior learning, problem-solving and creativity. Improvements in student thinking led to a deeper understanding of mathematics. Teachers reported that deep understanding made it easier for students to learn later concepts. While teachers did not necessarily provide data about academic gains, it is logical to surmise that students who are more interested and actively involved in mathematics would develop a greater and more in-depth understanding of the content and therefore have a better outcome academically in the long run.

In the biannual teacher surveys, although 86% of responses reported increased student engagement and 71% reported improved student learning/understanding, only one-fifth (22%) of responses reported better test results. However, despite a general lack of supporting student quantitative achievement data, many teachers made observations and related anecdotes about the impact of YDM in their classes both in their reflective journals and during school visits. Information of a general nature relating to improved student outcomes was often cited by HoDs and members of the school leadership team when YDC practitioners visited schools. There were many reports of increased teacher and student satisfaction levels. As evidence of improvements in student achievement, teachers cited evidence such as the nature of discussions between the teacher and students as well as among students, the questions asked by students and their increased ability to link what they were doing with other mathematical concepts:

I have found that the YuMi approach to teaching has REALLY increased the discussion around mathematics in the classroom! Confidence of students is higher and engagement is also up as they are loving it!!!!!! [Teacher 66, School 6D]

They liked finding out for themselves what worked for them and looking at what strategies everyone used. Sharing ideas and talking during the learning process!!!! [Teacher 18, School 4C]

However, hard information about student achievement was limited, with only a few schools able to provide concrete evidence. Three teachers provided (or referred to) quantitative information about student achievement in their reflective journals. One teacher from Cluster 9 presented at the YDC Sharing Summit held in October 2018 about the improvements achieved in a relatively short time in her school:

In Term 1 2018, our school began an intervention program following the YuMi Deadly Maths RAMR Cycle. Our intervention program targeted Pre-Primary to Year 8. Every student made progress and within the first 5 months 50% of our kids had moved up 1–2 year levels in maths. [Teacher from School 9B]

In one school in Cluster 2, the principal tracked semester achievement data for different cohorts of students across year levels. He was able to correlate variations in student results with the strategies teachers used in class. Teachers using YDM strategies obtained much better success rates with the same group of students. For example, in a cohort of students in which 63% of the group obtained a rating of C or above at the end of one year, this increased to 80% success the next year with a teacher using YDM strategies. The Indigenous students within that cohort moved from 50% to 86% success rate. Two schools in Cluster 8 provided documentary evidence (either through NAPLAN data or internal school data) of gains in student performance. In one of the schools, students working at the Year 5 level on individual education programs at the start of the PRIME Futures program were capable of being assessed using the Year 10 core standards for assessment by the end of the program.

The triangulation of the data using different ways of observing the same phenomenon lends weight to the conclusion that YDM has been effective in promoting student achievement.

3.5.4 Assessment issues

The previous section referred to comments from many teachers (in YDC Sharing Summits, discussions with YDC practitioners and reflective journals) that after adopting YDM their students showed increased understanding of mathematical concepts in class.

However, a feature of the active nature of the YDM pedagogy is that often students (and their teachers) do not have a record of their learning:

Teachers across the year met the challenge of having nothing written down or in students' maths books as evidence of learning after a rigorous maths lesson. They are much more at ease with this and are in the developing stages of creating simple and manageable systems which capture what students can do, know and understand. (photos, quick anecdotal notes, post-it scribbles, which are sometimes student managed). This is also an area in development but a challenge teachers faced and 'let go!' as they saw that the time spent recording was not the intent of the lesson but the discussion and problem-solving was. [Teacher 121, School 5C]

This is one possible reason for the paucity of quantitative student achievement data.

The lack of concrete data on student learning through active pedagogy is perhaps more of a problem in the secondary years where there was more pressure for teachers to provide evidence of their students' learning to both school management and parents.

The stress of ensuring you teach the mathematics so that students can achieve well on assessment, while still trying to engage students. Schools and parents see assessment results, however in secondary school they don't really get to see student understanding through 'hands-on activities'. [Teacher 52, School 1C]

YDM includes assessment as part of the Planning–Teaching cycle (see Figure 1.6), but only for diagnostic purposes. However, an important form of evidence of learning is summative assessment, especially for secondary teachers. It includes school-based assessment, external assessment and NAPLAN [16]. In some cases, teachers using YDM have reported that students were unable to demonstrate their knowledge and understanding in summative assessment:

I am very aware that my assessments need to change. I usually use a worksheet style assessment to keep as a record, however if the children do not do many worksheets they often do not do so well in a test. This may be something to cover and learn more about/ how to assess maths effectively in relation to the style of teaching. [Teacher 106, School 10A]

This teacher has diagnosed the situation correctly. Hands-on activities successfully promote learning and understanding. However, students also need to be able to demonstrate that they have that knowledge in standard forms of assessment items. This means that they must be given opportunities in the 'mathematics' phase of the RAMR cycle to practise responding to questions that resemble assessment items. This is an ideal way of seamlessly embedding NAPLAN and test preparation into teaching and learning activities. It may also mean that the nature of school-based assessment items must change. However, as changes to assessment practices may have implications for an entire year level, it would require all teachers in the year level to be using YDM.

3.5.5 Summary

Both quantitative data and anecdotal evidence from teachers' reflective journals demonstrated improvements in student engagement. In many cases, this was attributed to the use of real-life contexts, kinaesthetic activities and a pedagogy that allowed students to experience success in mathematics. Many teachers described the improvements in students' attitude, enthusiasm, interest, enjoyment, confidence and motivation as a result of using YDM methods.

Many teachers reported that after introducing YDM, student behaviour improved and mathematics had become their students' favourite lesson. However, a smaller number of teachers found that problems with student behaviour continued, or even increased, after introducing YDM. Therefore, it would appear that student behaviour was both a benefit and a challenge associated with the implementation of YDM.

16 The material issued by ACARA and the Australian Government describes NAPLAN as a form of diagnostic assessment. However, the high-stakes nature of the testing and the consequent pressure placed on some teachers and schools to improve NAPLAN performances has effectively turned it into summative assessment.

Despite a paucity of hard evidence, there were many reports of improvements in student achievement and learning, evidenced by the nature of student questions and discussions, and their increased ability to see the connections to other mathematical topics.

In some cases, teachers using YDM have reported that students were unable to demonstrate their knowledge and understanding in summative assessment. Students must be able to demonstrate their mathematical knowledge in assessment items. This means they must be given opportunities in the 'mathematics' phase of the RAMR cycle to practise responding to assessment-type questions.

The findings are summarised in Figure 3.4.

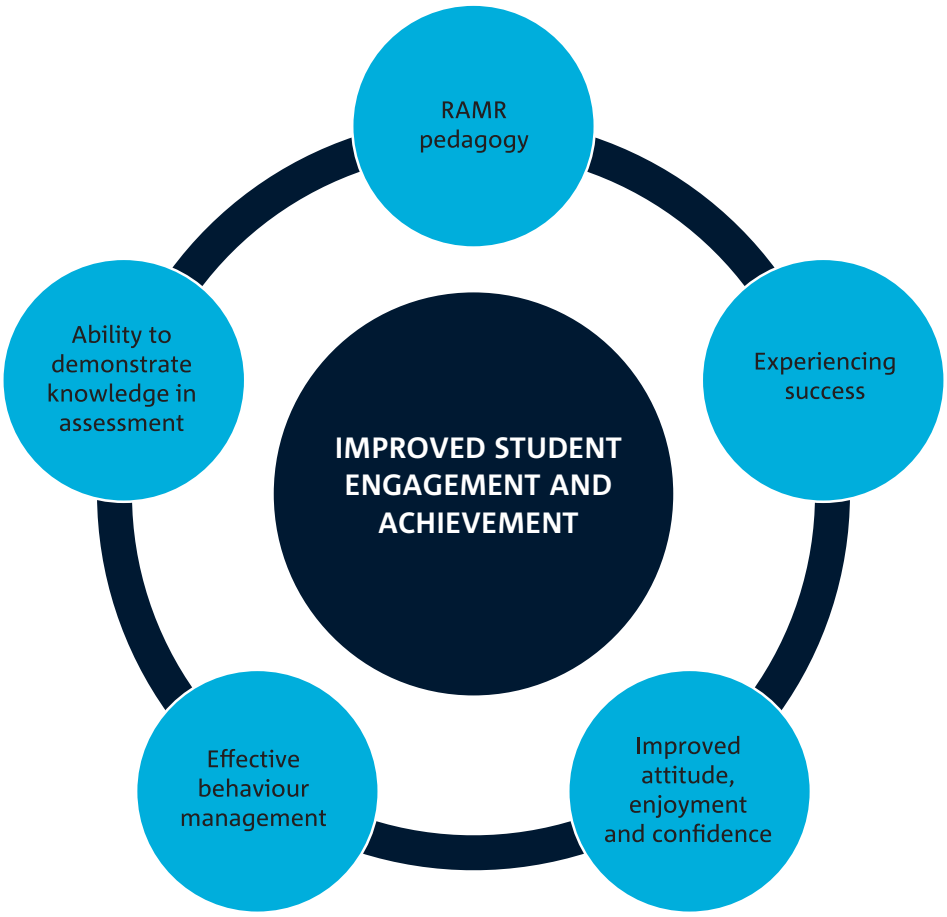


Figure 3.4 Factors influencing student outcomes in the PRIME Futures program

4 FINDINGS AND CONCLUSIONS

The PRIME Futures program discussed in this report was the mathematics element of a broader Indigenous STEM Education Project managed by CSIRO in partnership with the BHP Foundation. The overarching goal of the Indigenous STEM Education Project was to provide supported pathways that improve the participation and achievement of Aboriginal and Torres Strait Islander students in STEM fields.

The PRIME Futures program was delivered by QUT's YDC across four years from September 2015 to August 2019. The main aims of the program were:

- to increase the participation of Indigenous students in mathematics
- to increase the achievement of Indigenous students in mathematics
- to improve teacher capacity in the teaching of mathematics to Indigenous students.

The presentation and discussion of the results of the PRIME Futures program in Chapters 2 and 3 clearly indicate that the program substantially achieved each of these three aims. However, the analysis of data collected during a series of design-research studies conducted during the four years of the PRIME Futures program identified two categories of factors that needed to be addressed if both theory and practice in the teaching of mathematics in Indigenous and low-SES schools were to be significantly advanced:

- factors within the domain of the theoretical framework
- factors outside the domain of the theoretical framework.

These major factors and their sub-factors are examined in the following sections, and recommendations are made for modifications at both the theoretical and practical level to advance theory informing future research and practice in the teaching of mathematics in Indigenous and low-SES schools.

4.1 Factors within the domain of the theoretical framework

The three-layered theoretical framework that was used to inform the research and development of YDM theory and practice within the context of the PRIME Futures program was presented in Figure 1.1. The middle layer of the theoretical framework (re-presented in Figure 4.1) consists of a network of five components that includes:

- two sociocultural components (numbered 2—recognition and utilisation of students' cultural capital, and 5—whole-school and school–community partnership approach), which formed a vertical symmetry with the two cognitive components on the right (numbered 3—systematic addition of cultural capital, and 4—focus on the structure of mathematics)
- a component (numbered 6—teacher as learner) that provides two-way indirect links between the sociocultural and cognitive components.

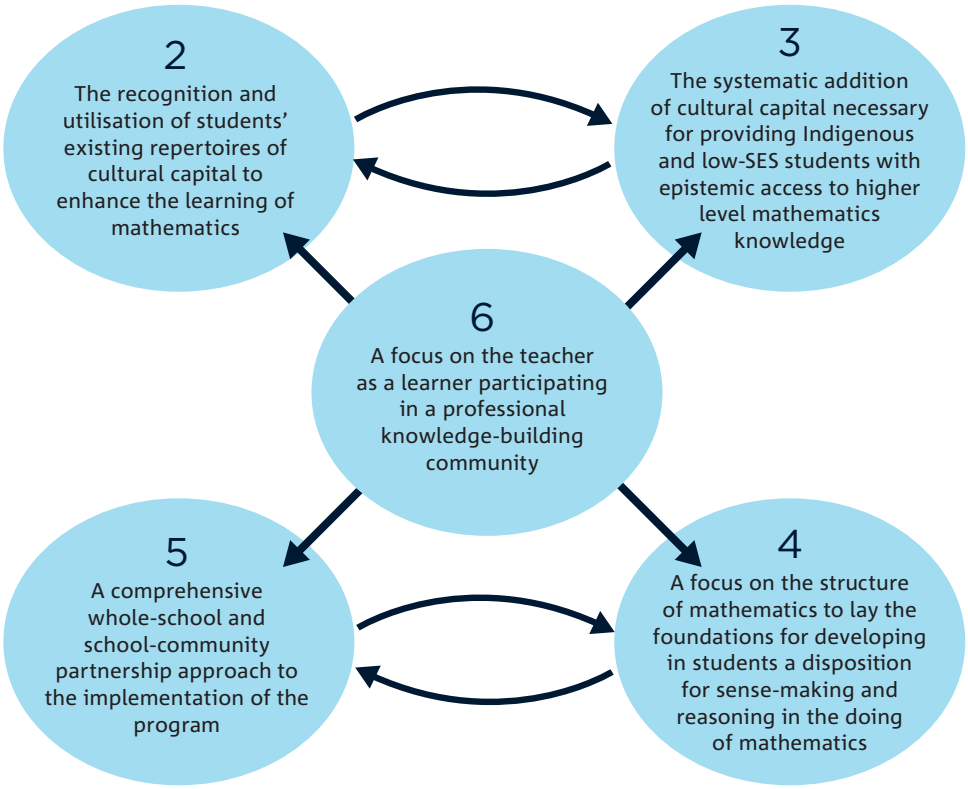


Figure 4.1 Middle layer of the YDM theoretical framework

The analysis of data collected from a series of design-experiment studies conducted during the course of the program confirmed the educational efficacy of Components 2, 3 and 4. However, the analysis of data also revealed that modifications needed to be made to:

- Component 6 (teacher as learner)
- the cycle of school change and leadership within Component 5.

4.1.1 Modification of Component 6

Macro-level modification

In the schools where the implementation of YDM was most successful, it was found that two important characteristics differentiated them from the other schools:

1. teachers had fully adopted the role of action researcher
2. teachers had fully adopted the role of mentor/influencer.

Adopting the role of action researcher

During the implementation of the cycle of school change and leadership (encapsulated in Figure 1.3), teachers were provided with information and training in action research. The benefit of action research within the context of the PRIME Futures program was that it provided teachers with a framework for the systematic inquiry of their own practice. It also provided feedback to YDC on how to improve resources and processes. In the schools where the implementation of YDM was most successful, a significant proportion of the teachers had not only enthusiastically adopted the role of teacher as a learner, but they also had fully engaged in the role of an action researcher.

Adopting the role of mentor/influencer

During the implementation of the cycle of school change and leadership, each school was required to nominate staff to take on the role of teacher-trainers at their schools after they had attended PD workshops. During the series of design-experiments conducted in the course of the program, how the teacher-trainers were selected was found to be a vital component for successful implementation of YDM. The most effective teacher-

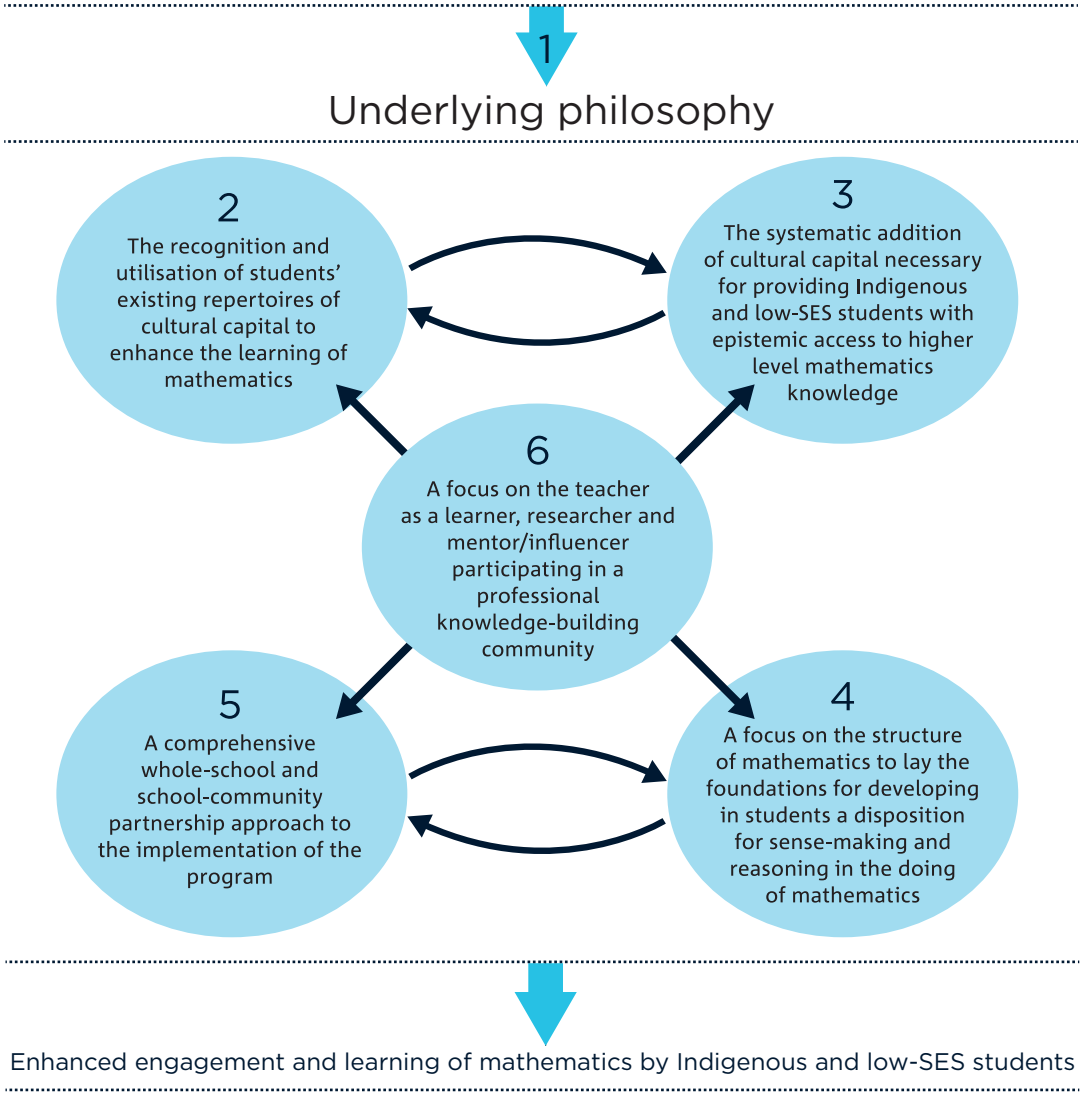


Figure 4.2 Modified YDM theoretical framework

trainers generally were found to be well regarded by their fellow teachers and school administrators, prior to their school's participation in PRIME Futures program, for their effectiveness as a teacher, experience, maturity and/or seniority in the school and passion for mathematics. These qualities enabled these teachers to legitimately undertake the role of a mentor/influencer within their schools.[17]

Based on these two findings, Component 6 within the theoretical framework was modified from Teacher as learner to Teacher as learner, researcher and mentor/influencer (see Figure 4.2).

Micro-level modifications

Curriculum development templates such as the RAMR framework (encapsulated in Figure 1.5) and the Planning–Teaching cycle (encapsulated in Figure 1.6) were included in Component 6 of the YDM theoretical framework to facilitate learning by teachers during the course of PD programs.

The analysis of data collected from the teachers, teacher-trainers, school administrators and YDC practitioners during the series of design-experiment studies conducted over the course of the PRIME Futures program indicated that the RAMR framework and

17 This finding is consistent with the research literature on the successful mentoring of novice teachers (see Galvez-Hjornevik, 1986) and on the re-culturing of schools (Fullan, 2007) to create more inclusive schools that meet the needs of Indigenous and low-SES students.

Planning–Teaching cycle generally were found to be very effective templates for scaffolding the implementation of YDM into the teachers' classrooms. However, three challenges were encountered by some of the teachers during their implementation of the two templates:

1. how to incorporate the RAMR framework and the Planning–Teaching cycle into existing programs
2. finding suitable 'realities' for implementing the RAMR framework in their classrooms
3. how to integrate YDM with 'traditional' assessment protocols.

Incorporating the RAMR framework and Planning–Teaching cycle into existing programs

Before commencing the PRIME Futures program, some of the schools were locked into existing programs. For example, in some of the Queensland schools EDI programs were already in place. Many of the teachers and administrators in these schools expressed concerns about YDM's compatibility with their existing EDI programs. Similar concerns were raised by a group of four primary schools located in Geraldton. Other programs were already operating within these schools. The existing programs, being locally based and supported, were seen as being easier to sustain. Because of this, this group of four schools withdrew from the project early in 2018, having attended two PD workshops and received one school visit.

Finding suitable 'realities'

Within the RAMR framework, three types of reality are identified as being possible starting points for the planning of structured instructional sequences:

- local knowledge
- prior experience
- kinaesthetic activities involving students' bodies.

With most primary school mathematics topics (e.g., the inverse operations of addition and subtraction), this is a relatively simple task. Thus, most of the exemplars provided to the teachers during the earlier phases of the PRIME Futures program focused on the teaching and learning of primary school mathematics topics. Unfortunately, many of the secondary school teachers found that these exemplars provided little guidance in helping them to identify suitable realities as starting points for the planning of structured instructional sequences for many advanced mathematics topics in the secondary school mathematics curricula. For example, although most of the secondary school teachers readily accepted that kinaesthetic activities involving students' bodies could be used in teaching the processes of addition and subtraction, they were unable to comprehend how the teaching of advanced mathematics concepts such as variables could be based on kinaesthetic activities involving the whole body. Some of the secondary school teachers also indicated that the exemplars provided did not really help them to understand how they could use their students' local knowledge and prior experiences as starting points for the teaching of complex secondary school mathematics topics.

Integrating the RAMR framework and Planning–Teaching cycle with 'traditional' assessment protocols

In many of the schools, the teachers indicated that they felt they were under much pressure to achieve good results in formal assessments such as end-of-semester assessments and NAPLAN (ACARA, 2016). Thus, particularly prior to and in the initial stages of implementing YDM into their schools, many teachers were quite reasonably concerned about how implementation of the RAMR framework and Planning–Teaching cycle would impact on their students' formal test scores and also how they could use data from 'traditional' assessment protocols within the RAMR framework and the Planning–Teaching cycle. Once YDM had been fully implemented, some teachers noted a disconnect between students' understanding demonstrated during YDM learning activities and in 'traditional' assessment items; the high levels of understanding shown by some students during the course of YDM learning activities were not being replicated in formal tests.

To address these three challenges, the following four micro-level modifications were made to Component 6 of the theoretical framework during the PRIME Futures program:

1. The **planning** and **management** elements of the YDM Planning–Teaching cycle were adapted to facilitate the incorporation of many existing programs such as EDI into the YDM framework.
2. The range of mathematics topics addressed in the exemplars provided to the teachers was widened to include advanced mathematical secondary school topics.

3. The **diagnosis** and **analysis** elements of the YDM Planning–Teaching cycle were adapted to facilitate the integration of data from 'traditional' assessment items into the RAMR framework and the Planning–Teaching cycle.

4. The **planning** and **teaching** elements of the YDM Planning–Teaching cycle were adapted to ensure higher degrees of congruence would be achieved between students' understanding demonstrated in YDM activities and in 'traditional' assessment items.

4.1.2 Modification of cycle of school change and leadership in Component 5

To have optimal impact on Indigenous and low-SES students' learning of mathematics, a comprehensive approach involving whole-school processes and school–community partnerships was proposed in the initial theoretical framework. This approach was incorporated into the cycle of school change and leadership encapsulated in Figure 1.3 (YuMi Deadly Centre, 2014).

However, it has been found that most teachers' knowledge about and application of the school–community element of Component 5, after starting from a low base, was not being significantly enhanced by the provision of resources and PD activities focusing on this element. For example, the summary of the Engoori charts generated by teachers during the Engoori PD sessions in PD 3 or 4 (presented in Figure 2.1) indicates there was much scope for improvement in this area.

To address this, ongoing modifications have been made at the practical level to the school–community resources and PD activities during the course of the PRIME Futures program. However, despite these modifications progress in the application of this aspect of the theoretical framework has been minimal and may have been a factor limiting the success of YDM in the context of the PRIME Futures program. This indicates that a major modification at a theoretical level is probably needed in the future to the cycle of school change and leadership within Component 5.

4.1.3 Professional knowledge-building communities of practice

The analysis of data collected during the course of the PRIME Futures program indicated that the professional knowledge-building communities established and maintained by YDC played a significant role in scaffolding teacher learning of the knowledge necessary for the successful implementation of CRP mathematics education practices in Indigenous and low-SES schools.

However, for the YDC team, one of the most pleasing developments that occurred during the course of the PRIME Futures program was the initiation and set up of the closed Facebook community called 'YuMi Deadly Teacher Connect' by Cluster 1 teachers. This social media community now has a membership of more than 200 teachers from around Australia. This was most pleasing for two reasons. First, it is helping to sustain YDM in schools that have received training by enabling the teachers to share their ideas and inspire one another. Second, it is an indication of how many teachers have taken ownership of the program.

This successful incorporation of social media into the PRIME Futures program indicates the need for future research into how social media can be best used to facilitate the collective advancement of teacher knowledge about CRP mathematics education practice by teachers engaged in mathematics education programs similar to the PRIME Futures program. A productive focus for this research would be the development of computer-based collaboration tools for scaffolding social media discourse between teachers that not only facilitates the sharing of ideas and experiences such as that occurring in 'YuMi Deadly Teacher Connect', but also the development and extension of shared understandings by the teachers.

4.2 Factors outside the domain of the theoretical framework

The analysis of data collected during the four years of the PRIME Futures program identified that the following four non-theoretical factors had a bearing on the levels of success achieved by the program:

1. criteria for clustering of schools
2. participant-related factors
3. provision of resources
4. school leadership.

4.2.1 Criteria for clustering of schools

For operational efficiency, the PRIME Futures program was delivered to 10 geographical clusters of between six and nine schools. Unfortunately, the clustering of the schools primarily by the criteria of geographical location often had negative impacts on the operations and outcomes of the program.

In most cases, schools within each of the clusters had not engaged in professional relationships (e.g., secondary schools networking with their feeder primary schools) with other schools in their cluster before their participation in the program. This lack of history of professional relationships between the schools within the clusters most often resulted in the schools operating in isolation from one another during the program.

This predicated against teachers networking with other teachers from outside of their school. In the cases where teachers were able to network with teachers from outside of their schools (e.g., Clusters 5 and 6 in South Australia), they reported that the networking facilitated the establishment and maintenance of professional learning communities with teachers from other schools. These professional learning communities enabled teachers to share and reflect on ideas, engage in partnerships and motivate one another. Operating largely in isolation also often resulted in systemic and regional directives overshadowing or lessening the impact of participating teachers' efforts to implement the PRIME Futures program successfully in their schools.

The criteria of clustering by geographical location also resulted in schools with varying enrolment patterns and clientele being grouped into the same cluster. This meant that schools within each of the clusters experienced different challenges in the implementation of the program. This had deleterious implications for the design and implementation of PD workshops presented to the clusters. For example, the different challenges being faced by the different schools within a cluster made the process of selecting the foci for many PD workshops a difficult task. YDC personnel were often confronted with the dilemma that what teachers from some schools in a cluster may find very useful could be found by other schools in the cluster to be irrelevant because of the different challenges they were facing.

In the past, YDC has found that the clustering of schools by criteria such as a history of professional relationship, types of challenges being faced and/or types of clientele have overcome many of the negative impacts on the operation and outcomes caused by the geographical clustering of schools in the PRIME Futures program. With the advent of social media that enables teachers from diverse geographical locations to engage in discourse with one another, the efficacy of these three criteria has been significantly increased. This is well illustrated by the 'YuMi Deadly Teacher Connect' Facebook community created by some of the teachers in Cluster 1 schools. Many of the approximately 200 teachers from many different geographical locations in Australia have found that discussing and sharing ideas with teachers who are facing challenges similar to those they are facing or who have clientele similar to theirs via 'YuMi Deadly Teacher Connect', has been very beneficial in helping them to implement YDM in their schools.

The implications of this for future programs focusing on the teaching of mathematics in Indigenous and low-SES schools is that the clustering of schools by geographical location, although it may seem to be operationally efficient, can have many negative impacts on the implementation and outcomes of a program. Better implementation and outcomes can be achieved by using other criteria such as a history of professional relationships, types of challenges being faced and/or types of clientele. Issues caused by geographical dispersion of locations can be addressed by the establishment and maintenance of social media or other online networks that enable teachers within a cluster to discuss and share ideas and to develop and extend shared understandings.

4.2.2 Participant-related factors

During the course of the PRIME Futures program, three participant-related factors were found to have major effects on the implementation and outcomes of the program:

1. selection of staff to attend PD workshops
2. high turnover of teachers
3. changes to and loss of mentor/influencers during the program.

Selection of staff to attend PD workshops

The findings from the series of design-experiment studies conducted during the course of the PRIME Futures program clearly indicate that the selection of suitable staff to attend the PD workshops is a vital component for the successful implementation of programs such as PRIME Futures. YDC practitioners reported that for schools to maximise the value of their investment in PRIME Futures, school management needed to consider carefully which staff should attend the PD training workshops.

Data from the schools where YDM was successfully implemented clearly indicates the staff who should be selected to attend PD workshops are not young and inexperienced teachers incapable of initiating change because of their relatively low status within the school's formal and informal structures. Instead, they should be teachers capable of initiating change because they are well established and well regarded for their effectiveness as a teacher, experience, maturity and/or seniority in the school, and have a passion for mathematics.

The findings from the series of design-experiment studies also clearly indicate that teachers chosen to participate in the PD workshops should be willing to devote the time and energy needed to act as teacher-trainers. One of the cluster coordinators noted the challenge of working with teachers who attended the PD sessions only for themselves.

High turnover of teachers

Teacher turnover in schools was a challenge that arose as a consequence of the extended duration of the PRIME Futures program. The impact of losing a teacher involved in the program was twofold:

- If the departure of the teacher occurred before the PD was completed then he/she was unable to complete the program, diminishing the potential benefit for that teacher.
- If the departure of the teacher occurred after the PD was completed while the school was trying to implement YDM, then the other teachers in the schools lost their in-school trainer and mentor, diminishing the potential benefit for the school.

Unlike the factor of selecting staff for PD workshops, the high turnover of teaching staff proved to be a rather intractable problem because of the many reasons beyond the control of the schools. First, many of the teachers employed in government schools were on fixed-term contracts that may not have been renewed or extended. Second, for some teachers, the remote and low-SES schools in the program were seen as being less desirable places to live and/or work, leading them to seek transfers to other schools when possible. Finally, transfers of family members to other locations, resignations, retirements and extended leave all added to the loss of teachers from a school.

Some of the participating schools lessened the impact of high turnover of teachers to a certain extent by taking the opportunity to have some of their paraprofessional staff included in the training. Having them included in the training had two positive benefits. First, because most of the paraprofessional staff were locals, they were less likely to leave the school than the teachers during the course of the program. Second, the inclusion of these local paraprofessionals, who worked across several classes and year levels in their schools, meant that a higher number of students were being given access to YDM pedagogy and teachings.

Changes to and loss of mentor/influencers

Changes to or the loss of mentor/influencers led to the lessening of the effectiveness, and therefore the uptake, of YDM across the schools. Frequent changes to mentor/influencers such as the leadership teams of some schools over the duration of the program made it harder to sustain the process of school change. For example, changes at the HoD position often resulted in changes to a school's strategic direction that in turn led to a significant reduction in a school's commitment to the PRIME Futures program. Frequent changes in a school's strategic direction were found to be wasteful of school resources and frustrating to teachers who had been trying to implement the previous managers' vision for the school. The loss of mentor/influencers such as teacher-trainers meant that many of the schools lost the potential benefit of their teacher-trainers' expertise developed during the course of the PD program. As with the factor of high turnover of teachers, the factor of changes to or loss of influencers proved to be a

rather intractable problem. This led to a decision by YDC practitioners to focus PD workshops on the generic YDM pedagogy for teaching any topic well, using particular topics as exemplars of the theory in practice.

4.2.3 Provision of resources

The schools and the teachers were asked to devote significant financial, personnel and material resources towards the PRIME Futures program. For example, each school was required to bear the cost of their employees' absences from their usual duties to attend PD workshops. Included in these costs were the wages of replacement teachers and travel and accommodation expenses for the teachers attending the PDs. The cost of replacing teachers attending the PDs prevented some schools from accepting the invitation to join the program.

Teachers attending the PD workshops were asked to train the other mathematics teachers in YDM methods. These teacher-trainers often had to be released from their usual duties to observe lessons by other teachers and/or engage in team teaching and the provision of time in staff meetings or on student-free days for training in YDM methods. Teacher-trainers also required time to prepare for meetings and/or demonstration lessons and to assist teachers in developing lesson plans.

In addition to these costs, schools participating in the PRIME Futures program were required to acquire particular classroom teaching resources; for example, the maths mat. Many teachers commented about the resource demands of YDM and the time and/or money needed to acquire them. Some resources had to be purchased thus incurring financial costs for the schools or the teachers. Others were constructed by staff members at the schools, thus incurring costs in terms of the staff members' time. Storage of the resources was also another cost factor that the schools had to consider.

Funding from the BHP Foundation through CSIRO did not provide funding for these financial, personnel and material resources. The South Australian Government was the only educational authority to assist some schools with the cost of participation in the program. In all other cases, the necessary funding had to be found from within the existing school budget, usually by reallocating funds. While this might be possible in a large school, the limited budgets of small schools made this almost impossible.

The clear implications of this for organisations considering providing funding for programs similar to the PRIME Futures program in the future is that they need to be aware that delivery of the program represents only part of the cost. Many schools will need assistance in managing the cost burden imposed on them by participating in programs such as PRIME Futures.

4.2.4 School leadership

The most successful examples of YDM implementation during the PRIME Futures program occurred in schools where teachers received support and high expectations from school leadership.

Leadership at the school management level in these schools provided committed and visible support to the teachers involved in the program by the provision of financial and material resources. The provision of moral support by school management was also an important factor in the successful implementation of YDM in these schools. In particular, moral support from school management did much to help overcome the challenges faced by teachers involved in the PRIME Futures program when they tried to inspire other teachers in their school to implement YDM in their classrooms and thus widen the impact of YDM across the school. Without this involvement and leadership, teachers participating in the PRIME Future program largely confined YDM practices to their own classroom.

At the classroom level, the type of leadership provided by the teacher-trainers was found to be crucial. In those schools where the implementation of YDM was most successful, teacher-trainers first were able to make significant changes to their own practice and then spread what they had learnt during the implementation of YDM in their own classrooms to other teachers in their school. This was done through:

- demonstration lessons
- school-based in-service workshops
- sharing of lesson plans and teaching materials
- engagement in team teaching with other teachers
- mentoring less experienced/confident teachers.

The clear implications of this for future programs aiming at increasing student participation and achievement and improving teacher capacity in schools with Indigenous and low-SES students is that efforts in enhancing school leadership at both the school management and classroom levels, are an important condition for the successful implementation of such programs.

4.3 Concluding remarks

Most mathematics education programs in schools with Indigenous and low-SES students have tended to set low goals in terms of student achievement. They have tended to primarily focus on the teaching/learning of 'practical maths' that covers how mathematical concepts and processes are applied on the job and not on enabling these students to legitimately engage in the nature and discourse of mathematics. More often than not, this focus on practical maths has been based on the beliefs and assumptions that:

- Indigenous and low-SES students are incapable of handling the more complex concepts, processes, structures and language of mathematics and therefore will not to be able to legitimately engage in the nature and discourse of mathematics.
- Indigenous and low-SES students, because of their sociocultural heritages, will not be willing to legitimately engage in the nature and discourse of mathematics.

YDC practitioners and researchers refute these beliefs and assumptions. Instead, we hold that Indigenous and low-SES students are capable of learning and understanding the complex concepts, processes, structures and language of mathematics that will enable them to legitimately engage in the nature and discourse of mathematics, to understand their world mathematically and to solve problems in their reality. YDC also asserts that:

- All Indigenous and low-SES students can excel in mathematics while remaining strong and proud in their culture and heritage if taught actively, contextually, with respect and high expectations, and in a culturally safe manner.
- A strong empowering mathematics program can profoundly and positively affect students' future employment and life chances and have a positive influence on school and community.

Another assumption underlying most mathematics education programs in schools with Indigenous and low-SES students is that building teacher capacity to levels where they are capable of legitimately engaging students in the exploration of the complex concepts, processes, structures and language of mathematics is an impossible task because of the teachers' paucity of what Shulman (1986, 1987) refers to as subject matter and pedagogical content knowledge. YDC practitioners and researchers instead believe that:

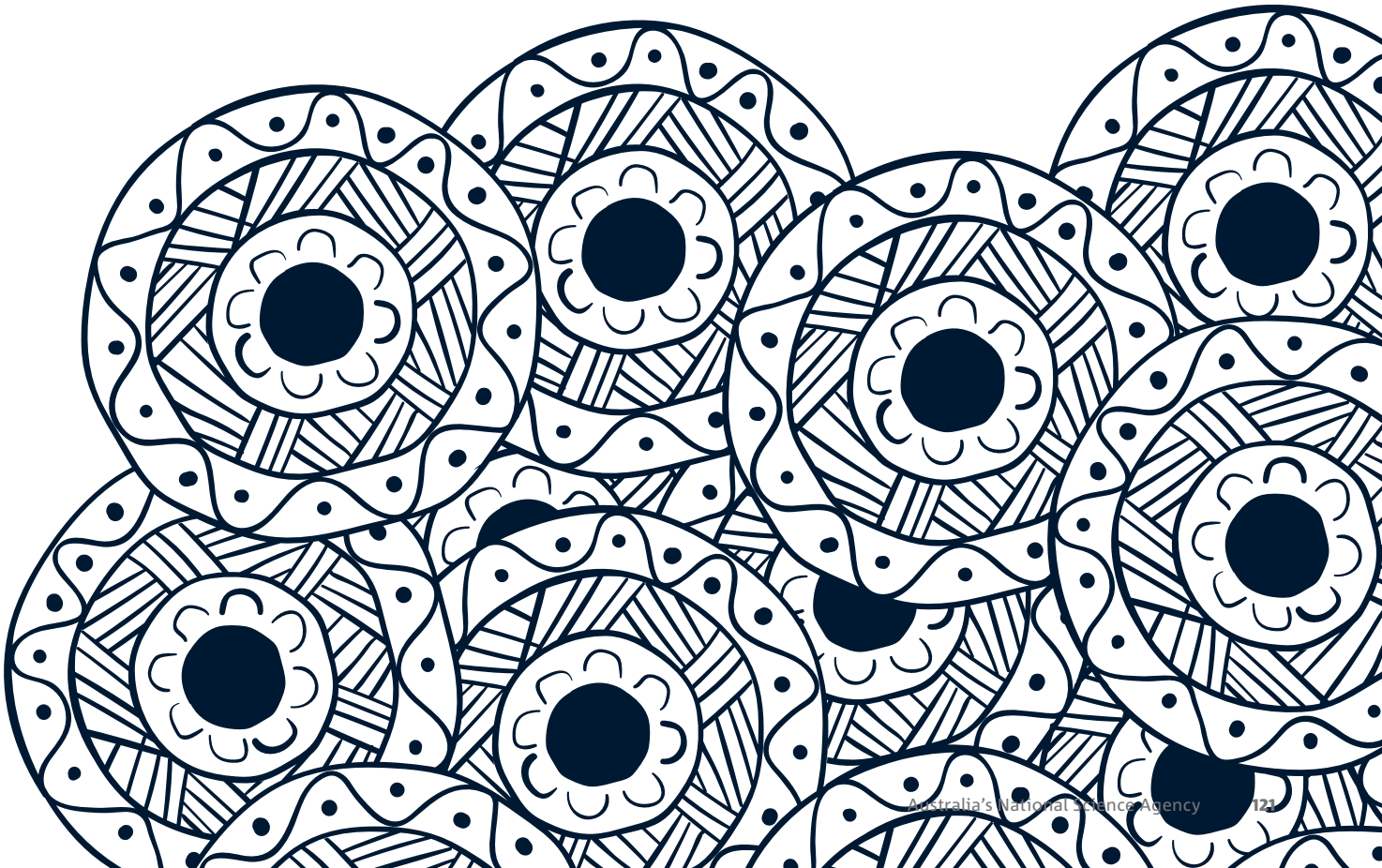
- All teachers can be empowered to teach the mathematics that enables students to legitimately engage in the nature and discourse of mathematics if they have the support of their school and system and the knowledge and resources to deliver effective pedagogy.

YDC's refutation of the beliefs and assumptions underlying most mathematics education programs in schools with Indigenous and low-SES students led to the research and development of YDM, an alternative mathematics education program for Indigenous and low-SES students that was found to be effective for all students. YDM formed the basis for the PRIME Futures program.

During the course of the PRIME Futures program, teachers were introduced to the YDM philosophy and presented with associated YDM materials such as resource books, mathematical learning activities, templates, pedagogical frameworks and exemplars. Teachers were also presented with focused PD workshops, during which they were immersed in YDM philosophy and practice. For example, many of the PD sessions focused on the 'big ideas' of mathematics and other key underlying concepts and processes. The PD workshops also focused on how the learning of mathematics could be made fun for Indigenous and low-SES students and how difficulties being faced by the teachers in the implementation of YDM could be resolved.

The analysis of data from the PRIME Futures case study presented in this report has substantially confirmed the position held by YDC. That is, Indigenous and low-SES students are capable of learning and understanding the complex concepts, processes, structures and language of mathematics that will enable them to legitimately engage in the nature and discourse of mathematics, to understand their world mathematically and to solve problems in their reality. Further, teachers can be empowered to teach the mathematics that enables Indigenous and low-SES students to legitimately engage in the nature and discourse of mathematics if they have the support of their school and system and the knowledge and resources to deliver effective pedagogy.

Throughout the PRIME Futures program, both the teachers and students engaged in deep learning and powerful mathematics. Many teachers came away from the program not only with a set of resource books, mathematical learning activities, templates, pedagogical frameworks and exemplars but also with a profound understanding of the theory underlying YDM. This profound understanding of YDM's underlying theory enabled them to make more informed decisions around the design, development and delivery of mathematical learning activities in their schools. In the schools where YDM was most fully implemented, students' deep learning of mathematics was evidenced by the quality of students' questions and discussions about mathematics, their deeper understanding of mathematics, their enhanced problem-solving and creativity in mathematics, and their intentional linking of new mathematical concepts and processes to their repertoires of prior knowledge about mathematics.



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Appendix A: Data collection methods

This appendix outlines the data collection methods used in the PRIME Futures program. Data was collected by YDC using a mix of quantitative and qualitative methods. In view of the large numbers of schools and teachers involved in the program, the processes of collecting, storing and analysing the data were automated as much as possible.

Data were collected in 14 ways, listed below.

1. Teacher-trainer information survey (online). This survey collected basic demographic data at the time of entry to the program from everyone attending PD workshops. It obtained personal details, email address, qualifications, teaching responsibilities and experience.
2. PD sign-on sheets (on paper). The sign-on sheets recorded the name and school of each attendee at each day of PD.
3. PD evaluations (on paper). At the end of each day of PD, participants were asked to complete an anonymous evaluation form providing standard information such as rating individual sessions on a five-point scale, most and least useful parts, suggested improvements or changes in the program, and suggested areas of focus in the future.
4. Teacher beliefs and practices (online). This survey asked participants to rate (on a five-point scale) the extent of their agreement with statements on their beliefs about mathematics and their practices as teachers. The statements had been used by YDC in previous projects. This information was obtained at the beginning of the program.
5. Teacher opinions (online). Participants were asked to complete this survey at six-monthly intervals during the program; that is, up to five times in total. It used a 'tick and flick' approach to collect quantitative information about changes in teaching responsibilities (if any), evaluation of the YDM books, the extent and outcomes of sharing the YDM approach with other teachers in the school, student engagement and program effectiveness.
6. Exit survey (online). This survey was conducted at the end of the active phase of the program and asked participants to rate (on a five-point scale) the extent of their agreement with statements on their beliefs about mathematics and their practices as teachers. It used similar questions to those of the teacher beliefs and practices survey, but asked teachers for their retrospective perceptions of the extent of improvements by comparing situations before and after participation in the program. The exit survey also collected quantitative information about the extent and outcomes of sharing the YDM approach with other teachers in the school, student engagement and program effectiveness.
7. Teacher reflective journals (online). Participants were asked to maintain a reflective journal throughout the life of the program and to submit it to YDC at annual intervals; that is, up to three times in total. To assist teacher-trainers in focusing their thinking, and facilitate analysis by YDC researchers, it used a 'semi-structured' approach involving some open-ended, optional prompts and a section without prompts to record any other information. It allowed the collection of qualitative information that included the use of the YDM approach, attitude to mathematics, inclusion of Indigenous perspectives in teaching, and challenges in implementing the YDM approach.

8. Group discussions with teacher-trainers (during PD workshops). YDC practitioners took notes and/or audio-recorded some PD sessions in which participants shared stories of their progress over the previous six months and/or their plans for the future.

9. Principal questionnaire (online). Principals (or their delegates) were asked to complete this survey at the beginning of their school's involvement in the program and at six-monthly intervals thereafter throughout the active phase of the program; that is, up to five times in total. It used a 'tick and flick' approach to collect quantitative information about Indigenous community involvement in the school, use and outcomes of YDM methods in the school, school planning and challenges experienced in implementing YDM. Except in Western Australia, principals were also asked to provide enrolment and attendance data each semester in a spreadsheet that was uploaded into the response to the principal's questionnaire.

10. Group interviews of school community members (during school visits). Up to two group interviews were conducted (and audio-recorded) with the community members associated with each school participating in the program. These interviews were conducted by an Indigenous researcher during school visits and sought information about the schools' engagement with their communities and the community members' views of mathematics.

11. Post-PD report by YDC cluster coordinator. YDC cluster coordinators reported to YDC on each block of PD; that is, five reports for each cluster. This permitted regular monitoring and evaluation of the PRIME Futures program and provided information used to prepare reports and for research.

12. Post-school visit report by YDC cluster coordinator. YDC cluster coordinators (or assisting YDC practitioners) who visited the schools reported on each school visit; that is, four reports for each school. This permitted regular monitoring and evaluation of the PRIME Futures program and provided information used to prepare reports and for research.

13. Online activity. Data was collected about the use of the Blackboard site by participants.

14. Withdrawal from the program. Where a school advised that it intended to withdraw from the program, the principal concerned was asked by email to give the reason(s) for this decision. In the absence of a response from the principal, this information was obtained from the YDC cluster coordinator.

Databases and/or spreadsheets were established to store and analyse the quantitative data.

Appendix B: Literature review on teacher perceptions

USING TEACHER PERCEPTIONS OF STUDENT ACHIEVEMENT AS INDICATOR FOR STUDENT ACHIEVEMENT IN MATHEMATICS

INTRODUCTION

This literature review provides an understanding of the validity of using teacher perceptions of student achievement as an indicator of how students are actually performing in mathematics. In line with the literature on this topic, the term teacher judgement will be used interchangeably with teacher perceptions of student achievement. The aim of this literature review is to determine whether there is support in the literature for the proposition that the judgement of mathematics teachers about their students' achievement in mathematics is comparable with actual student achievement in mathematics tests. It is aimed to illuminate the level of accuracy that teacher judgements can provide in terms of student assessment.

TEACHER JUDGEMENT ACCURACY

Südkamp, Kaiser and Möller (2012) defined teacher judgement accuracy as 'the correlation between teachers' judgments of students' academic achievement and students' actual test performance' (p. 755). An understanding of this correlation is necessary for gauging the validity of teacher judgement of student performance in surveys for program evaluation. Teacher judgement accuracy is of particular importance for student evaluation, learning diagnostics (Thiede et al., 2015), instructional decision-making and the development of students' academic self-concept (Südkamp, Kaiser, & Möller, 2014). Making accurate predictions is an important teacher skill for the regulation of student learning (Thiede et al., 2015). Südkamp et al. (2014) therefore described judgement accuracy as 'one of the key characteristics of a good teacher' (p. 5).

Many studies suggest moderate to high correlations between teacher judgement and students' actual achievement (Areepattamannil & Kaur, 2013; Demaray & Elliott, 1998; Hoge & Coladarci, 1989; Südkamp et al., 2012). Areepattamannil and Kaur (2013) found a positive relationship not only between teacher perceptions of students' mathematical competence and mathematics test results but also between students' attitudes towards mathematics and teacher perceptions of students' competence. In addition, these authors report a correlation between teachers' perceptions of student competence in mathematics and students' self-reported engagement in mathematics (Areepattamannil & Kaur, 2013). Thus, there is an indication of a positive link between teacher perceptions of students' mathematical competence, students' engagement in mathematics lessons, students' attitudes towards mathematics and students' standardised test results. This study drew on data of Singaporean and Australian students' achievement in the 2011 Trends in International Mathematics and Science Study (TIMSS) (Areepattamannil & Kaur, 2013).

Similarly, teacher predictions with regard to their students' achievement in the National Assessment Program: Literacy and Numeracy (NAPLAN) are of particular importance for the Australian context. A study by Carmichael (2015) showed that there was a moderate correlation (r = 0.61) between teacher judgement of student achievement in mathematics and NAPLAN numeracy scores, except for special needs students. While his study indicated higher teacher judgement accuracy for literacy than for mathematics (Carmichael, 2015), Südkamp et al. (2014) found no consistency in empirical studies on the influence of the subject on teacher judgement accuracy.

However, these mostly positive results with regard to the correlation between teacher judgement and students' test performance must be seen critically. Helmke and Schrader (1987), for example, highlighted the differences between individual teachers and their judgement accuracy. Südkamp et al. (2014) similarly emphasised the variations of teacher judgement accuracy in meta-analysis studies that ranged from very low to very high correlations (Demaray & Elliott, 1998; Südkamp et al., 2012). These variations in correlations point towards influential factors on teacher judgement that may be related to context and/or individual characteristics (e.g., Connolly, Klenowski, & Wyatt-Smith, 2012). Südkamp et al. (2014) subdivided influential factors on teacher judgement accuracy into judgement and test characteristics, as well as teacher and student characteristics.

INFLUENTIAL FACTORS ON TEACHER JUDGEMENT ACCURACY

Test characteristics

The meta-analysis study of Südkamp et al. (2014) did not find a significant influence of testing procedures, the subject or the domain on teacher judgement accuracy. Therefore, the literature on teacher judgement accuracy in both mathematics and literacy has been reviewed as being able to provide an indication of teacher judgement accuracy in general.

Judgement characteristics

There are often higher correlations for direct ratings, such as estimating the number of correct answers in a test, compared to indirect ratings, such as scale ratings (Hoge & Coladarci, 1989; Südkamp et al., 2014). It seems, however, that teacher judgement accuracy can be increased by using rating scales with more categories (Südkamp et al., 2014), as well as by increasing the congruence between the rating task of the teacher and the actual test (Südkamp et al., 2012). In general, Demaray and Elliott (1998) concluded 'that one can generally rely on teachers' judgments, whether through an academically focused rating-scale or direct judgments, to provide highly accurately characterizations of students' academic achievement' (p. 23).

In their meta-analysis, however, Südkamp et al. (2012) distinguished between teachers who were informed about the test content prior to providing their judgement and teachers who were not informed. Their results have shown higher judgement accuracy for informed teachers (Südkamp et al., 2012).

It should also be noted that class characteristics may play a role in teacher judgement accuracy. Südkamp and Möller (2009), for example, found that students who performed identically received better indirect student teacher judgments if they were in low average achievement classes than if they were in high average achievement classes. Similar results on the influence of class composition have been reported by Meissel, Meyer, Yao and Rubie-Davies (2017).

Student characteristics

Bennett, Gottesman, Rock and Cerullo (1993) found that student behaviour influenced teachers' judgement accuracy in that students who showed bad behaviour were judged poorly in their academic skills, regardless of their real academic skills. Carmichael (2015) found that the socio-economic status (SES) of students was not associated with the discrepancy between teacher judgement and mathematics test results in NAPLAN. Ready and Wright (2011), however, emphasised the importance of class composition as well. These authors found that teachers judged a student's academic performance in literacy better in higher SES classes with higher achievements compared to a student's academic skill in lower SES classes with lower achievements—regardless of the student's individual background (Ready & Wright, 2011).

The study by Meissel et al. (2017) showed that, after having controlled for differences in standardised achievement, teachers judged the literacy achievement of marginalised students lower compared to their non-marginalised classmates. Similarly, ethnicity generally seems to influence teacher expectations of academic skills (Tenenbaum & Ruck, 2007). However, the studies by Kaiser, Südkamp and Möller (2017) showed no support for this hypothesis. With regard to the level of accuracy of teacher judgement of students from different ethnic backgrounds, Kaiser et al. (2017) also found no clear evidence for differences. Instead, they found that a student's belonging to a minority group increased teacher judgement accuracy for this student. This means that not a particular ethnic background but the minority status in itself can increase teacher judgement accuracy (Kaiser et al., 2017). The authors explained this, with reference to Fiske and Taylor (1991), as due to the salient nature of minorities; that is, salient individuals can be remembered better, they are being paid more attention, and teachers are better informed about them. Therefore, the classroom context needs to be considered in the judgement of students: 'An individual student's characteristic needs to be seen in the context of the class the student is in, because the characteristic might have an additional impact on teachers' judgments in this context' (Kaiser et al., 2017, p. 883).

Teacher characteristics

The level of teacher education (Demaray & Elliott, 1998) or years of teaching experience (Carmichael, 2015; Demaray & Elliott, 1998; Impara & Plake, 1998) do not seem to impact significantly on judgement accuracy. However, individual teacher knowledge, frames of reference or different interpretations of achievement standards have been mentioned as influential factors on teacher judgement (Connolly et al., 2012). The study by Südkamp et al. (2014) also showed that the higher a teacher's cognitive ability, the higher a teacher's judgement accuracy. The following section describes the competencies that could be developed in teachers to improve their judgement accuracy.

IMPROVING TEACHER JUDGEMENT ACCURACY

Thiede et al. (2015) found that teacher professional development on mathematics instruction increased judgement accuracy of participating teachers. Drawing on the work of Brunswick (1956), Thiede et al. (2015) highlighted the importance of identifying 'cues' in the assessment of student learning, which then inform the next step of instruction. The level of judgement accuracy then depends on the 'diagnosticity of the cues used to make the judgment' (Brunswick, as cited in Thiede et al., 2015, p. 38, emphasis in original). Consequently, Thiede et al. (2015) noted that mathematics instruction should be structured to give cues that more precisely diagnose the learning that will be assessed and then these cues used for judgement of student learning. Their study showed that teacher professional development that focuses on 'progressive formalization' that builds on the ideas of students and their context and attends to the structure of mathematics, multiple solutions and strategies, as well as misconceptions, is particularly suited to addressing the skills necessary for accurate judgement of student learning (Thiede et al., 2015).

The professional learning model Thiede et al. (2015) used promotes contextualised learning in which mathematical concepts are developed by building on the reality of students. Student reality is used as a starting point for the learning of more sophisticated and abstract mathematics (Thiede et al., 2015). This Developing Mathematical Thinking (DMT) model is therefore closely related to the Reality, Abstraction, Mathematics and Reflection (RAMR) model (Matthews, 2009; YuMi Deadly Centre, 2014) used in YuMi Deadly Maths professional development courses (Spina et al., 2017). Both models use contextualisation and existing student knowledge to develop new and more formal mathematical knowledge and skills in students (Matthews, 2009; Thiede et al., 2015). The progressive formalisation of the DMT model requires teachers to gain knowledge about a student's current state of knowledge and thinking using cues to plan the next step of instruction (Thiede et al., 2015). Thus, the participation of teachers in professional development courses that attend to the monitoring of student learning by using cues generally seems to increase teacher judgement accuracy (Thiede et al., 2015). However, it should also be noted that Thiede et al. (2015) emphasised greater effectiveness for teachers who show more fidelity in using multiple strategies, attend to misconceptions, provide peer learning opportunities and use student-engaging tasks and activities.

Besides professional development in mathematics instruction and assessment as described by Thiede et al. (2015), a way forward to increase teacher judgement accuracy may be 'moderation', whereby teachers discuss student work samples in collaboration to determine whether the work meets certain agreed-upon standards (Klenowski & Wyatt-Smith, 2010). This would help teacher judgement of student achievement to become more reliable and consistent against the standards (Klenowski & Wyatt-Smith, 2010). Still, the influence of the wider context on teacher judgement—that is, the localities or systems in which teachers are situated—needs to be considered (Connolly et al., 2012).

CONCLUSION

This literature review has investigated whether the use of teacher judgments or teacher perceptions of student achievement is a valid approach to assessing student achievement in mathematics. If testing is regarded as an appropriate student assessment tool, this literature review suggests that teacher judgement on student achievement should be similarly regarded, considering the generally moderate to high correlations between the two. However, similar to the lack of reliability and validity that is often attached to student testing (e.g., Klenowski & Wyatt-Smith, 2010), it has been shown in this literature review that there are threats to the validity and reliability of teacher judgments as well. Nevertheless, professional development can increase teacher judgement accuracy (Thiede et al., 2015), and having many judgments from a diversity of teachers from different contexts who judge the achievement of students using the same instructional model is likely to provide a reasonable picture of actual student achievement.

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Appendix C: Literature review on retrospective evaluation of training programs

RETROSPECTIVE PRETEST-POSTTEST EVALUATION OF TRAINING PROGRAMS—A LITERATURE REVIEW

TRADITIONAL PRE-POST TESTING

An important aspect of educational and organisational research is the evaluation of the effectiveness of training courses or programs (referred to in this paper as *interventions*). This evaluation may include objective measures of change identified by others (such as behavioural and performance measures, trainer observations, etc.) or *subjective measures* reported by the participants themselves (such as personal perceptions, beliefs and attitudes and assessments of self-efficacy). One of the most common techniques to measure change in these self-reported variables is the traditional pretest-posttest.

The traditional pretest-posttest occurs in three stages (Gall, Gall, & Borg, 2003):

1. administration of an initial test/questionnaire/survey (referred to as the *pretest*) asking participants to respond to questions or statements about the variable(s) of interest, often using a Likert scale
2. implementation of the intervention
3. administration of a second test/questionnaire/survey (referred to as the posttest) that measures the variable(s) of interest again.

The pretest and posttest results are compared to measure the change that has occurred as a result of the intervention, often using paired sample t-tests.

As it is the research subjects themselves who make the judgements about how the variable(s) of interest are measured, the results must be used with caution (Hoogstraten, 1982). The pretest-posttest approach assumes that participants have an internalised perception of their level of functioning with regard to those variable(s) and that this internalised frame of reference does not change from the pretest to the posttest. In other words, a common metric must exist between the two sets of scores. If the metric changes between the pretest and the posttest, the comparison will reflect this difference, known as *response-shift bias*, in addition to the changes attributed to the intervention. This renders it invalid as a measure of the variable(s) concerned (Howard, Ralph, Gulanick, Maxwell, & Gerber, 1979).

There are further reasons why evaluations of programs that seek to measure change using a traditional pretest-posttest methodology can be difficult to plan and execute (Lynch, 2002; Martineau, 2004). Allen and Nimon (2007) identified three causes of difficulty. First, the consent and cooperation of responders need to be obtained on at least two occasions, and then they are asked to respond to the same questions on each occasion. Second, problems occur when participants change over time, causing them to miss either the pretest or posttest, resulting in an incomplete dataset. Finally, it can also be challenging to develop questionnaires that are sufficiently sensitive to detect small changes in post-intervention outcomes (Lynch, 2002).

Response-shift bias

Response-shift bias occurs when self-report measures are used to enable participants to judge their own level of ability (Mann, 1997) and those participants are unable to respond to the pretest in an informed manner. It may occur for three reasons:

- ***Reconceptualisation***: Participants may not have the prior knowledge needed to interpret the question accurately (Auld, Baker, McGirr, Osborn, & Skaff, 2017). For example, in an intervention that provides training about nutrition, when questioned about the amount of whole grains in their diet, participants may respond differently before the intervention because of an inadequate understanding about whole grains.
- ***Recalibration***: The participants may not have an accurate frame of reference for assessing their own level of functioning before the intervention. That is, participants do not know what they do not know. For example, participants in a management training course may initially feel they have reasonable managerial skills, but during the course they learn about new (to them) managerial techniques and realise how little they knew previously, causing them to revise their opinion of their managerial skills at the time of commencing the course (Mann, 1997).

- ***Reprioritisation***: There may be a change in the participant's values; that is, a re-evaluation during the intervention of the importance of the variable being measured. For example, the value of inquiry-based pedagogy may only become apparent to a participant after they have attended a training program on the subject.

The arguments for response-shift bias are based on a comparison of qualitative and objective data collected in the same study. In cases where a statistically significant difference between a traditional pretest and a retrospective pretest were found, participants noted that their internal standards of measurement had changed as a result of participating in the program (Nimon, 2014). A retrospective pretest allows participants to apply knowledge acquired during the intervention in reporting on their pre-intervention behaviour.

RETROSPECTIVE PRE-POST TESTING

In the past 50 years, researchers have explored a possible remedy for response-shift bias, known as the *retrospective pretest-posttest model*. It differs from the traditional pretest-posttest model by the temporal relationship of the pretest to the intervention. The pretest is administered post-intervention, asking participants to recall and report on their behaviour before the intervention (Allen & Nimon, 2007). As the pretest and posttest are completed at the same time, it is assumed that participants use the same frame of reference when completing both tests (Hill & Betz, 2005).

In considering response-shift bias, control groups are important for differentiating experience limitation in traditional pretest data from other forms of subject bias in retrospective pretest data (Nimon, 2007). Studies of this type compared traditional and retrospective pretest-posttest methods with more objective measures of change and found that the objective measures correlated more highly with gains based on retrospective pretest data (Coulter, 2012; Howard et al., 1979). In particular, during 1979 and 1980, Howard and his colleagues published at least 12 studies in a series of papers involving response shift and related methodological problems. Taken together, these studies provided strong support for the contention that when self-report measures are used in a traditional pretest-posttest design, the results can be confounded by a response shift. Their studies favoured the retrospective pretest-posttest approach as providing a more accurate estimate of the effect of an intervention.

Empirical research supports the contention that, if participants change their perceptions of their initial level of functioning as a consequence of an intervention, a retrospective pretest provides a more accurate pre-intervention measure than a traditional pretest (Nimon, 2014). Bray, Maxwell and Howard (1984) examined correlations between results obtained from traditional pretests, retrospective pretests and posttests to demonstrate quantitatively that the traditional methods of statistical analysis do not consider response-shift bias and thus, produced biased estimates of the treatment effect. They found that the only unbiased estimates of the treatment effect occurred when the posttest minus retrospective pretest difference scores were used. They concluded that there can be a substantial loss in the statistical power of the analysis of traditional pretest-posttests when response-shift bias occurs.

Bursal (2015) demonstrated that, in the context of evaluating the impact of a science methods course for pre-service teachers, the difference in the results of the retrospective and traditional pretest-posttest methods could not be attributed to gender, nationality or achievement in the course, leading to the conclusion that the difference was due to the nature of the measurement methods. Their review of the literature led them to conclude that differences between the retrospective and traditional measurements can be seen in almost all educational studies around the world. Pratt, McGuigan and Katzev (2000), reporting on a child-abuse prevention program for new mothers, demonstrated that mothers for whom the program was implemented more extensively showed a greater response-shift bias than mothers who attended an abbreviated version of the program. These results support the hypothesis that the program produced the response shift.

In most studies, the response-shift bias resulted in errors of conservatism; that is, when participants do not have sufficient knowledge to gauge their pre-intervention behaviour, they tend to overestimate their level of functioning (Allen & Nimon, 2007). However,

Hill and Betz (2005) showed that response-shift bias can operate in the opposite direction; for example when substance-abusing clients exaggerated their pre-intervention condition (i.e., 'faked bad') to be selected for the intervention program. Mann (1997) also reported that a response-shift bias in the opposite direction was caused by inadequate prior information about the content of the intervention. Many respondents initially overestimated the level of the training; that is, they were expecting a more advanced program. They originally believed that what they could do was low compared to what they expected to learn, but when they saw that the level of training was relatively basic, they realised they had undervalued the skills they already possessed.

In addition to catering for response-shift bias, other advantages of retrospective pretest-posttest methods include (Auld et al., 2017):

- less time is spent on data collection
- they ensure matched pre- and posttest data
- they potentially reduce anxiety among some participants by not seeking an evaluation in the first class
- they are cheaper and easier to implement and analyse (Hill & Betz, 2005).

Threats to validity

Although the retrospective pretest-posttest design controls for response-shift bias effects, it is susceptible to a variety of other validity threats:

- *Recall bias* occurs when an assessment of the pretest level of functioning after the intervention relies on the accuracy of participants' memory of their pre-intervention behaviour (Allen & Nimon, 2007; Hill & Betz, 2005). This presumably becomes more problematic as the duration of the intervention increases.
- *Effort justification* is the belief that because one worked hard during the intervention, a change must have occurred (Hill & Betz, 2005; Nimon, 2014).
- *Impression management* occurs when participants reconstruct their retrospective measures. Three examples have been identified:
  - Pressure to produce quality programs with measurable results can induce participants to demonstrate that change has occurred or to present themselves in the most favourable manner (Nimon, 2014).
  - People are consistently more critical of their past selves than of their present selves, regardless of whether improvement has actually occurred (Wilson & Ross, 2001).
  - Where post-training action plans are developed during the training, it is possible the action-planning process may induce participants to report a change that may affect the participants' judgement of their prior state. This is exacerbated if the action plans are developed towards the end of the program, close to the time when the retrospective pretests are conducted.
- *Social desirability bias* is when participants are reluctant to be truthful about their behaviour or lack of knowledge before the intervention. This is greater when the topic deals with strong social norms, where people feel that they should have changed (e.g., those items that embody socially desirable behaviours). In these cases, they are more likely to magnify the degree of change in the retrospective test. Hill and Betz (2005) demonstrated this in the context of a parenting program and Auld et al. (2017) found similar results in the context of a program about food hygiene.
- *Personal recall theory* suggests that if participants accept a program's validity, they are likely to anticipate change from the outset and report such a change. When programs are not deemed valid, participants may well reconstruct their initial state to discount the entire exercise and report that no change has occurred (Mann, 1997; Nimon, 2014).
- *Test design* is when the process of just asking the retrospective pretest question may indicate an expectation of change. Arranging retrospective pretest and posttest questions side-by-side on a single post-program survey explicitly signals to participants that change is expected to occur (Nimon, Zigarmi, & Allen, 2011). Schwarz (1996) theorised that participants use contextual information in interpreting survey items. Program effects were consistently higher in designs that incorporated a single post-intervention survey (with adjacent posttest and retrospective pretests) than designs that used separate forms for the posttest and retrospective pretest (Nimon et al., 2011).

Sprangers (1987) showed that a response shift may not occur if effort justification is controlled for, and social desirability is not present. However, he stated that the occurrence of these confounding influences depends on the specific experimental setting, the nature of

the intervention and the corresponding measures. Similarly, in a study of a food and nutrition education program, Auld et al. (2017) revealed that while improved understanding of the subject matter was detected post-intervention, a response-shift bias was not detected. They concluded that the likelihood of a response shift may depend on the topic and the audience.

When participants are likely not to know what they do not know at the onset of a program, the retrospective pretest may provide more valid data than a traditional pretest. However, because the retrospective pretest is also an imperfect tool, replacing traditional pretests with retrospective pretests may simply be trading one set of biases for another, unless the optimal contexts for each type of test can be determined. Some of the biases identified above are consequences of the self-report methodology, rather than the timing of the pretest (Moore & Tananis, 2009; Nimon, 2014).

Taylor, Russ-Eft and Taylor (2009) proposed that questionnaire design should be the preferred method of eliminating response-shift bias. They recommended that, in light of the substantial inflationary bias in effects that can be introduced by using retrospective pretests, response-shift bias should be addressed through careful construction of clearly worded measures. They argued that evaluators can take steps to minimise the possibility of response-shift bias in traditional pretests by making both the items and the associated response scale anchors as behaviourally specific as possible, and then by pilot-testing measures to ensure respondents' accurate understanding of those measures without having to have undertaken the intervention.

Nimon (2014) identified four general implications for the use of the retrospective pretest:

- consider the cognitive implications of asking participants to recall information
- select an appropriate evaluation design to encompass the retrospective pretest, preferably using a control group
- consider how to provide evidence of the concurrent validity of retrospective pretest data, possibly by asking participants to explain the difference between their retrospective and traditional measures
- conduct additional research to evaluate and consider how elements of the evaluation process may moderate retrospective assessments.

When there are differences between retrospective and traditional pretest measures, researchers should consider how to justify which is more valid. When retrospective pretest accounts are lower than traditional pretest measures, it cannot be presumed that the traditional pretest is biased due to experience limitation and that the former is more valid than the latter. While response-shift theory suggests the retrospective judgement is more valid, effects such as recall bias, effort justification, impression management and others listed above support the traditional judgement methods. Thus, evaluation designs incorporating the retrospective pretest should include measures to validate the resultant data. To achieve this, Piwowar and Thiel (2014) proposed that the evaluation of response-shift bias needs to be an integral part of program evaluations that rely on participant self-report measures. Otherwise, it cannot be concluded that differences in pre- and posttest outcomes reflect only a change in the variable being measured or include a change in the response behaviour of the participant. They recommended that stratifying participants by the degree of exposure to the intervention, as well as retrospectively measuring items for which response shift is not likely to occur (as a control group), are two techniques that could be used to enhance the retrospective pretest design (Piwowar et al., 2014).

SELECTION OF THE FORM OF PRETEST-POSTTEST

Most research studies indicate that retrospective pretests provide a more accurate measure of pre-intervention behaviour (Allen & Nimon, 2007). Allowing individuals to report their pre- and post-intervention level of functioning retrospectively, using the knowledge they gained from the intervention, mitigates the effect of measurement variation that can occur in traditional pretest-posttest designs. In most cases, when participants do not have sufficient knowledge to gauge their pre-intervention behaviour, they tend to overestimate their level of functioning at the time of the pretest. This effect has a negative influence on program outcome measures.

However, this literature review shows that replacing traditional with retrospective pretests does not eliminate bias entirely. Although Miller and Hinshaw (2012) argued that traditional pretests were unnecessary, Auld et al. (2017) concluded that it is difficult to make consistent recommendations regarding which methodology to use because the type of bias differs. In addition, the extent of the bias can be affected by the topic, characteristics of the respondent, and even the format of a questionnaire. Hill and Betz (2005) proposed that if the goal of evaluation

is to describe change as experienced subjectively by intervention participants—that is, a subjective examination of program effects—a retrospective pretest-posttest is appropriate. Piwowar and Thiel (2014) stated that retrospective pretesting appears to be adequate if pretesting effects are probable and recall bias or socially desirable answers are unlikely. Conversely, if the goal of evaluation is to provide an objective estimate of mean program effects, a traditional pretest-posttest is more appropriate. Norman (2003) argued that if the variables to be assessed include socially desirable behaviours and/or specific behaviours targeted by an intervention—that is, item types that are especially prone to multiple sources of motivational bias—the traditional pretest-posttest provides a more conservative test of program effects.

Mann (1997) argued for the collection of pretest information both before and after the intervention to allow a comparison between the traditional and retrospective pretest-posttest results. This may provide insights into aspects of the training, such as the nature of information given to trainees prior to the event.

Allen and Nimon (2007) considered that retrospective pretesting-posttesting is an underutilised assessment tool that can serve as a practical and appropriate evaluation technique to assess the learning and performance improvements gained during professional development. However, they noted that this technique is not a replacement for traditional pretest-posttest techniques, arguing that it is an evaluation technique best used when the ability to independently assess learning and performance improvement gains is limited due to time and resources.

CONCLUSIONS

Several studies (e.g., Bursal, 2015; Coulter, 2012; Howard et al., 1979) have argued that because of the broad range of settings and instruments in which the response shift has been observed, it seems likely that a sizeable portion of the extant literature on program evaluation (and other areas) might be influenced by response-shift bias. In most instances, the bias operated to increase the probability that the experimental hypothesis would be rejected. Therefore, it is likely that the use of the traditional pretest-posttest design may result in errors of conservativism, with the result that a study may erroneously fail to identify the benefits of an intervention. Such an underestimation of the real training benefits can have serious organisational consequences, such as abandoning an intervention or reducing the relevant budget allocation(s) (Mann, 1997).

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Appendix D: PRIME Futures implementation timeline

QUT YuMi Deadly Centre: PRIME Futures Program
Actual Implementation Timeline 2015–2019

					2015		2016		
CLUSTER NAME	EDUCATION REGION	STATE	NO. OF SCHOOLS[1]	NO. INDIGENOUS STUDENTS[2]	TERM 3	TERM 4	TERM 1	TERM 2	
Cluster 1 Emerald	Central Queensland	QLD	8	469		PD 1	Visit 1 & PD 1	PD 2	
Cluster 2 Townsville	North Queensland	QLD	7	1538		PD 1	Visit 1	PD 2	
Cluster 3 Townsville 2	North Queensland	QLD	6	530					
Cluster 4 Brisbane North	North Coast	QLD	8	741					
Cluster 5 Port Lincoln	Port Lincoln	SA	8	365					
Cluster 6 Adelaide	Para Hills & Flinders Park	SA	7	457					
Cluster 7 Brisbane South	South East & Metropolitan	QLD	6	467					
Cluster 8 Far North Qld	Far North Queensland	QLD	8	1887					
Cluster 9 Geraldton	Midwest	WA	9	1309					
Cluster 10 Albany	Southwest	WA	8	410					
Total schools/students			75	8173					
Cumulative clusters						2	2	2	
Active schools[3]						16	16	16	
Workshop days per term[4]						6	2	6	
School visits per term[5]						0	16	0	

Notes:

1. Number of schools at the start of the program (a school that moved from Cluster 2 to Cluster 3 in Term 3, 2016 is only counted in the Cluster 3 number in this column).

2. Number of Indigenous students for the year the school started in the program, obtained from the My School website (https://www.myschool.edu.au).

3. Number of participating schools each term. The following school withdrawals occurred: one school in Cluster 1 at end of Term 2, 2016; two schools in Cluster 4 at end of Term 4, 2016; one school in Cluster 10 in Term 4, 2017; two schools in Cluster 3 and four schools in Cluster 9 at start of 2018; one school in Cluster 9 in Term 2, 2018; one school in Cluster 8 at start of 2019. Also, two schools in Cluster 6 merged to become one school from the start of 2017.

4. Number of workshop days = 3 days per PD for Clusters 1 to 8 plus 2 extra days for Cluster 1 repeat of PD 1; 2 days per PD for Clusters 9 and 10.

5. Number of individual school visits from a YDC practitioner.

YEAR													
	2016		2017				2018				2019		
	TERM 3	TERM 4	TERM 1	TERM 2	TERM 3	TERM 4	TERM 1	TERM 2	TERM 3	TERM 4	TERM 1	TERM 2	TOTALS
	Visit 2	PD 3	Visit 3	PD 4			Visit 4	PD 5					
	Visit 2	PD 3	Visit 3	PD 4	Visit 4			PD 5					
	PD 1	Visit 1	PD2	Visit 2	PD 3	Visit 3	PD 4	Visit 4	PD 5				
	PD 1	Visit 1	PD2	Visit 2	PD 3	Visit 3	PD 4	Visit 4	PD5				
		PD 1	Visit 1 & PD 2	Visit 2	PD 3	Visit 3	PD 4	Visit 4	PD 5				
		PD 1	Visit 1 & PD 2	Visit 2	PD 3	Visit 3	PD 4	Visit 4	PD 5				
				PD 1	Visit 1	PD2	Visit 2	PD 3	Visit 3	PD 4		Visit 4 & PD 5	
				PD 1	Visit 1	PD2	Visit 2	PD 3	Visit 3	PD 4	Visit 4	PD 5	
				PD 1	Visit 1	PD2	Visit 2	PD 3	Visit 3	PD 4	Visit 4 & PD 5		
				PD 1	Visit 1	PD2	Visit 2	PD 3	Visit 3	PD 4	Visit 4 & PD 5		
	4	6	6	10	10	10	10	10	10	10	10	10	**10**
	28	43	40	71	71	70	64	63	63	63	62	62	**62**
	6	12	12	16	12	10	12	16	12	10	4	6	**142**
	14	14	29	27	38	27	34	24	23		17	4	**267**

School/Cluster identification and planning

YDM PD workshops:
PD 1 = Overview & Number; PD 2 = Operations & Measurement; PD 3 = Algebra & Geometry; PD 4 = Statistics & Probability

School visits, in-school trialling and training, online support

Cluster-directed sustainability PD (PD 5) plus remaining visits and online support

Continuing in-school trialling and training, online support and planning for sustainability

Appendix E: PRIME Futures cluster statistics

QUT YuMi Deadly Centre: PRIME Futures Program
Cluster Statistics

PRIME FUTURES THREE-PHASE IMPLEMENTATION 2015–2019					NUMBERS IN STARTING YEAR (75 SCHOOLS)				
PHASE	CLUSTER NAME	EDUCATION REGION	STATE	START DATE	NO. OF SCHOOLS (START)	NO. OF TEACHER-TRAINERS	TOTAL STUDENTS (START)	INDIGENOUS STUDENTS (START)	
PHASE ONE	Cluster 1 Emerald	Central Queensland	Qld	2015 Term 4	8	52	2243	469	
	Cluster 2 Townsville	North Queensland	Qld		7	47	5214	1538	
PHASE TWO	Cluster 3 Townsville 2	North Queensland	Qld	2016 Term 3	6	25	3171	530	
	Cluster 4 Brisbane North	North Coast	Qld		8	40	5673	741	
	Cluster 5 Port Lincoln	Port Lincoln	SA	2016 Term 4	8	44	2065	365	
	Cluster 6 Adelaide	Para Hills & Flinders Park	SA		7	38	2773	457	
PHASE THREE	Cluster 7 Brisbane South	South East & Metropolitan	Qld	2017 Term 2	6	44	4131	467	
	Cluster 8 Far North Qld	Far North Queensland	Qld		8	52	5851	1887	
	Cluster 9 Geraldton	Midwest	WA		9	32	3459	1309	
	Cluster 10 Albany	Southwest	WA		8	51	3080	410	
	Total schools/teacher-trainers/students				**75**	**425**	**37,660**	**8173**	
Number of teacher-trainers excluding PD5-only attendees (47)						378			
Phase One total:								2007	
Phase Two total:								2093	
Phase Three total:								4073	

				2018 NUMBERS FOR 62 SCHOOLS STILL INVOLVED						
	% INDIGENOUS STUDENTS (START)	NON-INDIGENOUS STUDENTS (START)	% NON-INDIGENOUS STUDENTS (START)	NO. OF SCHOOLS (END)	NO. OF TEACHER-TRAINERS	TOTAL STUDENTS (2018)	INDIGENOUS STUDENTS (2018)	% INDIGENOUS STUDENTS (2018)	NON-INDIGENOUS STUDENTS (2018)	% NON-INDIGENOUS STUDENTS (2018)
	21%	1774	79%	7	47	2179	449	21%	1730	79%
	29%	3676	71%	7	47	4785	1498	31%	3287	69%
	17%	2641	83%	4	17	1428	358	25%	1070	75%
	13%	4932	87%	6	33	4440	591	13%	3849	87%
	18%	1700	82%	8	44	1967	345	18%	1622	82%
	16%	2316	84%	6	38	2824	464	16%	2360	84%
	11%	3664	89%	6	44	4282	440	10%	3842	90%
	32%	3964	68%	7	47	5357	1713	32%	3644	68%
	38%	2150	62%	4	15	1988	741	37%	1247	63%
	13%	2670	87%	7	47	3067	376	12%	2691	88%
	22%	**29,487**	**78%**	**62**	**379**	**32,317**	**6975**	**22%**	**25,342**	**78%**
					332					
							1947			
							1758			
							3270			

Appendix F: Examples of RAMR lessons shared by teachers

Teachers were encouraged to share details of their lessons based on RAMR and body–hand–mind in their reflective journals. Many did so—too many to include in the body of the report. However, to do justice of the creativity of teachers, these additional examples are provided in this appendix.

- *Introduction to Ratios and how to work with them. A RAMR plan was implemented to give an introduction to the new concepts. The reality part was related to the ratio of boys to girls in the class, how ratios are used in cooking and other examples. In the lesson we used different coloured counters to express ratios. … Once the hands-on activity with the counters had taken the concept as far as it could go, the students were provided with questions to complete. To wrap up the lesson they were asked to write a sentence with a ratio in it as well as a question that everyone had to complete before they left the classroom.* [Teacher 104, School 7C]

- *Letter count for most common letters: Analysing the samples of English Harry Potter text … Analysing the samples of Spanish Harry Potter text. Find the percentages of each letter as a total of entire word count for both English and Spanish alphabet. Graph results from letter count onto a single x/y graph. 2 graphs. Comparing points and frequencies of letters.* [Teacher 90, School 8A]

- *I could not wait to try the fraction walk with my class. All I needed was a suitable area that could be easily divided into quarter, half, 3 quarters and the 'whole' distance across. The topic therefore was fractions with a focus on parts of a whole. We went outside. The children were excited and there was an air of anticipation as I announced 'we are doing maths outside today'. The children enjoyed walking across the field as we all chanted the quarter of the way across, half way across, 3 quarters across, the whole way across. … I then followed up with another lesson a week later using jugs (straight ones) and water to measure one quarter full, one half full, 3 quarters full and all full. We followed a similar procedure with the water, children marking the jug with the written representation of the fraction.* [Teacher 118, School 9E]

- *Algebra challenge grouping (body); Algebra challenge blocks (hands): Working in groups and using students to model the problems. Using props in class that were used as visual clarification to students' answers. … After the 3rd group challenge, some students started to thrive on the different approach to the challenges and as it was a competition against another group they worked harder to win. … Students asked to look for patterns and formulate an equation or explanation as to what was occurring. Hands activity involved students using paddle pop sticks and cups to create patterns and record observations.* [Teacher 59, School 6A]

- *Algebra challenge grouping (body); Algebra challenge blocks (hands): Working in groups and using students to model the problems. Using props in class that were used as visual clarification to students' answers. … After the 3rd group challenge, some students started to thrive on the different approach to the challenges and as it was a competition against another group they worked harder to win. … Year 8 maths class 20 students—inclusive lesson (Aboriginal & Torres Strait Islanders, CHI, NEP) … Students asked to look for patterns and formulate an equation or explanation as to what was occurring. Hands activity involved students using paddle pop sticks and cups to create patterns and record observations.* [Teacher 59, School 6A]

- *Students manipulated their bodies to hopscotch some modified nets before we then predicted what this net shape would make if we folded and joined it together. This was the springboard for then brainstorming what we knew about this shape (the cube), to then draw out distinguishing properties. Students quickly began to make connections with similar shaped objects around the room.* [Teacher 46, School 5C]

- *RAMR cycle in an angles unit. I have Year 5/6 students but wanted to begin at Year 3 where they must know what an angle is. We made angles with our arms outside on the basketball court. We created right angles, 180 degree angles and full revolutions with chalk outside. I also had a student use his skateboard to demonstrate these angles/turns … they also went on an angle hunt in the classroom so they could see that they exist all around us.* [Teacher 56, School 5C]

- *Prior to lesson 1 I asked the students to draw/show me what they understood about half – quarter – third and any other fractions … some (mostly Year 3s) were able to show whole/part concept while others missed the whole idea … We walked the basketball court … Walked 1/2, 1/4 … On return to class we used strips of paper to fold 1/2 and 1/4 and had [a] discussion.* [Teacher 43, School 5B]

- *Year 2 data sorting students were asked to sort things, they were in groups of 4, all I asked them to do was to sort any way you would like. … One group was great they sorted into colour, size, type of material. Another group sorted in groups of two … they had pencils, stars, counters and highlighters. My last group didn't have a clue on sorting, they grabbed their own items and started to sort by themselves and not as a group … Maybe I should have told them how to sort but I wanted them to find out for themselves. … Today we did teen numbers and we went outside with hoops and cones and I drew ten frames into the dirt. I would say a teen number and the students had to work out how many cones to put in the ten frames.* [Teacher 26, School 4E]

- *Area/Measurement and square numbers: Discuss reasons for knowledge of above, referring to real-life issues (e.g., create a garden/sandpit). … Used masking tape to mark out 'garden spaces' in classroom. Students could use area/perimeter formulae to calculate materials required for gardens (surprisingly well).* [Teacher 89, School 3B]

- *I have used the number line taped to the carpet for adding numbers in sequence which worked well and generated some good dialogue between students as they placed then repositioned the numbers they had chosen.* [Teacher 25, School 4A]

- *Working with a group (4–7 students) of Year 7, 8 and 9 Indigenous boys the concept of fractions using YuMi Deadly approach and resources. … The initial lesson involved students using paper strips to demonstrate 1/2, 1/4, 1/3, 1/5 and 1/7. … The following lesson had students estimating the same fractions on a rope with pegs. Each student came up with their estimate and then moved back and viewed their estimate before making final adjustments. The other students were given the opportunity to agree or disagree with the estimate. Then the rope would be subdivided into the exact fraction to see how accurate the estimate was. … The following lesson involved representing the above fractions on a comparison chart. The following lesson started with a cartoon clip showing the addition of fractions with same denominators, followed by a rap clip of fraction addition. The students then started to actually see the concept of a 'fraction as being part of a whole'. We then used manipulatives of pie pieces to add fractions with mixed fraction answers.* [Teacher 139, School 9A]

- *This lesson came within a series of lessons throughout Term 3 and beginning of Term 4. I had previously got the students to identify perimeter and area of the rectangular classroom and then got them out of their seats to measure this to determine different ways of working and how students went about measuring and calculating these; both pace length and measuring tapes were used and discussions about differences in answers were deliberated and some misconceptions with measuring were unravelled as students started to recognise different units on measuring tapes and came to the realisation that to measure you need to start at zero.*

  Once the idea of measurements and rules were embedded we started to look at different shapes. Students were quick to be able to determine the rule for the perimeter of a triangle based on their previous knowledge. To determine the rule for the area of a triangle I gave them rectangular cards (made from old manila folders), I asked the students to find the area and perimeter of the rectangle (to recall measurement skills and practice of area and perimeter). I then asked the students to cut the rectangle to form a triangle. Most students automatically cut the rectangle in half—diagonally. I asked other students how they cut their rectangles and put these on the board to discuss. For each of the different ways we looked at how the different sized triangles could combine to make larger triangles and discussed the idea that 2 triangles of the same size make up the full rectangle. The students set out to prove me wrong and asked for more rectangles so that they could cut them up in different ways to see if they could get more than 2 triangles of the same size to make up their rectangle. As they did this they were amazed that it was true. We finished the lesson discussing the relationship between rectangles and triangles to develop the area rule for a triangle. [Teacher 105, School 7C]

- *Year 1, Topic—Skip Counting: Reality—Counting pictures of lollies, apples, drinks for a party. Abstraction—Body activity—Used 3 number lines with numbers visible. Students jumped in 2s, 5s and 10s and counted aloud as they did so. … We swapped the movements to include hopping, skipping etc.* [Teacher 96, School 7A]

- *One big number line on the floor … We looked at tenths again—had a great discussion about how there are ten tenths between every whole number—made links to place value columns. Then we discussed what is in between every tenth, 10 hundredths, etc. Some students made the connection to the patterns within the place value columns being divided by ten as we get smaller. I found this part of the lesson great for my lower students, as we made connections to what a whole number is and how we can put wholes on the left side of the decimal point. I was also able to address some misconceptions around what a decimal actually is, a part … 'So we have 0 whole and a bit … how many parts do we have?' Etc.* [Teacher 98, School 7A]

- *[The teacher] brainstormed new concept (length). Students shared prior knowledge of what length means. Students used bodies to compare length of body parts. Used hands to measure objects using informal units (Unifix cubes) then ordered according to length. Visually compared lengths of lines on board.* [Teacher 94, School 8B, reporting on implementation by another teacher at the school]

- *I used the mat to gauge student understanding of perimeter and area. I also wanted to gauge how receptive they would be to using hands-on materials. … I asked volunteers to make pond shape using string. I asked them to recall a project they did last year where they designed a backyard. 3–4 girls stepped forward to make a pond in the shape of a crocodile. I asked for them to show me what the area and what is perimeter, thinking I just wanted to get to definitions. I then asked them that if I was going to work out the area, how could I change the shape to make it easier. They made it into a rectangle and said they could just count the squares. … We moved back to seats and worked from the textbook. … I have referred to that activity in a later lesson, particularly with students who show a bit of confusion between the terms perimeter & area.* [Teacher 93, School 8C]

- *I have been using YuMi in my classroom in particular the RAMR planning tool and implementing lessons from this plan. The topic my class [Reception] has been doing has been around patterns. For reality we looked at photos of patterns in real life, walked around the school looking for patterns, made patterns using bathroom tiles and the children brought in an object from home that had a pattern on it. For Abstraction the children made patterns using their bodies (a child standing, a child sitting…), I also linked in to classroom routines and the children lined up in a boy/girl pattern. We used objects to make patterns including classroom resources and environmental resources.* [Teacher 63, School 6B]

- *I followed the unit plan 'how many quads' and then adapted this for other multiplications that needed to be taught to Year 3 and 4 students. … I created a double, double-double, double-double-double board for a hands activity which showed x2, x4, and x8.* [Teacher 71, School 5D]

- *We did shape this term and it was great to apply some of the YuMi Body experiences to their learning. … I got students to use their bodies to make shapes. … I will keep using story and song as that has been great with my transition group. … We have a garden and wetlands at our school so we tried to use resources like sticks and rocks and items growing in the garden as part of our measurement unit.* [Teacher 73, School 6E]

- *We used the real-life boat in the Prep area for capacity. We made a life-size clock with our bodies and open-ended materials. This brought up lots of exciting questions about where the numbers go and how many numbers are on a clock. We talked about the functions of all the parts of the clock.* [Teacher 62, School 2B]

- *Excursion to a local island to investigate the penguin activity. … Students … considering lunch options, the capacity of a boat … and the weight of classroom items in relation to that of an adult penguin. … Reality and Abstraction … Students … arranging their bedroom spaces. They considered their current bedroom spaces (their reality) and the furniture contained to plan for a 'new bedroom' with furniture taking up 1/3 of the total floor space.* [Teacher 46, School 5C]

- *A secondary teacher presented more than one method for binomial expansion and allowed students to choose their preferred method … We used the array method alongside the FOIL method to show students both ways at the same time. … We found that some students picked FOIL and some the array method and were surprised at who picked what. Some of our very high level students chose the array method while some of the lower level students selected FOIL. We did not encourage one over the other and left it up to the students as a choice.* [Teacher 9, School 2A]
- *Estimated, walked it and then measured different places of the school.* [Teacher 31, School 3D]
- *Once we were graphing the line and I taught them how to find the slope by checking the change in y over the change in x they were able to clearly see how the line was plotted because they had already made the table to check the pattern.* [Teacher 50, School 2C]
- *Our unit is time, reading time and converting between 12 and 24 hr time to then extend to reading and interpreting timetables for public transport. The reality was school bell times and using our school diaries as a way to manage our time. The abstraction phase was using a paper plate to draw a clock face on. (I first let the students do this themselves, to see their prior knowledge, we then discussed the different ways students determined the placement of numbers on their clock.) Once they were done I asked them to represent certain times on the clock and getting them to show me their answers by lifting up the plates, this was a quick way to evaluate their knowledge on this. I realised quickly that the students were very comfortable with this concept and so I needed to extend them so we started to discuss 24 hr time. At this point we added another plate underneath their first with 24 hr time. They were then able to see that 1:00 pm would translate to 1300 hrs in 24 hr time. We used this to develop their understanding of 12 and 24 hr time and consolidated it with some worksheets.* [Teacher 105, School 7C]
- *Abstraction with Time—making a human clock—provided lots of opportunities for problem-solving and collaboration. … Measurement … conversations about different attributes and explaining and justifying their understanding to each other.* [Teacher 122, School 5C]
- *I spent a lot of time in the abstraction stage of the RAMR cycle and progressing from the more concrete to abstract materials. We spent time making teen numbers with hands, toes, tens frames, bundles, and MAB blocks. … This has now progressed to numbers beyond teen numbers with very little teaching required.* [Teacher 41, School 3B]
- *This group of students … seem to respond to visual cues [rather] than just talking. Therefore I decided to set the RAMR model up using a PowerPoint presentation. They responded well to the visual cues to the reality section and enjoyed the whole-body activity of moving into different groups … as well as the hands-on paper clip activity. Dividing a quantity in a given ratio—For this section we used the mat … and play money to divide up quantities of money. … It was a great activity.* [Teacher 35, School 3A]
- *Using an actual café menu instead of made up prices … Measurement—using actual tools all the time before pictures of.* [Teacher 127, School 8B]
- *We used shapes to make different fractions out of the same shape which worked extremely well as a hands-on activity with many AHA moments from lots of students!!* [Teacher 66, School 6D]
- *Dividing a quantity in a given ratio—For this section we used the mat … and play money to divide up quantities of money. This was an AHA moment for some students. … Using the paper strips and dividing them into the total parts and then finding one part and colouring in the number of parts has helped the students understand the concept of ratio.* [Teacher 35, School 3A]
- *Students have made connections with how the patterns can be represented with symbols. Introduced tables for the class to record the figure/case and number. This was fantastic as it helped students to identify the link and patterns in the numbers … Reflection at the end of each lesson I had students saying 'well each time you times the number by 2 and add 1' and 'You add 4 each time', etc. I then went into how you would write this in a formula BIG discussion/reminder to students of how Maths is always using symbols to shorten the story of what is happening e.g. symbols and numerals to represent the numbers, etc!!!* [Teacher 66, School 6D]

- *The topic … was fractions with a focus on parts of a whole. We went outside. The children were excited. … The children enjoyed walking across the field as we all chanted the quarter of the way across, half way across, 3 quarters across, the whole way across … Success and greater understanding about the concept of the fractions. Many of the students also came to realise the equivalence of 2 quarters and one half as well as 4 quarters and one whole.* [Teacher 118, School 9E]
- *Replica 3D cart inspired from the shared class novel My Place. While discussing its structure, the boys pointed out shapes such the rectangular prisms used for the main body and the storage compartment, the cylinders used in the handles and axle etc. The class had been looking at 3D shapes, and this making (abstraction) activity lent itself well to cross-curricular integration, and formed another assessment tool. It also allowed for some great science discussion around the axle itself and levers. This furthered our current mathematical learning on mass and carrying loads.* [Teacher 46, School 5C]

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