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YuMi Deadly Centre

Faculty of Education

Impact Evaluation Report

March 2017

Growing community through education

Acknowledgements

Traditional Owners

In keeping with the spirit of Reconciliation, we acknowledge the Traditional Owners of the lands where QUT now stands – and recognise that these have always been places of teaching and learning. We wish to pay respect to their Elders – past, present and emerging – and acknowledge the important role Aboriginal and Torres Strait Islander people continue to play within the QUT community.

YuMi Deadly Centre

The YuMi Deadly Centre is a research centre within the Faculty of Education at QUT which is dedicated to enhancing the learning of Indigenous and non-Indigenous children, young people and adults to improve their opportunities for further education, training and employment, and to equip them for lifelong learning.

The YuMi Deadly Centre can be contacted at ydc@qut.edu.au. For further information on the Centre's projects and activities, visit the website at http://ydc.qut.edu.au.

Impact evaluation report

This report was prepared by Nerida Spina, with substantial contributions from Merilyn Carter, Tom Cooper, Charlotte Cottier, Gillian Farrington and Alexander Stuetz. The authors of this report acknowledge and thank all staff of the YuMi Deadly Centre for their input and assistance with the preparation of this report. They are equal partners in contributing productively to the Centre's endeavours.

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Staff of the YuMi Deadly Centre, May 2016

Contents

List of Figures, Tables and Vignettes

List of Figures

List of Tables

List of Vignettes

List of Abbreviations

ACARA	Australian Curriculum, Assessment and Reporting Authority
ACER	Australian Council for Educational Research
AIM	Accelerated Inclusive/Indigenous Mathematics
AITSL	Australian Institute for Teaching and School Leadership
ARC	Australian Research Council
DEEWR	Department of Education, Employment and Workplace Relations (Commonwealth Government)
DET	Department of Education and Training (Queensland Government)
HEPPP	Higher Education Participation and Partnership Program
EALD	English as an additional language or dialect
ICSEA	Index of Community Socio-educational Advantage
ISM	Integrated School Mathematics
ISQ	Independent Schools Queensland
ISS	Integrated Secondary School
ISSU	Indigenous Schooling Support Unit
JSMP	Junior Secondary Mathematics Program
MITI	Mathematicians in Training Initiative
MSS	Mean scale score (NAPLAN)
NAPLAN	National Assessment Program – Literacy and Numeracy
NMS	National minimum standard (NAPLAN)
OECD	Organisation for Economic Co-operation and Development
PAM	Partnering to Accelerate Mathematics
PAT	Progressive Achievement Tests
PD/PL	Professional Development/Professional Learning
PEMO	Partnering for Enhanced Mathematics Outcomes
PISA	Programme for International Student Assessment
PRIME	Purposeful Rich Indigenous Mathematics Education
QAO	Queensland Audit Office
QUT	Queensland University of Technology
RAMR	Reality–Abstraction–Mathematics–Reflection
SAM	Sustainable Access to Mathematics
SES	Socio-economic status
SNAP	Sustainable Numeracy Academy Project
STEM	Science, technology, engineering, mathematics
TIMSS	Trends in International Mathematics and Science Study
WMR	Western Metropolitan Region (Victoria)
XLR8	Accelerate
YDC	YuMi Deadly Centre
YDM	YuMi Deadly Maths

1. Executive summary

The YuMi Deadly Centre was established in late 2009 to address challenges facing maths education in Australia. Declining student achievement in mathematics in Australia has led to ongoing concerns about Australia's ability to produce and sustain a workforce of skilled maths teachers, and to produce students who are willing and able to study maths at senior secondary and tertiary levels. There are also ongoing concerns about equity, with Indigenous students and students from low socio-economic areas performing at lower levels than their peers on a range of national and international standardised measures (such as the National Assessment Program – Literacy and Numeracy [NAPLAN], the Programme for International Student Assessment [PISA] and the Trends in International Mathematics and Science Study [TIMSS]).

Since its inception, the YuMi Deadly Centre (YDC) has managed and delivered more than 30 projects that have implemented a pedagogical approach known as YuMi Deadly Maths (YDM) across more than 240 schools in Australia (predominantly Queensland). While impact and evaluation reports have been generated within individual projects previously, this report assembles data from across YDC's activity to document the impact of YDM more broadly.

Section 2 provides an overview of the role and function of YDC, detailing its key projects and operations. Section 3 outlines the broader context of mathematics education in Australia and its implications for YDC projects. Section 4 details the methodology used for assessing the impact of YDM and sections 5 to 8 provide a range of data that demonstrates this impact. The key findings are summarised below.

1.1 Impact on student achievement

YDM has had a positive impact on student achievement in mathematics in both YDM-trained and YDM-active schools (section 5.1). First, trend analysis indicates YDM schools outperform their non-YDM-trained like-school counterparts in the NAPLAN numeracy domain. Second, a range of data exists to demonstrate that schools attain significant improvements in student achievement across both NAPLAN and non-NAPLAN measures after adopting YDM. Improvements in school-based achievement data (such as on the Australian Council for Educational Research's PAT-Maths test series) have often occurred alongside improvements in NAPLAN in YDM schools. Project schools in low socio-economic areas have indicated that many of these achievements (such as achieving at national mean on the NAPLAN numeracy domain) are significant because these milestones had never previously been realised in any NAPLAN domain.

The significant impact on students is also corroborated by student self-reports. Students from a range of school types (e.g., primary/secondary; high/low socioeconomic status) and geolocation indicate that students believe YDM has had a significant impact on their knowledge and achievement in maths. Student reports have been triangulated with school achievement data to demonstrate that students' perceptions of improved knowledge were correlated with increases in achievement on standardised test measures (such as the Australian Academic Assessment tests).

1.2 Impact on "closing the gap"

Evidence shows that YDM has been successful in improving achievement for students who were significantly underperforming, and had not mastered basic skills by junior secondary entrance. Qualitative and quantitative data from a number of schools has been triangulated and used to demonstrate the significance of impact on individual students and schools (section 5.2). For example, at the individual student level, there is evidence that YDM has closed the gap between Indigenous and non-Indigenous students, providing pathways into non-compulsory senior secondary maths subject selection (such as Maths A) for students who would have previously been unable to access this option due to unsatisfactory achievement and engagement in mathematics. Pre- and post-test data also indicates that YDM has been successful in closing gaps between Indigenous and non-Indigenous student achievement (section 5.2.1).

In addition to having a positive impact on Indigenous students, YDM has enabled schools located in low socio-economic areas to reach important benchmarks such as achieving at or above the national mean on NAPLAN (section 5.2.2). Schools have stated that achieving these targets has been a significant milestone in any NAPLAN domain. For example, one low-SES school moved from 82% of students achieving at or above the national minimum standard in 2012 (pre-YDM) to 100% in 2016 (excluding eight English as an additional language or dialect [EALD] students), after implementing YDM.

Although special schools do not have the same kinds of standardised achievement data as mainstream schools, section 5.2.3 provides a range of evidence to indicate that YDM has impacted student knowledge (on pre- and post-tests) and engagement in mathematics in special schools.

1.3 Impact on student engagement in mathematics

Evidence shows that YDM has had a significant, positive effect on student engagement with mathematics from the early years of schooling through to senior secondary mathematics in YDM-trained schools (section 5.3). These changes appear to occur relatively quickly. For example, a survey of teachers participating in the Purposeful Rich Indigenous Mathematics Education (PRIME) Futures program in 2016 found that over 80% of respondents believed YDM had increased student engagement after just six months. Both teacher and student reports indicate that students from the early to senior years of schooling have vastly increased motivation, enthusiasm and interest in mathematics.

Importantly, these changes are also providing opportunities for students who would have been unlikely to continue with maths study to consider choosing to participate in non-compulsory mathematics in senior secondary. YDM's accelerated maths projects were designed to teach underachieving Years 8, 9 and 10 students (who had previously achieved at a level at or below Year 3 level maths) with a view of accelerating their learning so they could access a range of mathematics options in senior secondary. A range of multi-level data (e.g., individual school, individual student) indicates that the YDM AIM projects have been successful in providing accelerated achievement (e.g., in NAPLAN), and have subsequently increased pathways for remedial students into senior maths subject participation.

1.4 Impact on teacher knowledge and confidence

One of the key impacts of YDM is the growth in teacher knowledge and improved pedagogical practice (section 6.1). Data from across YDM projects indicates that teachers largely believe YDM training has had an extremely significant impact on their confidence, knowledge and ability to teach mathematics (section 6.2). This was the case for both beginning and experienced teachers, from the early years to senior secondary. Teachers' reports included that YDM removed the "fear" of teaching maths, and that it had "demystified" maths teaching. In a survey of principals of 18 schools participating in the PRIME Futures program, over 60% of the principals reported a moderate to extensive improvement in teacher knowledge and confidence. Over 70% of principals reported improved pedagogical skills as well as an increase in teacher expectations of students (after approximately six months of YDM participation).

The positive impact on teacher knowledge and confidence is particularly important for out-of-field teachers, who make up a large proportion of the mathematics teaching workforce (section 6.3).

Evidence also shows that YDM training raised teachers' knowledge and expectations in special schools. Accounts from teachers and YDC staff were triangulated with student achievement data to highlight changes in teachers' expectations and practice from didactic, worksheet-based teaching towards engaging, hands-on teaching practice (section 6.4).

Further evidence indicates that YDM improves the knowledge and capacity of teacher aides and support workers (such as Aboriginal Support Workers) in maths teaching (section 6.5). This is especially important in regional, remote and remedial classrooms where support workers play a significant role in the school community.

1.5 Reach of YDM: Impact on schools and school systems

The reach of YDM's impact is evidenced by the total number of schools (249) having participated in YDC projects to date and the spread of these schools across all education regions of Queensland, as well as some interstate schools (section 7.1).

Teacher reports indicate that the YDM train-the-trainer model and the annual YDC Sharing Summits have increased the movement of knowledge across schools and education systems, and increased collaboration within (and sometimes between) schools. A number of teachers have described that participating in the Sharing Summits was both inspiring and beneficial (e.g., in terms of gaining practical knowledge and building "communities of practice").

The reach of YDM's impact is also evidenced by YDC's successful 2015 bid for $3.4 million in funding from CSIRO in partnership with BHP Billiton Foundation to deliver YDM to a minimum of 60 schools across Australia in the PRIME Futures program; the successful 2016 YDC-led QUT Faculty of Education application for Queensland Government funding to train out-of-field junior secondary mathematics teachers in the online Junior Secondary Mathematics Program (JSMP); and the use of YDM as a case study in a Federal Skills and Research Capacity Report (Commonwealth of Australia, 2011).

1.6 Impact on families and communities

YDM has provided new opportunities for schools to engage with parents and communities about maths teaching (section 7.2). A number of schools have reported activities such as holding community events in which they share their successes with the local community (for example attaining NAPLAN milestones); sharing teacher and student increased enthusiasm for maths via maths fiestas and demonstration days; and increasing parental support for maths by teaching families how to engage students in maths-based activities at home. Feedback from parents indicates that these events, and increased student engagement in mathematics, are valued by families.

Initial evidence (from the PRIME Futures program) shows that engaging with Indigenous communities is increasing community support for increased attendance and engagement in maths education.

1.7 Impact on knowledge

Through its collaborative work with multiple schools, regions and communities, YDC has contributed to the generation of professional knowledge about the teaching of mathematics (section 8.1). It has produced a corpus of teaching resources (including 87 exemplar lesson plans) and other materials that are used in schools across the country (see Appendix E and YDC website: http://ydc.qut.edu.au/resources/). YDC has also contributed to scholarly knowledge through academic publications and presentations at conferences and workshops (section 8.2). A list of publications and presentations is provided in Appendix F. Finally, staff from YDC have contributed to public knowledge by appearing in a range of public forums such as parliamentary proceedings and media reporting (section 8.3; Appendix H). Improving public perceptions of mathematics teaching and learning is a significant impact, given the context outlined in section 3.

2. The role and function of the YuMi Deadly Centre

This section briefly describes the aims, beliefs and activities of the YuMi Deadly Centre (YDC). It describes the central role of the YuMi Deadly Maths (YDM) pedagogy in YDC projects and summarises how YDC is organised around these projects. It describes how YDC sustains relationships with large numbers of school staff to effect significant and positive whole school change in mathematics education.

2.1 Nature of the YuMi Deadly Centre

2.1.1 Aims

YDC, situated in the Faculty of Education at Queensland University of Technology (QUT), was established in late 2009 to facilitate teaching and learning for mathematically underperforming Aboriginal, Torres Strait Islander, and low socio-economic status (SES) students and their teachers, schools and communities to enhance their mathematics learning and improve their employment and life chances. YDC's scope has since broadened, and YDM pedagogy has since been found to be effective with all students. The centre's aims were based on evidence of continued underachievement, inequity and declining student participation in mathematics in Queensland (and Australia), which is further explored in section 3 of this report.

Aims of the YuMi Deadly Centre:

- Facilitate whole school change that builds pride and positive identity, emphasises high expectations, and strengthens relationships with community.
- Train and support school staff to teach effectively.
- Develop innovative resources and processes to strengthen teaching and learning.
- Develop decolonising research methodologies to empower the researched.
- Support research capacity, particularly at Higher Degree Research (HDR) level.

2.1.2 Beliefs

YDC's approach towards mathematics education is based on the experiences of its founders, QUT researchers who had taught in, regularly visited and worked in classrooms since the 1980s, and in low-SES and Indigenous classrooms since 1999. The development of YDM is based on the following beliefs about mathematics teaching and learning.

Beliefs about mathematics teaching and learning:

- All people deserve the deepest mathematics teaching and learning that empowers them to understand their world mathematically and to solve their problems in their reality.
- All people can be empowered in their lives by mathematics if they understand it as a conceptual structure, life-describing language, and problem-solving tool.
- All people can excel in mathematics and remain strong and proud in their culture and heritage if taught actively, contextually, with respect and high expectations and in a culturally safe manner.
- All teachers can be empowered to teach mathematics with the outcomes above if they have the support of their school and system and the knowledge, resources and expectations to deliver effective pedagogy.
- All communities can benefit from the mathematics teaching and learning practices above if school and community are connected through high expectations in an education program of which mathematics is a part.
- 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.

2.1.3 Activities

The above aims and beliefs have influenced the way YDC interacts with systems, schools, teachers and students. Four positions have come to define the activities of the centre:

Positions defining the activities of YDC:

- Deep learning of mathematics requires students to construct their own knowledge by interaction with classroom activities and other students, a position that focuses teaching on constructivist epistemologies.
- School improvement is most effective when built around enhancing teacher capacity to effectively teach mathematics, a position that requires tailoring instruction to the culture and background of students, and requires teachers to design instruction, not to be given generic student materials.
- Effective change requires involvement of the whole school and community, a position that leads to professional development (PD) practices that focus on training to facilitate school planning and in-school activity that involves all school staff and community.
- Research activity should immediately empower the researched (Tuhiwai Smith, 2012), a position that focuses research activity on design experiments and action research.

The approach YDC has adopted sees effective change through providing teachers with "a fishing rod", that is, the ability to design their own classroom activities, rather than providing "fish", that is, a book of exemplar activities. The YDC approach tailors learning to the interests, backgrounds and cultures of each classroom of students, and requires teacher input on all tasks.

For efficiency, YDC has developed a professional learning process undertaken in an iterative cycle of PD, resources, supported in-school trialling and training, and action research, within a school change and leadership model, as shown in Figure 2.1.

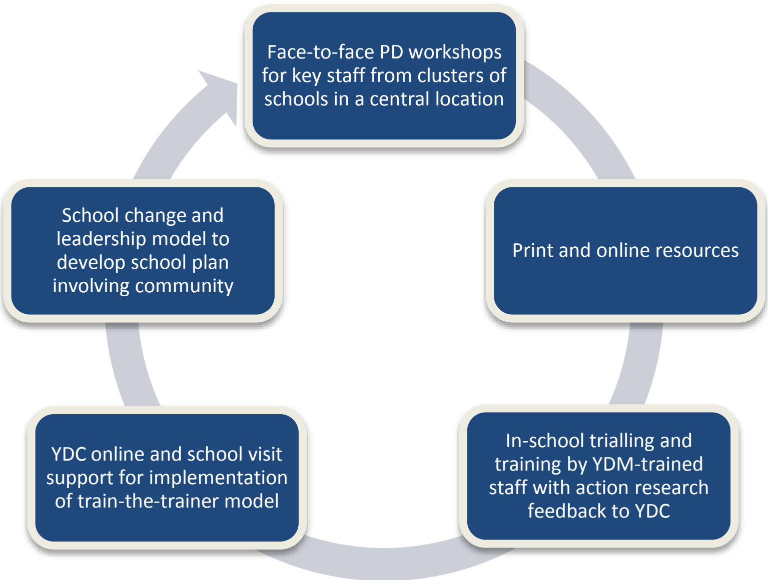


Figure 2.1 YDC professional learning process

2.2 Central pedagogy and project types

2.2.1 Pedagogical approach

The centre has developed a pedagogical approach to teaching maths, known as YuMi Deadly Maths (YDM), designed to increase student achievement, engagement and participation in non-compulsory (secondary and tertiary) mathematics education. In contrast to traditional approaches to mathematics education that are heavily reliant on textbooks, worksheets and student memorisation of facts and processes, YDM relates mathematics teaching to students' lived realities and focuses on deep learning of core mathematics concepts (Cooper & Carter, 2016). This deep learning requires teacher knowledge of connections between topics, seamlessly sequencing from early to late ideas and building understanding around big ideas (Cooper, Carter, & Lowe, 2016).

This emancipatory pedagogical approach uses students' cultural and social capital (Bourdieu, 1973) by providing teachers with a model that encourages students to explore mathematical concepts from their own world view and cultural values. The YDM approach has four components (Figure 2.2).

Mathematics

- The relational (Skemp, 1976) and emancipatory perspective of YDM sees mathematics as a connected structure that provides students with the knowledge to take control of their lives and become what they wish.

Mathematics learning

- The connected structure of mathematics knowledge provides students with portable knowledge that does not rely on the memorisation of rules and procedures, and can be translated or transferred to a variety of situations.

Mathematics teaching

- The social constructivist and inquiry-based approach aims to teach students to investigate and solve problems by providing experiences from which the students can construct their own knowledge based on discussion with teachers and peers.

School–community connections

- YDM acknowledges that school mathematics is part of a school that is connected to its local community, valuing community knowledge and welcoming community members into the school to share that knowledge.

Figure 2.2 Components of the YDM pedagogical approach

Because YDM is built on an approach grounded in reality, the train-the-trainer model has been adopted to improve teacher capacity, offering long-term sustainability for schools. For further detail on the history of YDC, refer to Appendix A.

2.2.2 Metacognitive framework

The central component of the YDM pedagogy is a metacognitive framework that supports teacher design of instruction by providing a structure for lessons and units of work. It is based on the Reality–Abstraction–Mathematics–Reflection (RAMR) cycle (see Figure 2.3). This cycle is a pedagogical framework for planning, teaching and learning mathematics. It proposes:

(a) working from students' reality and local culture (prior experience and everyday kinaesthetic activities);

(b) abstracting mathematics ideas from everyday instances to mathematical forms through representational activities (physical, virtual, pictorial, language and symbols, using body → hand → mind);

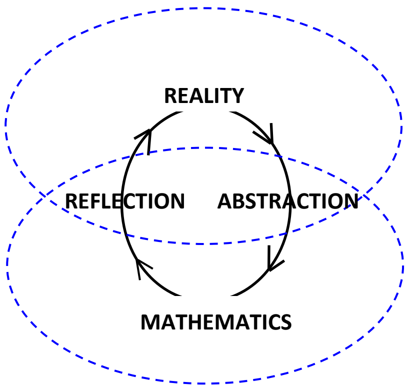


Figure 2.3 The RAMR cycle

(c) consolidating the new ideas as mathematics through language and symbols, practice and connections;

(d) reflecting these ideas back to reality through a focus on applications and problem-solving, and extending knowledge through flexibility, reversing, generalising and changing parameters.

The innovative aspect of RAMR is that the right half develops the mathematics idea while the left half reconnects it to the world and extends it. For example, whole-number place value built around the pattern of threes where hundreds-tens-ones applies to ones, thousands, millions, and so on, can easily be extended to metrics by considering the ones to be millimetres, the thousands to be metres and the millions to be kilometres.

2.2.3 YDC project types

All YDC projects are based on the YDM approach and pedagogy. Schools and education sectors that participate in YDC projects receive professional development in mathematics, mathematics pedagogy and general lesson management as part of the professional learning process shown in Figure 2.1. All projects focus on building a school plan for renewal of all mathematics teaching, involving the local community, and school-based training to support long-term sustainability. Some projects include visits by YDC staff to provide school-based support.

YDC projects are organised into three main categories according to their focus, as shown in Figure 2.4.

YDM general pedagogy projects

- Collaborative partnership schools are provided with PD, resources and online support to use the YDM approach to teaching mathematics (covers content for Years F–9).

YDM accelerated learning projects

- Collaborative partnership schools are provided with PD, resources and online support to develop materials that accelerate the mathematics learning of underperforming students from their ability level to their age level and above (covers content for Years F–9).

YDM enrichment and extension projects

- Collaborative partnership schools are provided with PD, resources and online support to develop a program that motivates and strengthens students mathematically to take up high-level senior secondary subjects and pursue university entry to science, technology, engineering and mathematics (STEM) professions (covers content for Years 7–12 with particular focus on 11 and 12).

Figure 2.4 YDC project types

YDC projects have also included those with a vocational, context-based or community learning focus. In 2016 YDC led a successful QUT Faculty of Education application for Queensland Government funding to deliver online training for out-of-field junior secondary mathematics teachers, called the Junior Secondary Mathematics Program (JSMP). This report focuses on projects in the three categories above. Key projects are described in the next subsection; a full list of YDC's 32 projects since 2010 is included in Appendix B.

2.3 Funding and key projects

Since its inception in late 2009 YDC has received project funding totalling $13,635,366 from the sources shown in Figure 2.5. Past and current key projects are shown in Figure 2.6 and summarised below.

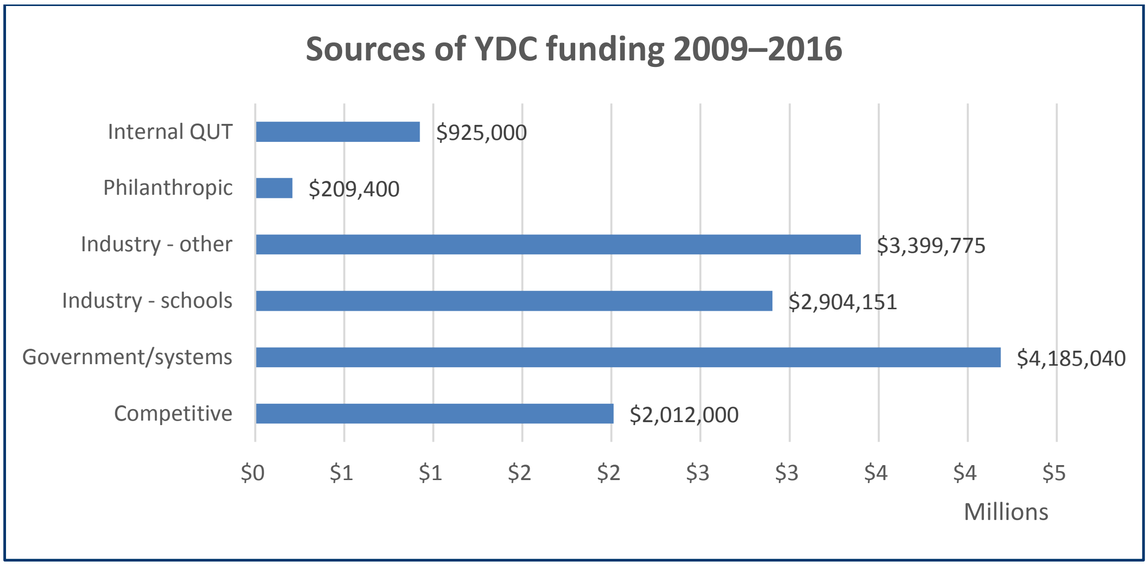


Figure 2.5 Sources of YDC funding 2009–2016

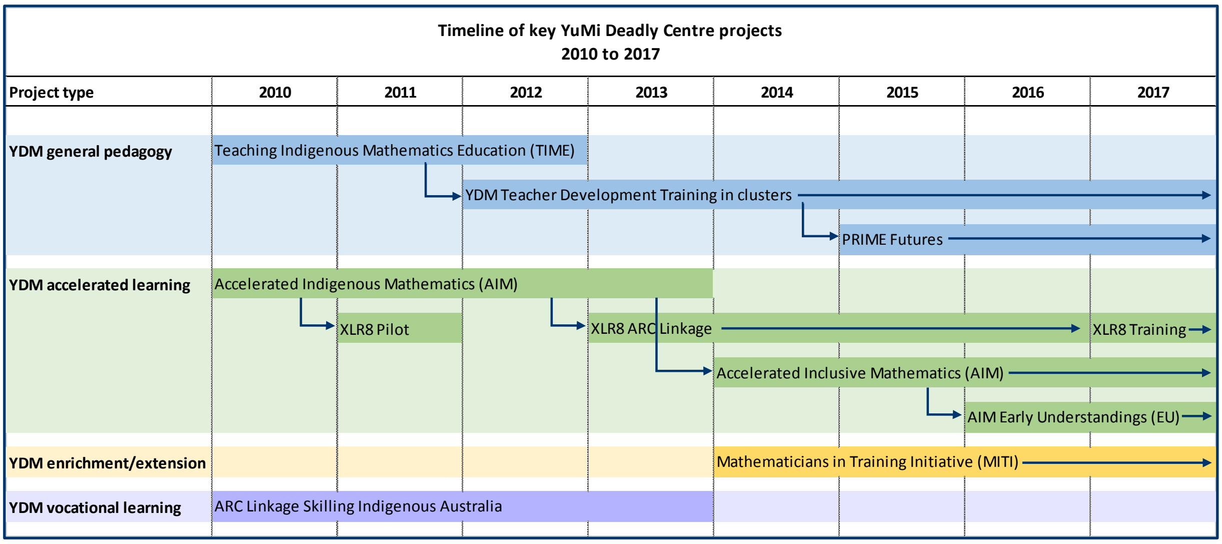


Figure 2.6 Timeline of key YDC projects since 2010

2.3.1 YDM general pedagogy projects

Teaching Indigenous Mathematics Education (TIME) (2010–12): This project was funded by the Queensland Department of Education and Training (DET), through the Division of Indigenous Education and Training Futures Indigenous Schooling Support Unit, Central and Southern Queensland. The project developed the YDM pedagogy and YDC's flagship mathematics train-the-trainer PD program. The project focused on Years P to 3 in 2010, Years 4 to 7 in 2011 and Years 7 to 9 in 2012, covering all mathematics strands of the Australian Curriculum: Number and Algebra, Measurement and Geometry, and Statistics and Probability. In all, over 100 Queensland schools participated in the project.

YDM Teacher Development Training (TDT) projects (2012 onwards): This is the collective name for a number of smaller projects that continue to trial and refine the YDM pedagogical approach in terms of its effectiveness in improving mathematics teaching and learning in relation to characteristics of schools, teachers and students. YDM TDT provides PD, resources and online support to build capacity of teachers and schools to teach mathematics. It provides 12 days of PD (usually four × three-day blocks), including two days for principals or administrators, across two years for up to four teachers per school. For efficiency, schools are grouped into clusters based around a central location to which all can travel for PD. Schools can join existing clusters or make new clusters. Schools can self-fund involvement if no external funding is available.

Purposeful Rich Indigenous Mathematics Education (PRIME) Futures (2015–19): This project delivers YDM TDT as described above, with some additional services, as the mathematics element of a larger Indigenous STEM Education project managed by CSIRO in partnership with the BHP Billiton Foundation. YDC has been subcontracted by CSIRO after winning a national tender to deliver this element. At least 60 schools across Australia with relatively high Indigenous student populations will be involved in the project across four years, working together in 10 clusters of at least six schools each. The project provides each cluster with 15 days (five × three-day blocks) of PD across 2½ years, plus school visits following each block of PD to reinforce in-school trialling and training. The final PD is driven by the needs of each cluster and is designed to support sustainability of YDM in the PRIME Futures schools to the end of the project in 2019 and beyond.

2.3.2 YDM accelerated learning projects

Accelerated Indigenous Mathematics (AIM) (2010–13): The AIM project was funded by the Commonwealth Government Department of Education, Employment and Workplace Relations (DEEWR) under the *Closing the Gap: Expansion of Intensive Literacy and Numeracy* program for Indigenous students. The project studied how the mathematical performance of underachieving Years 8–10 Aboriginal and Torres Strait Islander students could be accelerated to promote entry into higher-level mathematics offerings. The project developed 24 learning modules, based on YDM, that are vertical sequences of learning to take students from their ability level to their age level in mathematics. In 2014 the project was reconceptualised for wider use as the Accelerated Inclusive Mathematics project.

Accelerated Inclusive Mathematics (AIM) (2014 onwards): This project trials and refines the YDM-based accelerated remedial pedagogical approach for underachieving students, that is, those who are at least three years behind the expectations for their age group on entering secondary school. It studies how mathematical performance of these students can be accelerated across Years 7–9 by using a vertical curriculum to promote entry into the full range of Year 10 mathematics offerings. At present, schools are self-funding involvement in this project.

XLR8 (2013–16 and ongoing): This Australian Research Council (ARC) Linkage funded project worked with three Brisbane high schools to trial, refine and study the effectiveness of a YDM-based mathematics acceleration program aimed at improving the understanding of underachieving low-SES students in three years (Years 7–9) to enable access to mainstream mathematics classes. It is similar in focus to AIM, with the main difference being that the 15 larger modules developed for this project are built around themes, integrate both horizontally and vertically, and have more detailed and complete lesson materials. These XLR8 modules are now available for use in other schools through self-funding.

AIM Early Understandings (EU) (2015–16 and ongoing): In this project YDC has been partnering with a primary school in North Queensland since late 2015 to develop and trial a new set of nine AIM-style modules covering prior-to-school as well as Foundation to Year 2 content to improve Year 3 outcomes. The nine modules include Pre-Foundational to Year 2 units in Number, Algebra and Operations, covering counting, patterning, functions and equations, place value, quantity, thinking and solving, meaning and operating, calculating, and fractions. After trialling and refinement in this project, the modules will be available for use in other schools through self-funding.

2.3.3 YDM enrichment and extension project

YDM Mathematicians in Training Initiative (MITI) (2014 onwards): The MITI project trials and refines a YDM-based enrichment and extension pedagogy that aims to deepen understanding of powerful mathematics to increase participation in high-level (Years 11 and 12) mathematics subjects and university entrance for STEM careers. MITI's first stage is based on teaching with investigations and planning instruction to ensure smooth sequencing from Year 7 to Year 12. The second stage focuses on digital applications and the use of business/ industry/STEM contexts for Years 7–12. Schools can self-fund the program in clusters of schools, each sending up to four staff to PD workshops.

2.4 Summary

YDC's mathematics projects were developed by staff who had been involved in mathematics education for over 20 years before YDC's formation. The resulting projects are based on evidence and cover general YDM pedagogy, remedial (accelerated), and enrichment/extension projects. They focus on improving teacher capacity and are designed to provide teachers with metacognitive frameworks on which to base instruction and assessment, and to engage and extend students.

All projects are based on the YDM pedagogy and an approach to mathematics that foregrounds sequencing, connections and big ideas. The ideas and resources on which the projects are based were developed through government grants and have been maintained by schools self-funding training. The projects are innovative and based on structural understanding driving acceleration. They stress whole school change and community involvement. They require teachers to begin and end with the cultural context and background interests of the students, thus connecting knowledge to the students' real world.

The impact of YDM on students, teachers and schools is extensive, changing the ways schools operate, teachers teach and students learn. The impact is based on early understandings leading to later extensions and can be both short term and long term. The methodology for measuring impact is described in section 4, after the wider context of mathematics education in Australia and its implications for YDC projects are examined in the following section.

3. Mathematics education context and implications

This section focuses on the nature of mathematics education in Australia, looking at overall demand for mathematicians, overall decline in student performance, and inequity between Indigenous and non-Indigenous students, low-SES and high-SES students, country and city students, and mainstream and special school students.

This analysis of the current state of mathematics education in Australia illuminates the role and function of YDC in responding to the decline and inequities that testing shows are evident in Australia. Seeing YDC in the context of Australian mathematics education gives insight into its impact and provides a background for the methodology chosen to analyse that impact.

3.1 Australian mathematics context

3.1.1 Demand for mathematics skills

There are growing concerns about the teaching and learning of mathematics in Australia given ongoing declines in student achievement on standardised tests (see section 3.1.2) and low numbers of both secondary and tertiary students pursuing study and/or careers in mathematics and related disciplines. At the same time, there has been a rise in employment opportunities in areas where mathematics is required, notably STEM and trade occupations. Student disengagement in maths, along with declining maths achievement, has contributed to ongoing shortages of qualified mathematics teachers, which has the potential to further exacerbate the cycle of underachievement. This situation is likely to worsen in the near future as approximately half of the Australian maths teaching workforce is comprised of males aged over 50 (i.e., nearing retirement age) (Weldon, 2015).

3.1.2 Overall decline in student performance

Over the past decade Australian student achievement in mathematics has declined on both national and international standardised measures. Results of the three most commonly cited measures of achievement of numeracy and mathematics achievement are outlined below.

NAPLAN (National Assessment Program Literacy and Numeracy): NAPLAN is a standardised census-style assessment of Australian Year 3, 5, 7 and 9 students that occurs annually across several domains including numeracy. Since the inception of NAPLAN testing in 2008, there have been few statistically significant changes (either improvements or declines) in NAPLAN numeracy outcomes, aside from some small improvements (e.g., Year 5 student achievement has improved since 2008). Students who cannot reach the national minimum standard (NMS) for their year level are at risk of being unable to progress satisfactorily without targeted intervention.

PISA (Programme for International Student Assessment): PISA is an international assessment of scientific, reading and mathematical literacy of a sample of 15-year-old students conducted every three years by the Organisation for Economic Co-operation and Development (OECD). Australia’s national report on PISA 2015 (Thomson, DeBortoli, & Underwood, 2016) was released in December 2016, and revealed that although Australian students, on average, exceeded the OECD mean, Australia was one of ten countries whose performance in mathematical literacy declined significantly between 2012 and 2015.

TIMSS (Trends in International Mathematics and Science Study): TIMSS is a large-scale standardised international assessment (of mathematics and science) of students in Years 4 and 8 conducted by the International Association for the Evaluation of Educational Achievement. In 2015 Australia was one of more than 60 countries that participated. The TIMSS 2015 national report, released in November 2016, indicated that there have been few changes in the mathematics achievement of Australian Year 4 and 8 students since the 1990s; 30% of Year 4 students and 36% of Year 8 students did not achieve the TIMSS Intermediate international benchmark, which is the agreed standard of proficiency for Australia (Thomson, Wernert, O’Grady, & Rodrigues, 2016, p. 26). Further, Australia’s performance relative to other countries declined.

3.1.3 Indigenous/non-Indigenous achievement gap

Although some progress has been made, significant achievement gaps between Indigenous and non-Indigenous students remain, as evidenced by NAPLAN data. For example, in 2016, 82.6% of Indigenous Year 3 students reached the NMS compared with 96.4% of non-Indigenous Year 3 students (Australian Curriculum, Assessment and Reporting Authority [ACARA], 2016a, p. 284). By Year 9, 79.7% of Indigenous students reached the NMS, compared with 96.1% of non-Indigenous students. As was the case in the previous round of PISA testing, results highlighted entrenched inequities in Australian student achievement. For example, in the 2015 PISA, 57% of non-Indigenous students attained the "National Proficient Standard" in mathematical literacy, compared with 25% of Indigenous students (Thomson, DeBortoli, & Underwood, 2016, p. 54). The difference in mean scores between Indigenous and non-Indigenous students "equates to about one proficiency level or around two-and-a-third years of schooling" (p. 54) with Indigenous students achieving significantly below the OECD average, while non-Indigenous students performed significantly higher than the OECD average. Similarly, TIMSS data indicates that a significant gap remains between the mean mathematics achievement of Indigenous students compared to their non-Indigenous counterparts (Thomson, Wernert et al., 2016).

3.1.4 Low-SES/high-SES achievement gap

There are also significant and sustained gaps in NAPLAN achievement between students from lower and higher socio-economic backgrounds (using parental occupation and education measures) (ACARA, 2016a). There is also a correlation between geolocation, educational advantage and Indigeneity. Students in remote areas are consistently outperformed by regional and metropolitan students (ACARA, 2016a). PISA data also indicates ongoing gaps in performance between students with lower and higher socio-economic backgrounds (Thomson, DeBortoli, & Underwood, 2016). Like NAPLAN and PISA, the most recent TIMSS data also reported lower results among students from lower socio-economic backgrounds, as well as from non-English speaking backgrounds (Thomson, Wernert et al., 2016).

3.1.5 Special schools

Understanding the achievement of students in special schools is complex, as many students do not participate in standardised testing such as NAPLAN. This is a growing issue as Australia has experienced a significant increase in the number of special schools (Boyle, Anderson, & Swayn, 2015), and because there is a disproportionate number of Indigenous and other students from minorities in special schools (e.g., Graham, 2012). Although the use of individual plans and measures of achievement (as opposed to standardised measures) make standardised measurement comparison difficult, the growing numbers of students in special schools means that attempts to improve mathematical knowledge of students in special schools remains a significant national issue.

3.2 Implications for YDC mathematics programs

3.2.1 Demand for mathematics skills and decline in student performance

The philosophy underpinning YDM was to develop a pedagogical approach that would improve teacher knowledge so that teachers could focus student learning on building deep understandings of core mathematical concepts and principles. YDM projects are structured around a sequential process in which students are encouraged to make connections between their own understandings and mathematics concepts. This constructivist pedagogical approach, in which students are encouraged to gain deep understandings, is in contrast to the behavioural approach commonly used in mathematics teaching, in which students are encouraged to memorise and practise rules and procedures. YDM encourages teachers to engage students in the RAMR cycle in which students gradually move from their own knowledge towards abstract mathematics concepts. Taking a multisensory, kinaesthetic approach was further intended to improve student engagement and understandings in mathematics.

The YDM approach to teaching mathematics is designed to improve students' mathematical skills and performance, thereby increasing the pool of students available to meet demand and ameliorating the cycle of underachievement in mathematics within Australia.

3.2.2 Indigenous/non-Indigenous achievement gap

The low performance of Indigenous students was the starting point for YDC. The YDM pedagogy was developed to improve mathematics performance of Indigenous students, and to ensure equity in teaching regardless of students' background. YDC believes that changing mathematics pedagogy will not improve mathematics learning unless accompanied by a whole-of-school program to challenge poor attendance and behaviour, encourage pride and self-belief, instil high expectations, and build local leadership and community involvement (Sarra, 2011). The basis of YDM emerged from consideration of Indigenous mathematics education, for example, the notions that:

- all classes are different and need direct input from teachers who know the students in the classes for effective learning, implying that teaching cannot be outsourced to a textbook;
- all students should be able to place their mathematics learning within their community and culture, leading to a focus on reality and reflection;
- deep structure is important and needs a focus on whole-to-part teaching, rather than part-to-whole, and a focus on understanding big ideas, rather than rote learning of rules; and
- all students deserve the opportunity to learn the powerful mathematics of senior years, which led to the development of MITI and AIM.

The RAMR model evolved from an analysis of mathematics by Indigenous mathematician and mathematics educator Dr Chris Matthews. RAMR was based on the cycle within his Goompi model (see Figure 3.1). This model was designed to take account of the cultural capital students bring to the classroom, to relate to the nature of mathematics as a human construct, and to negate the traditional Eurocentric nature of school mathematics.

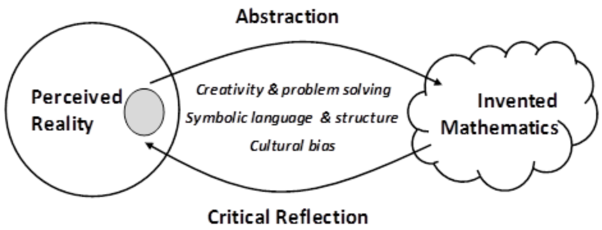


Figure 3.1 The Goompi model (Matthews, 2009)

3.2.3 SES-geolocation gap and special schools

The Indigenous materials were originally developed for schools with predominantly Indigenous students. However, the government funding for one of YDC's major projects changed the focus to a geographical area where most schools that had Indigenous students were low socio-economic schools and the Indigenous students were in the minority. The pedagogies were trialled and found to be successful for low-SES and rural/remote students; in particular, they were successful in schools with high numbers of migrants and refugees. Projects were renamed to reflect this broader focus.

YDM was also found to be successful for students with disabilities. The centre began to offer programs in special schools, drawing on the multisensory nature of the RAMR model to open up new areas of learning. Because YDM is based on a view of mathematics as much more than the symbolic and abstract learning, the body → hand → mind activity sequences provided new opportunities for students with disabilities to advance their mathematical understandings.

3.3 Impact scope

3.3.1 YDC objectives

Before analysing the impact of YDC on mathematics education, it was first necessary to determine the impact factors to be analysed. The most obvious target for analysis was the effect of YDC's projects on student achievement in mathematics, since YDM projects are focused around student performance in mathematics, within the Australian Curriculum (ACARA, 2016b).

Looking back at the aims of YDC as outlined in section 2.1.1, both the overall goal to enhance student learning to improve opportunities for further education, training and employment, and the five specific aims, it seems evident that if YDC has impact on mathematics teaching and learning, then there should be some measurable improvement with respect to the following:

- students' performance in, and engagement with, mathematics;
- teachers' capacity to teach mathematics, associated with whole school change;
- development of resources, including empowering research methodologies; and

- effect on research capacity.

Thus, the major focus of this report is impact with regard to students; teachers; schools, systems, partnerships and communities; and knowledge.

3.3.2 Project activity and data

The decision by YDC to focus on teacher capacity fits with a range of research that indicates that improving teaching quality is a significant factor in increasing student achievement (e.g., Cole, 2012; Hattie, 2012; Rowe, 2003). However, focusing on teacher knowledge and practice has created challenges in sustaining YDM in schools, as external factors such as principal, administrator and teacher turnover have had a significant impact on YDC projects.

The focus on improving staff capacity also means that YDM training is high impact as it embeds YDM pedagogies in classrooms. This approach of ensuring quality pedagogy and practice in classrooms uses resources to support professional learning in PD workshops and in schools. The resources assist in-school training to maintain the impact of whole pedagogical change.

Finally, working in multiple projects across a large number of schools entails working with many teachers and a large number of students. Data within YDC projects has been gathered from the trained teachers and the school administrators. Student data has mostly been collected via teacher de-identified class results. Most YDC data is based on publicly available NAPLAN data (e.g., via the federal government's My School website) and observational data provided by teachers who are being trained in YDM.

However, two large projects have provided funding to enable significant research and data gathering: the original AIM project (2010–13) and the current PRIME Futures project (2015–19). Consequently, this impact report draws more heavily on data from those two projects.

3.4 Summary

Analysis of mathematics education in Australia has shown a demand for mathematics-trained personnel that is not being met; a decline in overall student performance in mathematics; and entrenched inequities in performance between Indigenous/non-Indigenous, low/high SES, rural/city and mainstream/special schools. YDC was founded to meet these challenges and has done so by developing new pedagogies and teacher-based whole-school PD and undertaking long-term projects with many schools using these pedagogies and PD.

The next section looks at the methodology for evaluating impact and is followed by sections which reveal the high impact of YDC projects.

4. Methodology for assessing YuMi Deadly Centre impact

This section combines the ideas and arguments from sections 2 and 3 to develop the methodology used in this report to determine the impact of YDC.

4.1 Defining impact

The definitions and assessment of impact used in this report draw on current national and global trends for assessing university and academic research.

1. **Impact beyond academia**. In 2016 the ARC began to develop a range of quantitative and qualitative measures of research impact and engagement as part of the National Science and Innovation Agenda (ARC, 2016). In researching impact, the ARC noted that impact has typically been defined by impact beyond academia, citing the U.K. Research Evaluation Framework, which defined impact as "an effect on, change, benefit to the economy, society, culture, public policy or services, health, the environment or quality of life beyond academia" (ARC, 2016, p. 6).
2. **Danger of simplicity**. Analysing impact in this way is not without its challenges. Indeed, prior to stakeholder consultation in 2016, the ARC cautioned that assessing and measuring research impact using this definition is difficult as it "may advantage some disciplines over others", for example those with short-term, immediately measureable impacts, over research with longer-term or more "intangible" benefit (ARC, 2016, p. 6).
3. **Reach and significance**. In a report commissioned by the Australian Technology Network of Universities to review the Excellence in Innovation in Australia Impact Assessment Trial, the authors (Morgan Jones, Castle-Clarke, Manville, Gunashekar, & Grant, 2013) foregrounded the importance of accounting for the contribution of research projects to both the reach and significance of the impact. Reach is defined as "the spread or breadth of influence or effect on the relevant constituencies". Significance is defined as "the intensity or the influence or effect" (pp. xi–xii).

4.2 Implications for YDC

4.2.1 Broad definition

Using a broad definition of impact is important in assessing the impact of YDM programs, since YDC's operations have focused on building capacity with teachers, school leaders, communities and other stakeholders. The stated mission of YDC is "enhancing the learning of Indigenous and non-Indigenous children, young people and adults to improve their opportunities for further education, training and employment, and to equip them for lifelong learning" (QUT YuMi Deadly Centre, 2016). As described earlier, YDC achieves this by training teachers in a pedagogy that enables them to build mathematics knowledge, as well as knowledge of effective teaching and learning of mathematics, enabling them to prepare their own lessons and units.

4.2.2 Complexity in measuring impact

While the activity of YDC has provided a great deal of positive impact on education, such as individual student achievement, other impacts are more difficult to measure or quantify (such as changes in teacher knowledge and attitude towards mathematics teaching) and are more likely to provide longer term benefits to individuals and the wider Australian community (for example via potential increases in the number of students selecting and participating in non-compulsory mathematics subjects).

The data analysed in this report has already been collated in reports for individual YDC projects. This impact report draws together data from across the range of YDC activity to provide a clearer picture of the impact on students, teachers, communities, school systems and the research community. Because data has been collected across a number of projects that vary in scope, content, location and so on (see Appendix B), assessing the overall scale and significance of impact involves a variety of methods.

To illustrate the range of short-term and long-term impacts, a range of data (see section 4.3 below) is analysed and the structure of analysis is thematic. Multiple levels of both qualitative and quantitative analysis (for example, individual student or teacher, school-level and multiple-school analysis) are combined to illustrate the impact on students, teachers, school systems, and other stakeholders. The interaction between YDC staff and education departments, schools and communities is examined in order to unpack YDC's impact from the mutually beneficial exchange and creation of knowledge in mathematics teaching.

4.2.3 Context of analysis

Analysis of impact needs to take into account the following context of YDC projects.

1. YDC's priority is to focus on teacher-directed PD and only collect consent from teachers/administrators, due to the ethical consent process for students requiring consent from each parent/caregiver.
2. Different projects and different forms of funding mean that data is not the same across projects. Further, YDC does not have access to individual student NAPLAN data, and therefore is unable to undertake detailed analysis of student achievement gains, or comparisons with non-YDM students and schools.
3. The turnover of leadership and teaching staff in schools has had a significant impact on the implementation of YDM in schools because much of YDC's work is based on training teachers. When teachers change schools, retire and so on, this diminishes the effect of YDC's work, and creates complexities in understanding the impact of YDM. However, the knowledge is retained and often transferred to other non-YDM schools, thus increasing impact.
4. The funding for YDC projects limits the level of support that can be provided to schools for in-school training of staff, trialling in classrooms and building communities of practice, which could in turn affect the impact of YDM. For example, self-funded schools tend to focus on professional development and this can limit the amount and type of data that can be gathered.
5. Because YDC has adopted a decolonising methodological approach, project design has been grounded in the belief that research should always benefit "the researched", which can direct data gathering to student performance.

4.3 Evaluating impact

4.3.1 Components of impact assessment analysis

The methodological approach chosen to assess impact is as follows.

1. **Thematic analysis**. Thematic analysis was undertaken to identify the key areas of impact of YDM. Data was drawn from across a range of YDC projects to illustrate both the reach and significance of specific YDC projects. The themes were determined by analysing YDC's aims in relation to what would be expected of successful impact. This has led to the following themes:
   - impact on students (section 5);
   - impact on teachers (section 6);
   - impact on schools, systems, partnerships and community (section 7); and
   - contribution to knowledge (section 8).
2. **Triangulation of data**. This report uses a range of data to establish both the scale and depth of impact of YDM. This includes the use of qualitative and quantitative data; short-term (e.g., individual class pre- and post-tests conducted by teachers after participating in YDM PD) and longer term (e.g., NAPLAN) data. Triangulation of the datasets (see section 4.3.2 below) provides a meaningful picture of the impact of YDC.

   Throughout the report, triangulation is provided in a series of case studies and vignettes that are intended to illustrate both the depth of impact (e.g., by combining student reports of increased engagement with school-level student achievement data) and scope (e.g., by assembling the reports of teachers from across a range of schools).

4.3.2 Datasets

Empirical data is presented from a number of YDC projects to demonstrate the range and significance of impact of YDM on students (section 5); teachers (section 6); schools, systems, partnerships and communities (section 7); and of YDC's contribution to knowledge (section 8). Particular attention is given to detailing the impact of YDM for specific sub-groups, such as Indigenous students, students in low socio-economic schools and out-of-field teachers. The key datasets used are as follows.

1. **Systemic data on school performance**. NAPLAN data has been used to triangulate findings around the impact of YDM on student achievement. Publicly available NAPLAN data collected from ACARA's My School website (ACARA, 2016c) is provided to compare YDM and non-YDM statistically similar schools from 2011 to 2015. The methodology used to analyse NAPLAN data is outlined in Appendix C.
2. **Data collected by participating teachers, teacher aides and school leaders**. This dataset includes quantitative data such as pre- and post-test student achievement data for classes conducted by teachers implementing YDM. Commonly, this includes standardised tests such as the Australian Council for Educational Research (ACER) Progressive Achievement Tests (PAT) and NAPLAN. Qualitative data includes teacher reflective journals that document teacher action research. This dataset also includes quantitative and qualitative data presented by teachers and school leaders at conferences (including YDC's annual Sharing Summit). Participating school staff have also provided feedback from teachers, teacher aides and school leaders at PD days, and through written reflections on the modules, sent by email. Where possible, data obtained from schools has been independently verified (e.g., by cross-checking NAPLAN data on the federal government's My School website).

   The use of qualitative data such as student voice is increasingly being recognised as an essential source of knowledge in education research and practice (e.g., Harris, Spina, Ehrich, & Smeed, 2013). However, as described above, where possible, qualitative reports have been triangulated with quantitative data such as NAPLAN and school-based student achievement data.
3. **Data collected by YDC researchers**. This dataset includes a number of surveys conducted by YDC (e.g., to gauge teacher attitudes about teaching mathematics before and after participating in YDM training; to gauge teacher beliefs about student engagement in mathematics; to obtain participant evaluations of YDM PD workshops). YDC staff have also conducted both ad hoc and planned semi-structured interviews and focus groups with participating teachers, teacher aides, school leaders and administrators, and observations of in-school PD, classroom teaching and school meetings. YDC staff have also collected a range of artefacts (such as school and teacher lesson and unit planning and student work samples). Although this dataset was primarily used as an adjunct to the first two datasets, it is important because YDC staff have worked closely with schools, and are able to draw on both their own observations of teaching and learning, and conversations with teachers and students, to establish whether there have been significant changes in pedagogy. For example, although teachers may claim to have moved away from rote-learning pedagogies, it was useful to compare teacher, student and YDC-staff reports in order to establish the veracity of individual accounts.

4.4 Summary

The depth of YDC's activities and research requires a complex methodology for evaluating impact. The thematic analysis and range of data drawn on to demonstrate the multi-level impact of YDM is especially important given a national context in which mathematics education and knowledge are in a state of decline.

The four themes of students, teachers, schools and contribution to knowledge provide a sound framework that covers both significance and reach. For example, significance of impact can be demonstrated by triangulation of data from individual teachers, students and schools, while reach of impact can be demonstrated by projects that have had an impact across a large number of schools. Although impacts in some areas, such as student engagement in mathematics and teacher confidence, are difficult to measure, triangulation of quantitative and qualitative data allows for upward trends to be established.

5. Impact on students

This section reviews the impact of YDM projects on students. It shows the impact of YDM on student achievement by:

(a) comparing NAPLAN numeracy data for overall student achievement between YDM and other schools (5.1.1);

(b) presenting student achievement data using a combination of non-NAPLAN and NAPLAN measures, at the individual school and student level, including student beliefs about their own mathematics learning (5.1.2); and

(c) analysing aggregated pre-post student achievement data collected by teachers in the YDM AIM project, and an example of individual class student achievement data, as well as data from a YDM AIM survey in which teachers were asked about their perception of students' abilities to think mathematically (5.1.3).

Note: The methodology used to analyse the NAPLAN data is outlined in Appendix C.

Section 5.2 presents data that indicates the impact of YDM on closing statistical inequities between different groups and catering for students with special needs by:

(a) analysing the impact of YDM on closing the gap between Indigenous and non-Indigenous students in mathematics achievement (5.2.1);

(b) analysing the impact of YDM in low socio-economic schools (5.2.2); and

(c) analysing data for learning support and special needs students (5.2.3).

Section 5.3 reports on the effect of YDM on student engagement using qualitative data to instantiate claims of efficacy by:

(a) analysing student engagement with mathematics learning (5.3.1); and

(b) presenting data on student engagement in non-compulsory mathematics: Senior subject selection (5.3.2).

5.1 Student achievement

5.1.1 Student achievement – NAPLAN

> *"One thing that came out of NAPLAN this year (2015), is that the students who were in Deadly Maths… their relative gain in the mean scale score was about 20 points higher than our non-Deadly Maths kids."*
>
> *– Principal, Remote P–10 College*

To ascertain whether participation in YDM projects was linked to improvements in student achievement, NAPLAN gain-score data from YDM schools and similar schools (according to My School) were compared. Analysis indicates that YDM schools consistently achieved greater mean gains than their similar school counterparts in mean scale score over two-year periods between Year 3 to Year 5; and Year 5 to Year 7. This was the case for both "YDM-trained schools" and "YDM-active" schools. YDM-trained schools refers to schools in which nominated teachers completed a minimum of a one-year YDM training program. To better judge the effect of YDM on student results, analysis is also presented for schools that are known to YDC staff as having successfully implemented YDM pedagogy across the entire school. These schools are referred to as YDM-active schools. Analysis for both YDM-trained and YDM-active schools is presented below.

YDM-trained schools

Figure 5.1 reports on the mean gain from Year 3 to Year 5 in the numeracy domain for YDM schools and their similar schools. Figure 5.2 reports on mean gains from Year 5 to Year 7. Mean gains for all schools in Australia are also provided in Figures 5.1 and 5.2. Although the data taken from the My School website (green and blue columns) is not directly comparable to the data for all schools (orange column), it is provided as a reference and to indicate overall trends in the data, but not for direct comparisons. For further detail, refer to Appendix C.

The analysis shows that in every case the mean gain of YDM schools is larger than that of their similar schools. Converting the mean gains shown in Figures 5.1 and 5.2 to percentages, from Year 3 to Year 5, YDM schools outperformed their similar school counterparts by 13.69% in the period 2011–13; by 8.32% in the period 2012–14; and by 6.36% in the period 2013–15. From Year 5 to Year 7, YDM schools also outperformed their associated similar schools, by 36.16% in the period 2011–13, and by 14.26% in the period 2012–14.

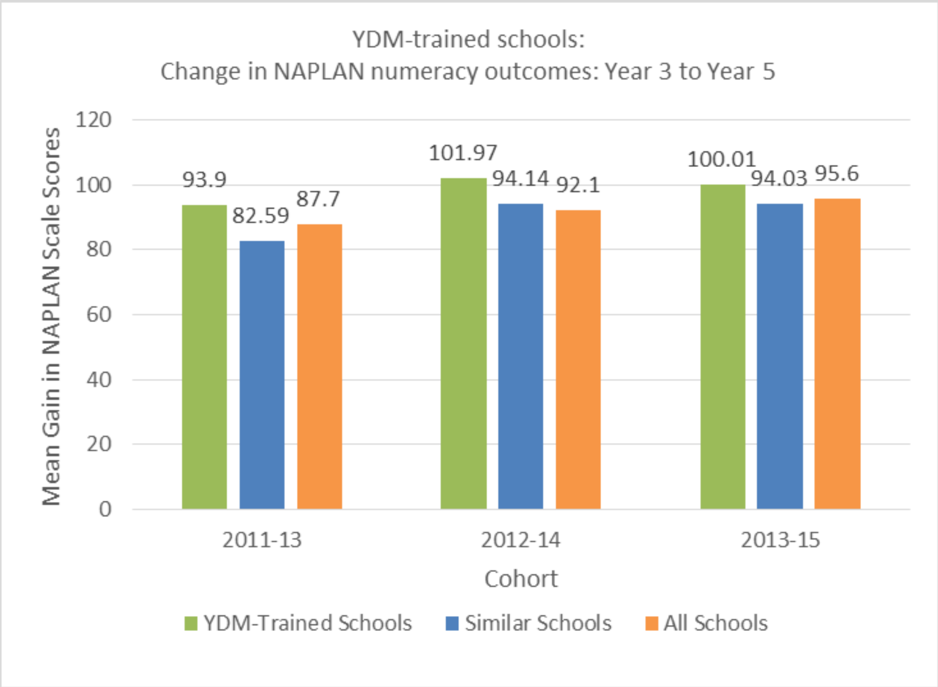


Figure 5.1 YDM-trained schools: Change in NAPLAN numeracy outcomes, Year 3 to Year 5

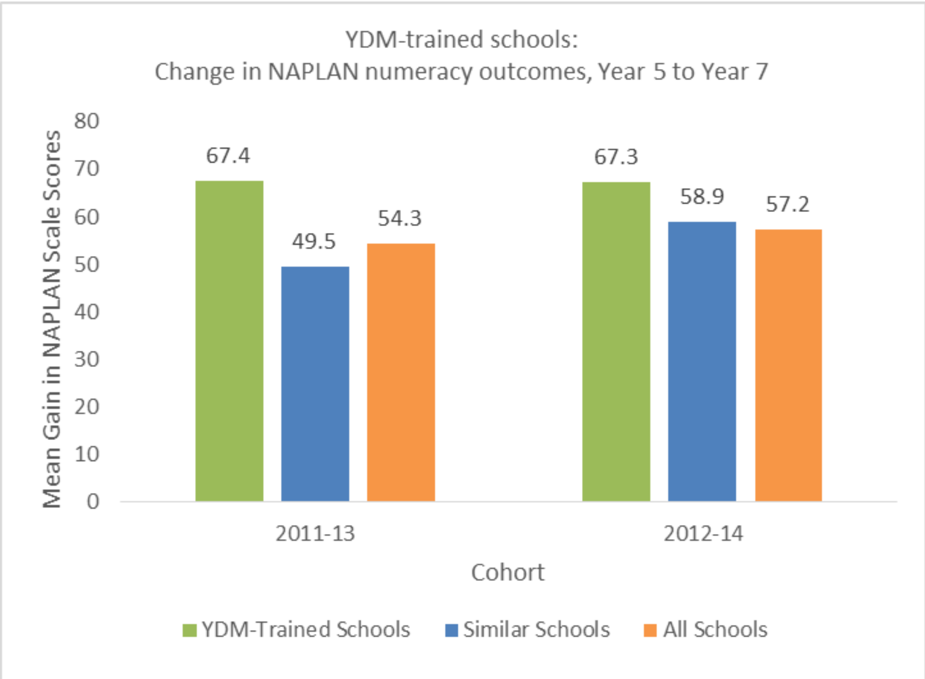


Figure 5.2 YDM-trained schools: Change in NAPLAN numeracy outcomes, Year 5 to Year 7

The data presented in Figure 5.1 and Figure 5.2 covers a relatively small number of schools, because only schools that completed YDM training were included. The analysis covers 10 schools in the 2011–2013 cohort, 17 schools in 2012–14, and 30 in 2013–15. Differences in achievement could be related to the slightly different focus of YDM training in each year:

- in 2010, YDM training focused on Preschool to Year 3 mathematics;
- in 2011 the training was extended to Years 4 to 7 mathematics, with some schools given the opportunity to repeat the Preschool to Year 3 training; and
- in 2012 the training focused on Years 7 to 9 mathematics, as well as providing some additional catch-up training in all year levels for selected schools and teachers.

The timing of the training is also reflected in NAPLAN numeracy results, with the gain of Years 3 to 5 students relative to students in similar schools showing a steady decline over time, reflecting the gradual loss of YDM-trained staff from schools as a result of teacher and principal retirements, transfers and so on. The marked improvement in mean gain in achievement amongst Year 5 to 7 students taught by YDM-trained teachers could be caused by one or more factors:

- older students may have more extended experience with YDM pedagogy over a number of years;
- the focus of YDM training on mathematics structure has more effect in the higher year levels;
- YDM requires a major change in mathematics pedagogy that takes time to have effect; and/or
- changing the way that mathematics structures are presented to students can take time, as students must have extended opportunities to accommodate new skills and knowledge into their existing mental schema (e.g., see Piaget, 1977).

It is also important to note that some schools included in the analysis may no longer be actively using the YDM program.

Since the data suggests that active engagement in the YDM program increases a school's average gain in NAPLAN numeracy, the inclusion of data from schools that are not active in YDM is likely to have caused an understatement of the mean gain of YDM schools. Nevertheless, to avoid the possibility of influencing the results by strategic selection of schools analysed, once included in this part of the analysis, schools were not removed. The following data is limited to those schools known to have continued to implement YDM methods.

YDM-active schools

To better judge the effect of YDM on student results, the analysis provided above has been repeated for those primary schools that were known to YDC staff as having successfully implemented YDM pedagogy across the school (called, for the purposes of this analysis, YDM-active schools). This included seven schools in 2011–13 and eight schools thereafter. If the analysis of all YDM-trained schools (above) represents baseline data for YDM effectiveness, then this analysis of the YDM successes represents the potential for improvement following the adoption of YDM methods in the recommended manner.

Figures 5.3 and 5.4 show that, in general, the results for the YDM-active schools followed the same patterns as for the YDM-trained schools. However, in most cohorts, the difference between the YDM-active schools and their similar schools was even more marked, with students in Years 5 to 7 attending YDM-active schools between 2012 and 2014 outperforming students in other schools with similar socio-economic status by more than 30%.

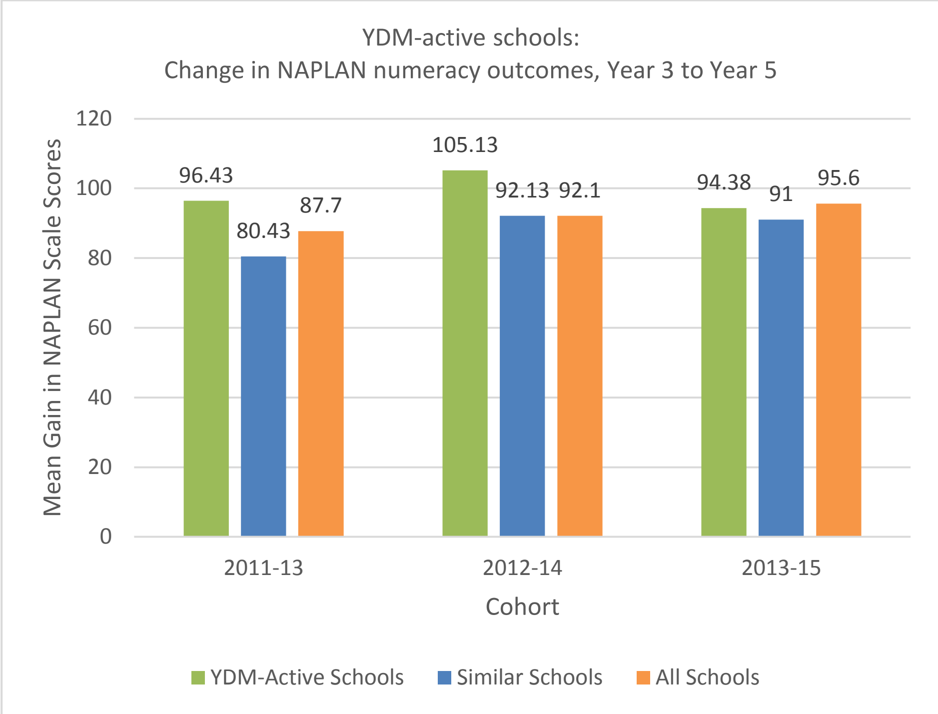


Figure 5.3 YDM-active schools: Change in NAPLAN numeracy outcomes, Year 3 to Year 5

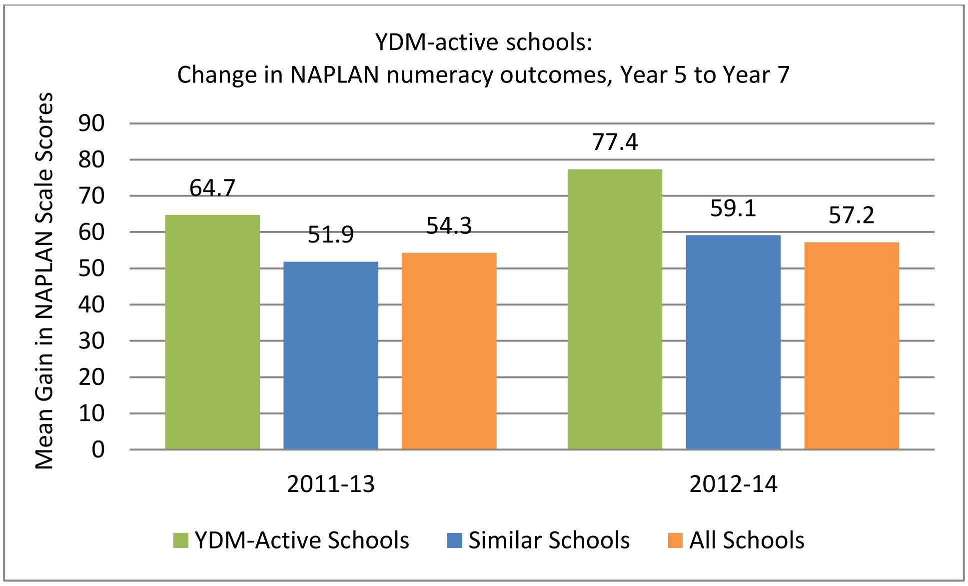


Figure 5.4 YDM-active schools: Change in NAPLAN numeracy outcomes, Year 5 to Year 7

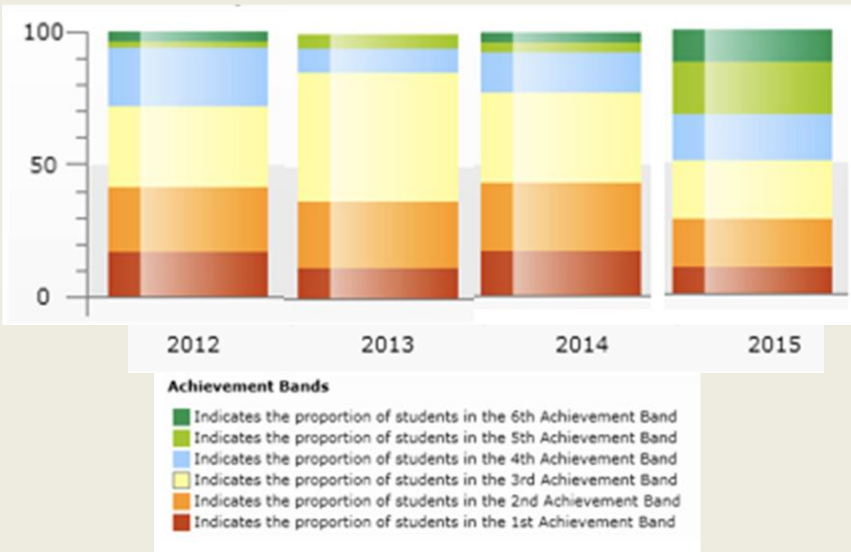
The following vignette is provided to illustrate the impact of YDM on student achievement in NAPLAN, where students have experienced a number of consecutive years of YDM learning.

NAPLAN achievement at a YDM-active school

A primary school situated in a below-average socio-economic metropolitan region has participated in YDM for a number of years. Approximately 20% of students identify as Indigenous, and a further 15% speak English as an additional language. According to My School, in 2012 (prior to YDM), Year 3 students achieved **significantly below** the national average in numeracy.

In 2015, the first cohort of students who had experienced YDM during Prep, Year 1, 2 and 3 sat NAPLAN. The school achieved above the average for similar schools for the first time (2015 was the first time the school's Year 3 numeracy data moved from below or significantly below the mean for similar schools.) The results also represented the school's first ever shift from significantly below to below the national average in Year 3 numeracy. Importantly, 2015 also represented the first time that 100% of Indigenous students achieved above the NMS. Looking at the spread of achievement across NAPLAN bands is also helpful in that not only are there far fewer students in the lower two bands of NAPLAN, but there are also substantially more students in the upper two bands.

NAPLAN Year 3 results by band (2012–15):



The Head of Curriculum explains the results: *"Our Upper 2 Band data… this year we have 91.9% of our kids reached NMS. So that is a blue flag for us. That is our first blue flag! And what we are even happier about is the 31.9% of our cohort sitting in the Upper 2 Bands. That is amazing. In the past we were very tiny in Upper 2 Bands. If we talk numbers-wise, we have averaged at about 8% in previous years. This year – 31.9%. So very close to the nation. That is our first ever flag in Upper 2 Bands! We are very happy and very proud of our littlies. They are now able to unpack a problem. We have had significant growth in the questions that required the children to work the answer out themselves. So, for example in one class, 18 out of 35 questions, the class scored higher than the nation, and only one or two in the other questions who didn't get it correct.*

In Year 5, we are also trending up. Our growth between 2012 and 2015 – we are now 85% NMS in numeracy. We have made gains of about 14%."

Vignette 5.1 NAPLAN results at a YDM-active school

5.1.2 Student achievement and learning – combined non-NAPLAN and NAPLAN measures

School-level data

Many schools have also reported increases in student achievement on non-NAPLAN measures. This includes increases in the number of students improving on both A to E reporting and other measures such as ACER's PAT-Maths series, Australian Academic Assessment Services Testing, as well as in-class pre- and post-testing. Further investigation into the results of schools with increases in non-NAPLAN measures demonstrates that there is often a flow-on effect in NAPLAN achievement. Many of these data sets are useful as formative assessment and inform teacher practice. Others are used as a summative tool for mapping progress and rewarding student success. For example, a Head of Curriculum at a low-socio economic primary school explains:

> *"We celebrate success with an annual academic growth parade, where we recognise those students…. So we use our PAT data from Term 3 last year to Term 3 this year, and we acknowledge all the students who receive an effect size of 1.0 or greater. We had 128 students who we acknowledged. Families came and it was an absolutely huge success. And these aren't the kids who get our As and Bs. These are – we have a lot of kids from our Special Ed program. We have the kids who continually struggle, but something has clicked with them, and they've shown that growth. And now they are being recognised, so that is something we will continue to celebrate."*

A Year 5 teacher at the same school said that:

> *"We are really excited to see that our kids have achieved on par with the national average levels around the nation. It is outstanding to see that blue crop up with our students. In the past we were hitting those red zones [below and significantly below the national mean]. We weren't hitting those standards that we'd like to see all of our kids achieve… [The improvement] all started about three years ago when we started to introduce YuMi and the RAMR cycle."*

For many students, the pre- and post-tests used in the YDM model have provided a source of encouragement and engagement. For example, a teacher at a regional primary school described:

> *"Our colleagues can really see the benefit of the short time data cycle. I mentioned earlier the powerful results from the pre- and the post-tests. And we are really seeing a lot of integrating of reality into all other KLAs… and ALL our staff are noticing a HUGE difference in student engagement, especially surrounding maths. And they are increasing in confidence a lot of the time as well. That is great to see."*

A Head of Department at a P–12 provincial college in a high socio-economic area said that:

> *"Here is a child who made a 933% gain in a test [comparing pre- and post-test gain scores]. That child was a low D or an E student. At the end of the test, they were right up there [at the top of the class]. They got it… those students who made growth… it meant that teachers were able to pull that out and say to parents, 'well yes your child may be a D. However – they have had a 30% or 40% or 100% growth in this topic, compared to what they knew at the beginning'. So it's been really worthwhile. And for the students – being able to say to students, 'look how much you have grown. Look what you have learned!' "*

Schools monitor increases in student learning and engagement in various ways. For example, some schools report that student attempts and working are important pieces of data that allow teachers to understand students' progress and understanding. Other ways that schools monitor their school success via YDM are through anecdotes and qualitative measures. For example, at one regional primary school, the principal reported that teachers maintain they can tell which students have come from a class with a YDM champion teaching the previous year, because "[students] have a deeper understanding of maths concepts". Another principal, this time at a regional primary school, explains:

> *"Students are empowered to have a range of strategies to find an answer. In the past when we have given students a working out paper, and we say, 'here is your working out paper, make sure you use it', then when we collect it back, it is blank. Whereas, this year, we've noticed they are coming back with a range of different strategies."*

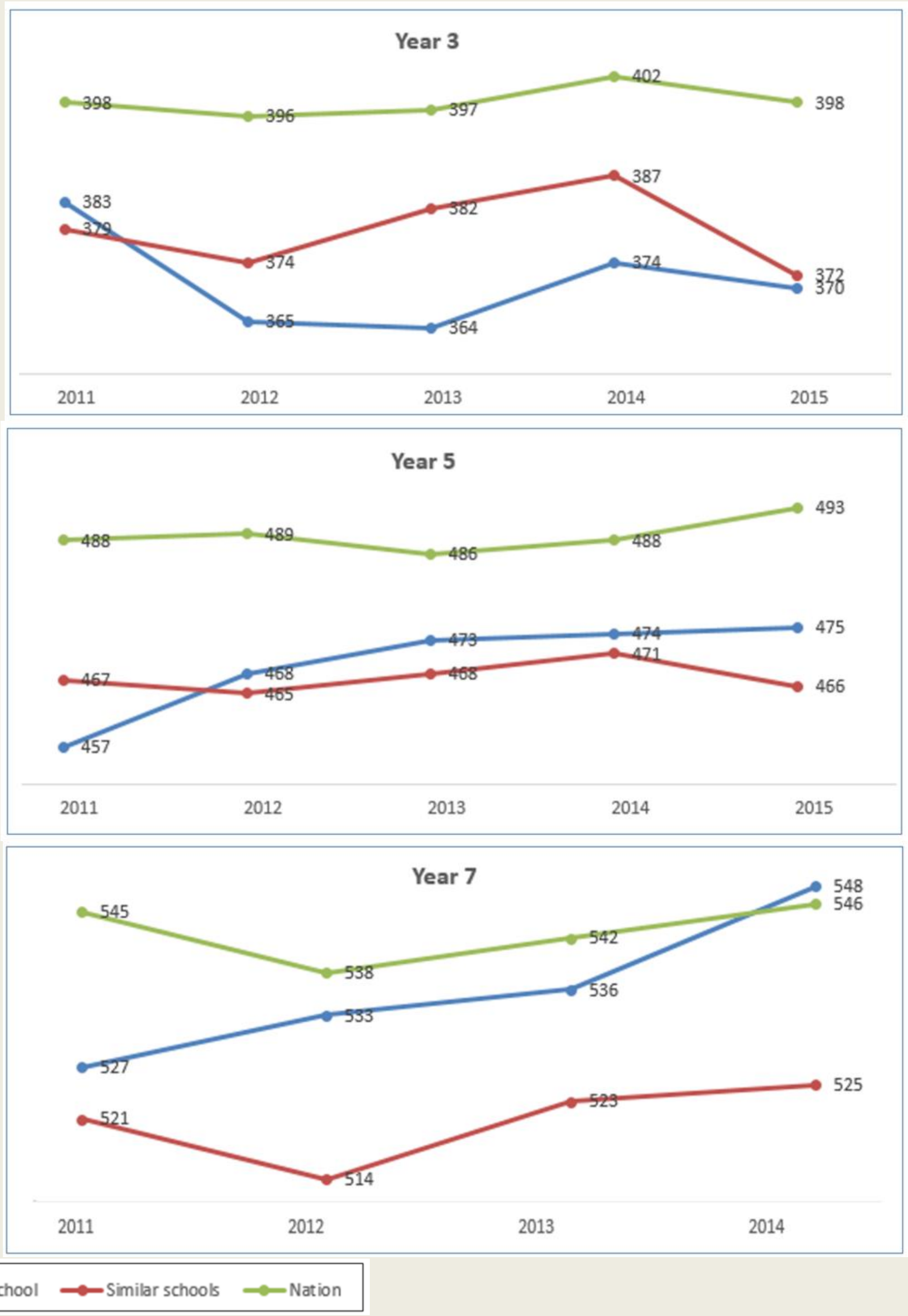
Because student learning takes time, growth is not always immediately reflected in NAPLAN data, particularly in complex schools. Factors such as student attendance, teacher turnover and student histories have a significant impact on learning and achievement on standardised measures. Unsurprisingly, schools state that a range of factors impact on student achievement. However, even when standardised achievement measures such as NAPLAN are less than hoped-for, schools have reported that student learning has been significant. Student attendance and engagement can also impact on how schools are able to record results on measures such as PAT-M, ICAS tests or in-class pre- and post-tests. A principal of a remote college explains NAPLAN results in 2015:

> *"For us, it is very challenging if you look at the data for this year, our Year 9 [NAPLAN numeracy] wasn't great. It just tells us we've got lots to do. But later I will share our individual student data that reinforces to me that what we are doing is important and is making a difference for our students. It's just a work in progress. It's not done.*
>
> *One of our teachers has a group of up to 10 students who have missed significant amounts of learning and often are working at Year 2 or Year 3 level in the secondary school. For her the key thing was the hands-on approach. The students hadn't engaged with paper-based learning for a long period of time. Once they did the hands-on it really made sense for them. [This teacher] has a number of students that might come into her classroom for a couple of weeks and then leave… often times she doesn't have full pre-test and post-test results, but she believes it is still meaningful for students because even if they are engaging for a short period of time, they are learning, and she is confident that is happening."*

For further detail about the impact of YDM on student engagement see section 5.3. What follows (Vignettes 5.2, 5.3 and 5.4) are reflections and data from three diverse YDM schools to exemplify the importance of measuring impact using multiple measures.

Snapshot of NAPLAN and non-NAPLAN achievement: Provincial primary school

A Master Teacher from a provincial primary school in Queensland reported in 2015 that *"YDM has improved our C standard maths results. That has been our focus… to improve the number of children reaching a C standard. So over the years of implementing YDM, our C standard has now reached the target of 80%."* (80% of students across the whole school now achieve C standard or above.) School NAPLAN data also indicates that the school has achieved a pattern of overall sustained improvement in the numeracy domain of NAPLAN. In 2015, Year 3 cohort results indicated a slight decline in achievement; however, it occurred at a rate significantly less than the overall decline of similar schools, and a similar rate to the national average.



Vignette 5.2 NAPLAN and non-NAPLAN achievement at a provincial primary school

Snapshot of NAPLAN and non-NAPLAN achievement: Metropolitan primary school in a low socio-economic area

The following data is drawn from a metropolitan primary school in a below average socio-economic area. According to the My School website, almost 60% of students are in the bottom quartile of socio-economic advantage. Approximately 20% of students identify as Indigenous and 25% of students speak English as an additional language.

The year 2015 represented the first cohort of students to have participated in four years of YDM (From Prep to Year 3) prior to NAPLAN (Year 3). This cohort experienced a 40-point increase in NAPLAN from 2014 to 2015. This was the first year that the school recorded achievement above the level of statistically similar schools in any domain in any year level. NAPLAN data is also provided in Vignette 5.1.

The Head of Curriculum reflected on student achievement in both NAPLAN and non-NAPLAN measures at the 2015 Sharing Summit. These included related increases in NAPLAN practice tests, the Early Childhood Developmental Assessment Tool, PAT-M, and pre- and post-test data.

"So from 2014–15 our national mean score jumped 40 points. We are closing the gap very quickly between our kids and the rest of the nation. So [the students in 2015 Year 3] have had four years of YDM… We have seen a significant increase in one year.

One of the classes, in the practice test, had an effect size of 1.27 in 10 weeks! So she had 10 kids who were in the bottom two bands [in the practice test]. By test time that was only two kids. So the teacher was able to shift nearly every kid in her class out of the bottom two bands into the middle two bands… This shows that we are now making strides with children connecting that.

That is huge, considering the nation is trending down. We are very proud of our little Grade 3s and the progress they've made. Our Grade 2s coming up are showing just as much progress.

Our Prep teachers have also just finished running Early Childhood Developmental Assessment Tool (CDATs) assessments, and it is completely green across the board except for counting backwards. Across the board, all the concepts are looking very good.

Pre- and post-test data is also super-impressive. We are very impressed with how the children are now not having to use the 'think board' anymore. They are able to do shorthand to solve problems. We aren't teaching test-wise skills. We aren't teaching them to say, 'here are four answers and get rid of the ones that are obviously wrong'. We are teaching them how to solve problems.

We are in the middle of PAT-M testing, and our Year 2 data again shows we've got 33% of kids in those upper three stanines of PAT testing. ***We say this is all down to how we teach mathematics.***

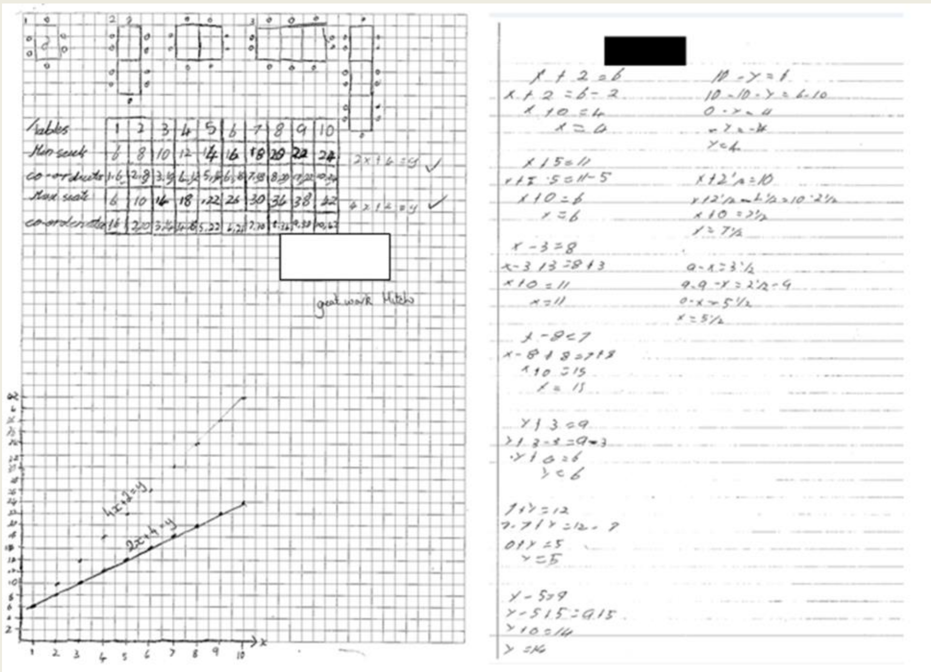
There is no difference between our boys and girls. In fact, this year we had 100% of our Indigenous students reach NMS in Years 3 and 5. That is 30 kids. And our mean scale score is above the national average in both Year 3 and Year 5. It is actually 33 points above the state in Grade 5."

Vignette 5.3 NAPLAN and non-NAPLAN achievement data at a metropolitan primary school

From non-attempts to algebra:
Increasing student achievement at a metropolitan secondary school

The following vignette is drawn from a metropolitan secondary school located in a below average (although not significantly so) area.

According to her teacher, at the start of the year, Year 8 student Mary (pseudonym) was *"uncommunicative and withdrawn in class and reluctant to participate, hardly putting pen to paper".* After participating in YDM, her teachers noted a dramatic change in her responses on written tasks, which had been single number responses and blank responses at the start of the year. The works sample below was provided by Mary's teachers to demonstrate her ability to recognise patterns both visually and in tabulated data; describe mathematical symbols; graph linear relationships, and so on. Her teacher described her level of understanding (and that of her peer group) as "*generally much higher than expected of students in high school foundation/remediation courses".*



According to her teacher, *"it is the first time students see themselves as participating in 'proper' high school maths on par with peers. [They] have gained confidence to attempt mathematical tasks that may at first appear difficult. The confidence comes from achieving success, and for some students… [YDM] has allowed them to be successful in mathematics class for the first time in their school history. Some students still have significant gaps in their mathematical knowledge… but it is the success and confidence gained in the initial stage [of YDM] that will provide the foundation for continued growth."*

All students in Mary's class achieved above the national mean in Year 9 NAPLAN (2014).

This individual student data is corroborated with the school's overall NAPLAN data, which has shifted from below national mean (in 2013) to at national mean (in 2015). The percentage of students in the bottom two bands of NAPLAN (Year 9 Numeracy) has decreased from 38% of students in 2013 to 23% in 2014 and 18% in 2015.

Vignette 5.4 Student achievement at a metropolitan secondary school

Student beliefs about their own mathematics learning

In addition to student achievement measured on the assessment instruments described above, and teachers' accounts, there is also evidence from students themselves that they believe they have experienced rapid and deep learning in mathematics. A number of schools have included videos of interviews with students about YDM, in which students discuss their learning. Across a wide range (e.g., geographically, socially and structurally) of schools, students have described vast and rapid improvements in their understanding of mathematical concepts. The following vignette is drawn from student reflections in a P–12 college located in a high socio-economic metropolitan area.

Student reflections on understanding mathematics after engaging in YDM at a high socio-economic P–12 metropolitan college

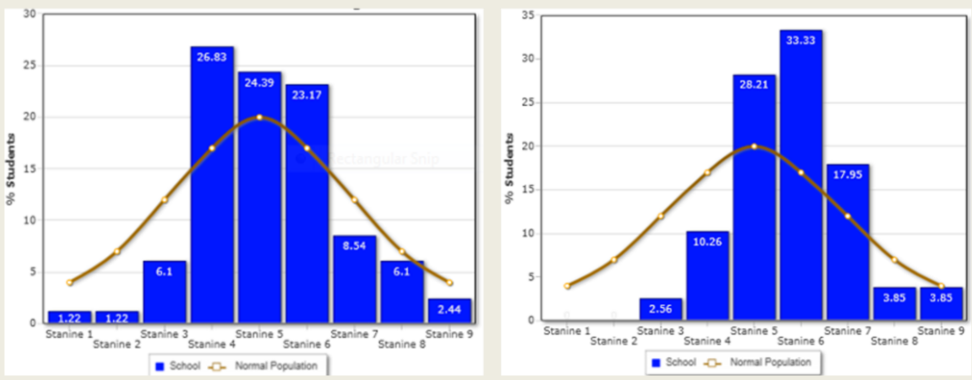
Year 4 students at a large P–12 college in a high socio-economic area were asked to reflect on their learning in comparison to maths understanding in previous years.

- *Well two years ago we were using textbooks, and watching clips about the textbooks. They never taught you how to do the strategies, or what to do. You would just sit down and write in the textbook. And so most people just flipped to the answers…*
- *I didn't like the textbook. It was boring. And you didn't remember the answers… I like now because we have fun and we do hands-on maths. We even do it with our friends. We write it in books and do more practical activities.*
- *Well this maths and my results I have found a lot better because the textbooks we used to use had all the answers, so you didn't really need to understand what you were doing, or what you should do. I didn't really understand it. So… therefore… when we are doing more hands-on, I find that I'm more able to understand.*
- *Now that I'm in Grade 4 and we have gotten rid of textbooks, it is so much easier to learn. It is so much easier to understand. When we had textbooks, we would just do the questions. And if you didn't know a question, you might ask the teacher. And the teacher would basically just show you the answer. You didn't understand it properly. I really like it now because the teachers actually talk to you and explain how to do it. And they do activities – fun activities – that really help. It isn't just good for me, but for all the other people in my class. Especially the people who have troubles.*
- *I never, ever, ever feel bored [with maths] now, but when we were just doing the textbooks it was very, very boring.* ***I basically never knew anything in maths (giggles) until recently when I've been learning this way…*** *I didn't even know what a decimal was until this year. So, now I really like all the mixed fractions and improper fractions and how they all work together… and a decimal is… well we use the power of ten. And I never knew that we used the power of ten! … decimals are really fun to work with….*

Student achievement data collected by the school corroborates students' beliefs about their growth in understanding. Pre- and post-test data shows significant improvements across Year 4. Data from Australian Academic Assessment Services Testing also demonstrates a significant improvement between 2014 (non-YDM teaching in Year 4) and 2015 (YDM teaching in Year 4).

Year 4 achievement on Australian Academic Assessment Services Testing

2014 | 2015



Vignette 5.5 Student achievement and student beliefs about their own mathematics learning at a metropolitan P–12 college

5.1.3 Student achievement – acceleration of learning for students significantly underperforming in mathematics

A 2012 OECD report echoed a longstanding literature indicating not only that significant numbers of students do not master basic skills, but that commonly used remediation practices such as grouping students by ability risk entrenching disadvantage (OECD, 2012). Teese and Polesel (2003) have described that a “cognitive architecture” exists in Australian secondary schools in which students begin to move into different pathways in primary school, via practices such as streaming, subject selection and timetabling. Rather than closing the gap between students, Teese and Polesel’s analysis indicates that these practices serve to increase inequities. Australia’s results on the 2015 round of PISA testing (Thomson, DeBortoli, & Underwood, 2016) demonstrate that the average mathematical literacy of Australian students has declined since 2003, but also that the percentage of low-performing students increased from 16% in 2003 to 24% in 2015. One of YDC’s most significant projects that was designed specifically to accelerate the mathematical achievement of students whose performance was up to five years below their peers at the commencement of early secondary school was the Accelerated Indigenous Mathematics (AIM) project. Analysis of the project is provided below.

Overview of Accelerated Indigenous/Inclusive Mathematics

YDM’s Accelerated Indigenous Mathematics and subsequently Accelerated Inclusive Mathematics (AIM) project was developed across 2010 to 2013, as a four-year longitudinal mixed-method study using design-experiment and action-research case studies to investigate the mathematics teaching and learning of underachieving Years 8, 9 and 10 Aboriginal and Torres Strait Islander students in Queensland. The students had mathematics achievement levels at or below Year 3 in their first year of high school (which at that time in Queensland was Year 8). The project worked to accelerate students’ mathematical understandings so they could access a range of mathematics options (in terms of subject selection) in the senior years of school.

The project used an acceleration framework that structured learning across the junior secondary years, while mathematics is compulsory, to teach content from the Australian Curriculum: Mathematics for Years 2–9 over three years (originally Years 8–10 in Queensland, now Years 7–9). For further detail on the pedagogical approach used in the AIM project, refer to the AIM Final (Evaluation) Report (QUT YuMi Deadly Centre, 2014).

Nine schools participated in the program from 2010 to 2013, with an additional three commencing in 2010 but withdrawing before completion of the project (for various reasons). Approximately 200 Indigenous students participated. As would be expected, the uptake of the project varied across each of the schools depending on factors such as leader and teacher support of the project, teacher turnover and background (e.g., participation of staff teaching out-of-field), and student attendance.

Accelerated learning at a remote secondary college, with individual student case study: NAPLAN achievement pre and post YDM AIM

John (pseudonym) is an Indigenous student who enrolled at a remote secondary school as a Year 8 student. In 2009, he was approximately three bands below the national average on Year 7 NAPLAN (numeracy). By Year 9, after four terms of YDM AIM, John was one-and-a-half bands below the national average. John's achievement (along with other similar cases) was presented by the school at the 2013 YDC Sharing Summit.

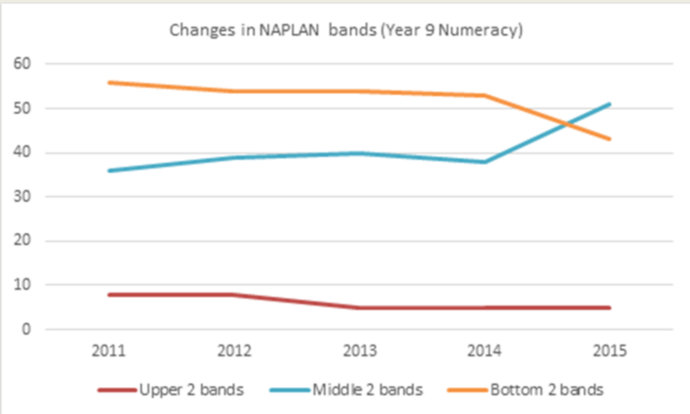
Year	Year level	Student scale score	Numeracy national mean	Student band	National average band
2009	7	408	544	Mid band 4	Mid band 7
2011	9	508	583	Mid band 6	Low band 8

According to the principal, *"the real success for us is that John chose to do Maths A in Year 11, and we are pretty excited that he got a B for his mid-semester and an A for his end of Semester 1 Maths A report card. So we are pretty chuffed about that!"*

Following is an excerpt of an interview conducted by the school principal with John when he was in Year 10:

Principal: *You said that other schools should think about doing Deadly Maths. Can you tell me why?*
John: *Because not all students in the school are intelligent with numbers. So if you are a lower student, you can still pick up on it. You can move up in maths.*
Principal: *Do you think it has helped you to improve your maths results?*
John: *Yes. Like, I got a C− last the term before and last term I got a B+ (John smiles).*
Principal: *That's fantastic! Are you proud of that?*
John: *Very proud.*
Principal: *What are you aiming for this term?*
John: *A+!*

John's improvements in tests are reflected in the college's student achievement data. Below is the school NAPLAN band data for Year 9 numeracy, which indicates that in 2015, the school had significantly fewer students in the bottom two bands of NAPLAN, and more students in the middle two bands (compared with 2014).



Vignette 5.6 Individual student and school NAPLAN achievement at a YDM-active school

Average student achievement and improvement on pre- and post-tests by year

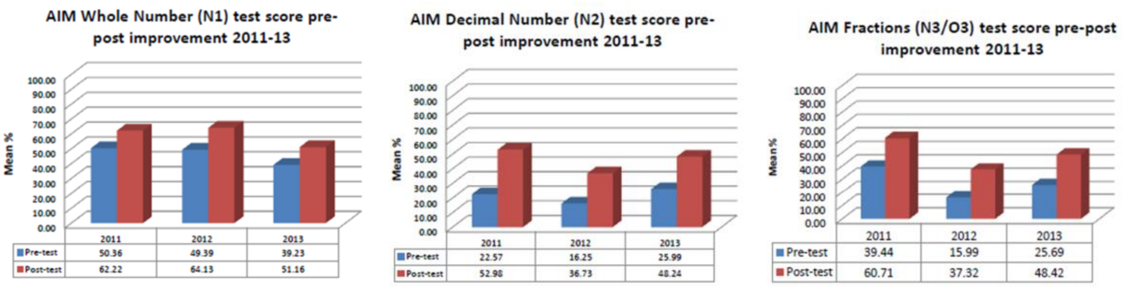
Trend data from participating schools indicates that implementing AIM has had a significant impact on student learning. The graphs (Figures 5.5 to 5.8) in this section average pre- and post-test results across cohorts of students for the years 2011 to 2013. A class was included as part of a cohort for a module if it had at least four students complete both pre-test and post-test. The average for a module covers students who could have done that module in Year 8, Year 9 or Year 10 (since the three levels did the same modules). The graphs demonstrate that nearly all students improved their achievement on tests after the modules had been taught. The level of improvement increased as teachers and students had more experience with AIM. Improvement in achievement was most marked in tests for decimal numbers (N2), fractions (N3/O3), measurement (particularly M2), geometry (G1 and G3), algebra (A1 and A2) and the first statistics and probability module (SP1).

Although only three classes completed all modules across the three years, analysis of pre- and post-test results for these students showed that:

- all cohorts improved their understanding of mathematics, that is, the average student achievement improved for all the modules in the post-test compared to the pre-test marks; and
- the extent of the improvements over time differed depending on the module, which was to be expected as the modules and the tests were continually refined as a result of feedback, and teachers reported difficulties with administering tests and encouraging students to do their best in completing them.

Figures 5.5 to 5.8 provide pre- and post-test data along with analysis to explain the variations in improvement across modules.

Aggregated pre- and post-test data (AIM schools): Number

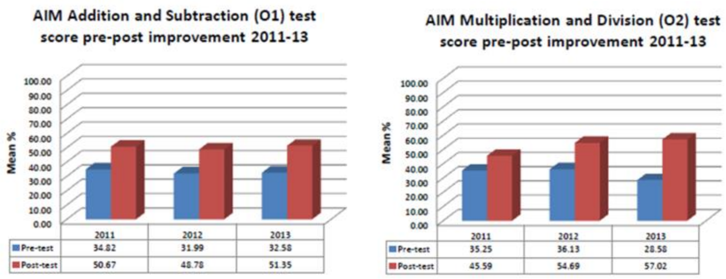


Whole Numbers, Decimal Numbers and Common Fractions (N1, N2, N3)

Improvements in N2 and N3 in each of the three years were more marked than improvement in N1. The first two Number modules are always the first two AIM modules attempted and, as such, they are always the modules on which teachers learn how to use the AIM pedagogy and students learn the expectation of operating in an active environment. There has been little change to the modules and tests since 2011. Although N1 shows more modest improvement, teacher and student experience in N1 seems to underpin improvement in N2 and N3.

Figure 5.5 Aggregated pre- and post-test data (AIM schools): Number

Aggregated pre- and post-test data (AIM schools): Operations

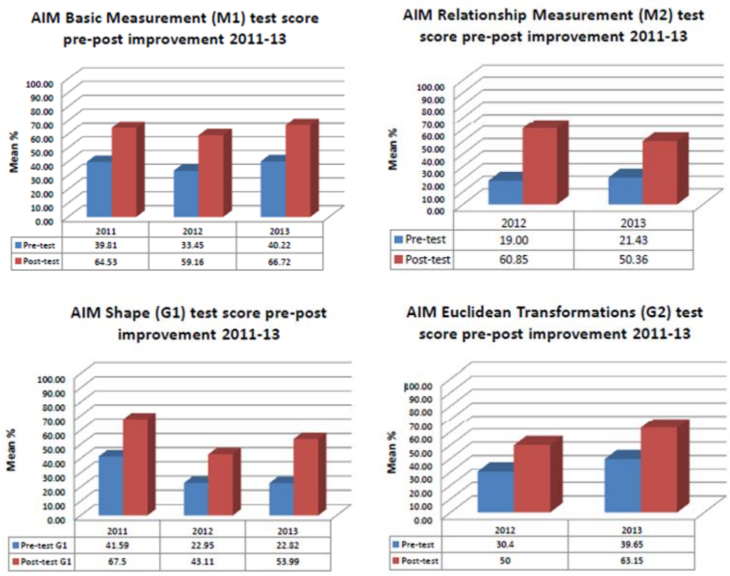


Addition and Subtraction (O1), Multiplication and Division (O2), and Arithmetic and Algebra Principles (O4)

The improvement in O2 across the years (29.3% in 2011, 51.4% in 2012 and 99.5% in 2013) and, to a lesser extent, O1 (45.5% in 2011, 52.5% in 2012 and 57.6% in 2013) demonstrates a positive result indicating sustained student learning. In early iterations, O1 and O2 were very complex modules covering topics and content that was new to many teachers and students. Principles and estimation were subsequently moved from O1 and O2 to a new module, O4 Arithmetic and Algebra Principles, in Year C. Nevertheless all modules still contained much complex and/or new material. The changes with the Operations modules drove the 2012 and 2013 refinements with modules and scope and sequence that resulted in improved teacher confidence in using all the modules. Regardless of ongoing modifications, pre- and post-test data indicates ongoing student learning. Greater differences in O1 between 2011 and 2013 indicate that modifications in response to teacher feedback have provided for increased positive impacts on student learning.

Figure 5.6 Aggregated pre- and post-test data (AIM schools): Operations

Aggregated pre- and post-test data (AIM schools): Measurement and Geometry

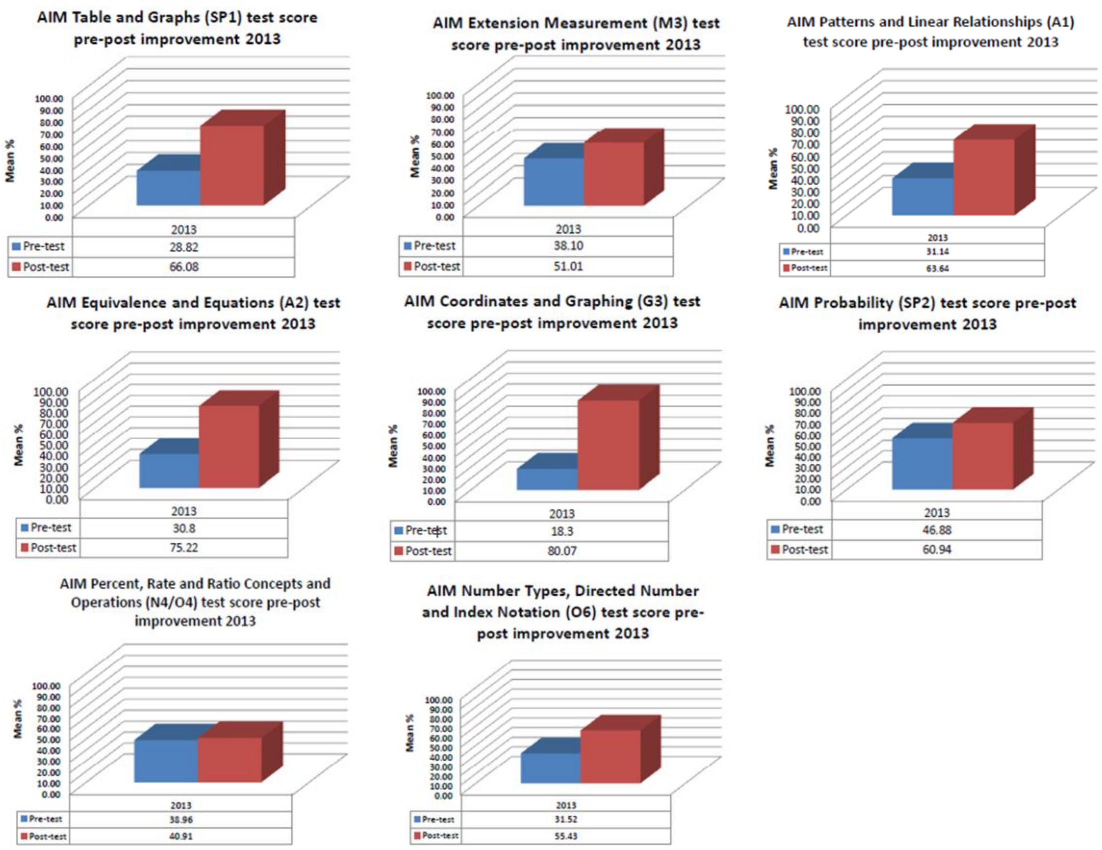


Measurement (M1 and M2) and Geometry (G1 and G2)

Student improvement in performance in these modules has been consistent across the years, with particularly strong improvement in M2 in both 2012 and 2013. This is important given that these modules have changed little in content or pedagogy, and have consistently been supported by teachers.

Figure 5.7 Aggregated pre- and post-test data (AIM schools): Measurement and Geometry

Aggregated pre- and post-test data (AIM schools): Other modules



Other modules

For a number of modules, such as Tables and Graphs (SP1); Extension Measurement (M3); Patterns and Linear Relationships (A1, recoded A2); Equivalence and Equations (A2, recoded A1); Coordinates and Graphing (G3); Percent, Rate and Ratio Concepts and Operations (N4/O4, recoded and renamed as N4 Percent, Rate and Ratio); Number Types, Directed Number and Index Notation (O6, recoded and renamed N5 Directed Number, Indices and Systems); and Probability (SP2), improvements in student test scores cannot be seen over a two-year or three-year period as data is not available. With the exception of N4/O4, where there were modest improvements, there were marked improvement in test scores for the post-test compared to the pre-test scores in all modules.

Figure 5.8 Aggregated pre- and post-test data (AIM schools): Other modules

As can be seen from Figures 5.5 to 5.8 above, data gathered from pre- and post-tests showed overall improvement in student learning across various topics such as whole numbers, decimal numbers, operations and measurement. As would be expected, the extent of improvement varied across schools and classes, and was influenced by a range of other factors such as teacher turnover and student attendance. For example, in two boarding schools where there was stability in attendance, students in the 2010 cohort had made significant improvements in achievement, achieving beyond early expectations for Year 11 mathematics by 2013. In one school, many students were able to participate in higher level school mathematics courses during the senior years of schooling (e.g., see Vignette 5.6). By re-engaging students prior to senior subject selection, YDM (in particular AIM) acts as an emancipatory project in that it provides students with the opportunity to escape the “cognitive architecture” (Teese & Polesel, 2003) of schooling in which timetabling and subject selection becomes a virtual form of streaming. By opening up opportunities to select subjects such as Maths A, B and C, YDM makes a significant difference in the long-term educational and life-course trajectories of students.

The impact of YDM on accelerating student learning:
Excerpts from interviews with teachers participating in AIM

The following excerpts are from interviews conducted with three teachers who had participated in four terms of AIM YDM:

"I find that this module [first year of participation, Term 2] specifically helps these children that have had so many gaps in their learning. It's very obvious whenever they do come in at the beginning of the year. I've been in the Year 8 groups now for a good number of years, … I think it's 6 years I've been with the Year 8s. This has always been a problem. Children, some have had some schooling, some have had very little primary schooling. So all those basic bits of information that they ought to have learnt in primary they don't have and they can't go on with the work, with what work they should be doing in Year 8. This unit is actually going a long way towards bridging that gap between those that have prepared in primary and those that haven't."

"I think it's been brilliant actually. I mean, this goes for last term as well. The modules, the activities, actually uncovered a lot of issues, uncovered a lot of problems that perhaps may not have been evident if we were just working on something else. Going back to the basics has uncovered all those little basic steps. There's a lot of little gaps and I think, that's, for me, that's what it's been brilliant for, uncovering, exposing those gaps."

"Well yes the modules are absolutely effective, it's giving these students an opportunity to go back and redo some basic concepts of maths which I think a lot of these kids have got big gaps in their mathematics and every time we do an activity, do anything hands on, they seem to understand the concept, they get the concept, they're understanding it and I'm finding as the teacher, it's been very beneficial."

Vignette 5.7 Teacher comments describing the impact of YDM on accelerating student learning in mathematics

Student growth in working and thinking mathematically

Figure 5.9 (below) details the outcomes of a teacher survey carried out over a 9-month period as part of the AIM project. The purpose of the survey was to gauge the teachers' perception of student growth in thinking and working mathematically. The survey used a 5-point Likert scale, and was conducted at the beginning (February) and end (September) of 2012. All AIM schools participated in this survey.

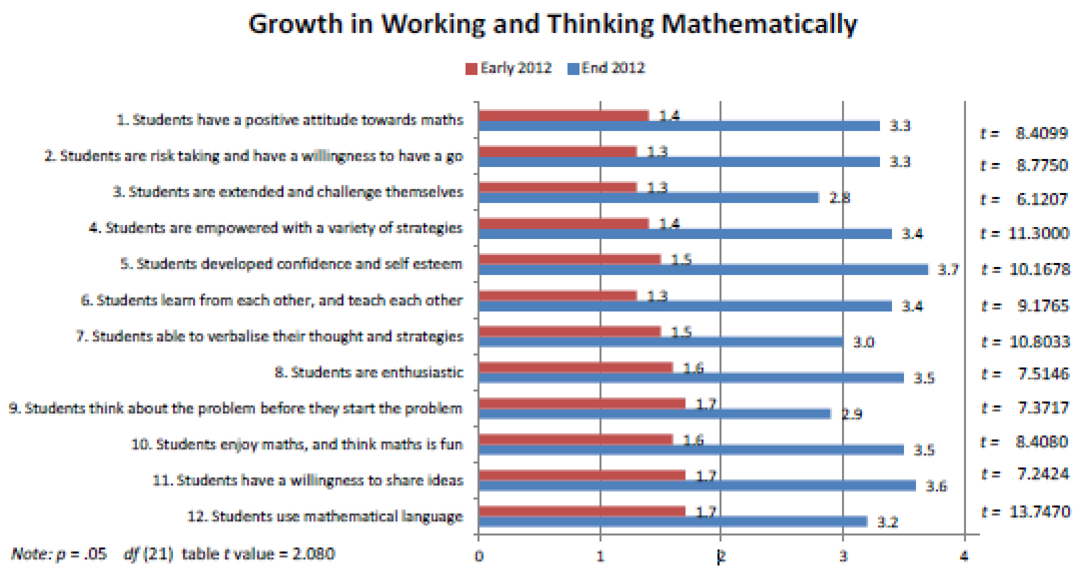


Figure 5.9 Student growth in working and thinking mathematically

The survey data reveals teachers' strong perception of growth in students' mathematics abilities across all 12 points (average across the 12 growth points surveyed rose from 1.5 out of 5.0 in February 2012 to 3.3 out of 5.0 in September 2012). Areas of growth included:

- Students developed confidence and self-esteem (1.5 --> 3.7; growth of 2.2 points);
- Students teach/learn from each other (1.3 --> 3.4; growth of 2.1 points);
- Students are empowered with a variety of strategies (1.4 --> 3.4; growth of 2.0 points);
- Students are risk-taking and have a willingness to have a go (1.3 --> 3.3; growth of 2.0 points);
- Students have a positive attitude towards maths (1.4 --> 3.3; growth of 1.9 points);
- Students are enthusiastic (1.6 --> 3.5; growth of 1.9 points);
- Students enjoy maths and think maths is fun (1.6 --> 3.5; growth of 1.9 points); and
- Students have a willingness to share ideas (1.7 --> 3.6; growth of 1.9 points).

Areas that had improved, but could be further enhanced included:

- Students think about the problem before they start the task (1.7 --> 2.9; growth of 1.2 points);
- Students are extended and challenge themselves (1.3 --> 2.8; growth of 1.5 points);
- Students are able to verbalise their thoughts and strategies (1.5 --> 3.0; growth of 1.5 points); and
- Students use mathematical language (1.7 --> 3.2; growth of 1.5 points).

The survey results indicate that teachers believed that students who have traditionally had low expectations in their mathematics ability and perhaps shied away from actively participating in classroom discussions and interactions were gaining confidence, and were willing to attempt problem-solving. The importance of developing confidence, increasing student risk-taking and building mathematical understanding and language have all long been recognised in academic literature as essential for student success (e.g., Clifford, 1988; Frigo et al., 2003; Meyer & Turner, 2002; Sullivan, 2011).

5.2 Closing inequities and catering for special needs

5.2.1 Closing the gap: Indigenous and non-Indigenous student results

Despite significant investment in closing the education gap between Indigenous and non-Indigenous students over many decades, the 2015 round of PISA (Thomson, DeBortoli, & Underwood, 2016) has demonstrated that Indigenous students achieved significantly lower scores than non-Indigenous students in scientific, reading and mathematical literacy domains. The 2015 PISA data indicates that Indigenous students are approximately two and a third years of schooling behind their non-Indigenous peers (p. 54); and that Indigenous students achieved "significantly lower in mathematical literacy than the OECD average (by 63 points), while non-Indigenous students performed significantly higher than the OECD average (by 17 points)" (p. 54) in mathematical literacy.

One of the most significant impacts of YDM (in particular the AIM project) is the convergence of Indigenous student results with non-Indigenous students. For example, 2012 pre- and post-test results for Indigenous and non-Indigenous students in the AIM project demonstrated a closing of the achievement gap between non-Indigenous and Indigenous students across all modules. Figure 5.10 and Figure 5.11 provide examples of this convergence in measurement and geometry modules.

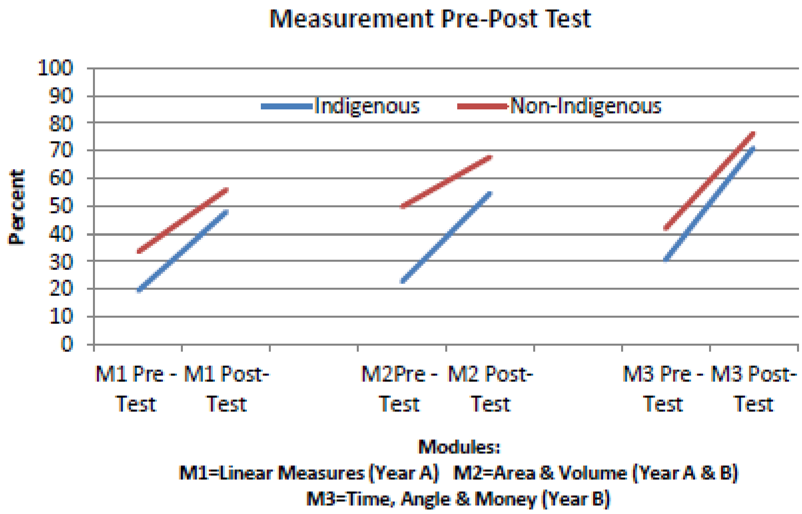


Figure 5.10 AIM non-Indigenous and Indigenous student achievement in Measurement

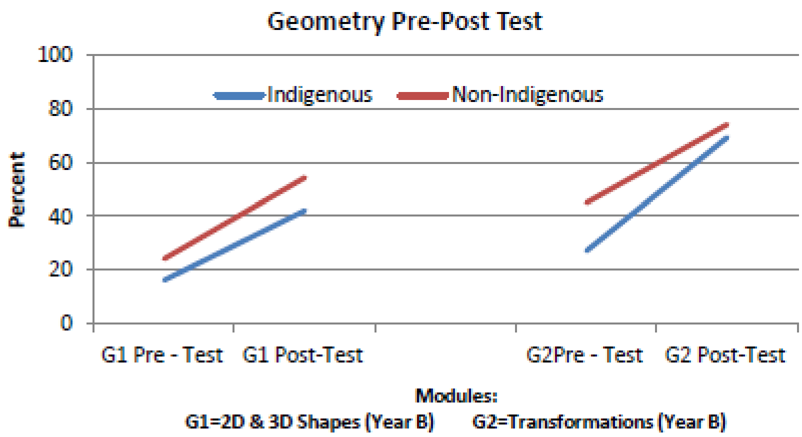


Figure 5.11 AIM non-Indigenous and Indigenous student achievement in Geometry

The following vignette includes an interview with an Aboriginal student conducted by a school principal of a remote college. The principal's reflections on the interview are also included to demonstrate the effect of increasing student achievement on Indigenous students, their families and teachers.

Accelerated learning in a remote community:
Interview with an Aboriginal secondary school student

This vignette begins with a reflection from the school principal:

"If ever there was a child who had every reason to be disengaged and angry in education, Dorothy's (pseudonym) history and background gives her every reason to be cranky. But she's not. She is the most lovely young lady. She is a mother. She is absolutely positive and 100% committed to wanting to get the best education that she can.

People who work with Indigenous students will understand. Dorothy and Karen are best mates. They are very quiet students… when I was talking to them in the playground knowing that I was going to [present at the YDC Sharing Summit], I said, 'girls, I want to talk to someone about what you are doing in class. Are you ok with that?' They said, 'oh shame, miss! Deadly shame!' … Anyway, come the day I wanted to do the video I grabbed Dorothy, and she was fine. I recorded a couple of snippets. One of the things she said to me, when I asked her if she was proud of it, she said, 'yes, and Miss Julie is too!' Miss Julie is her carer. So... the goosebumps that you get.

Then the next day, she brings Karen down, because Karen wasn't at school the day I recorded Dorothy. 'Miss, she wants to do it too!' Knowing those students – that tells me how much they value the program; how proud they are of what they've done. I said to them, 'I'm going to talk to all these important people in Brisbane, and I want to talk to them and show them what you're doing.' So, it didn't matter how deadly shame it might be, they were really proud of what they have done."

Principal: *Dorothy, what's great about Deadly Maths?*
Dorothy: *It's good. It's fun. You get to do maths mentals.*
Principal: *How are you going with your maths mentals?*
Dorothy: *Oh, good.*
Principal: *Good? Why is that?*
Dorothy: *Because I practise it at home.*
Principal: *Fantastic! How are your results going?*
Dorothy: *Good…*
Principal: *Better than they used to be?*
Dorothy: *Oh yeah.*
Principal: *Tell me about your teacher.*
Dorothy: *Oh, she is awesome!*
Principal: *What makes her awesome?*
Dorothy: *She helps us. If we are stuck she helps us.*
Principal: *And that makes you happy to go to that class?*
Dorothy: *Yep!*

Vignette 5.8 Excerpt from an interview with an Aboriginal student in a remote secondary college

5.2.2 Closing the gap: Socio-economic disadvantage

It is worth noting that many of the schools that participate in YDM are situated in socio-economically disadvantaged areas. A large proportion of data presented above that details improvement in student achievement is drawn from low socio-economic schools. YDM data from low-socio economic schools indicates that for many schools, enacting YDM pedagogies has enabled schools to reach benchmarks such as the national mean on NAPLAN.

A Head of Curriculum at a low socio-economic school (ICSEA ≈ 900) in a metropolitan area explains:

> *"This is the exciting part. 2014 was a very special year at our school. Like quite a few schools in our low socio-economic area, we don't often achieve levels [in NAPLAN] that are similar to that of the nation. This year we had our first blue [which indicates similar to the national mean]. Our first – ever – blue. In any strand. In any strand, over any year. We are very, very, very excited. This was our first year that went through YDM. They were our first year that went through Prep as well. So our whole school has ownership over that success."*

To celebrate their success, the school held a "blue day", where teachers and students came to school dressed in blue in honour of having achieved "blue" for the first time ever.

Similarly, a secondary school principal in a provincial city where many students attend prestigious private schools described that her school was residualised, in that it serves many families living in poverty (approximately 50% of students are located in the bottom quartile of socio-economic advantage according to My School) as well as large numbers of refugee students. The school has managed to increase the number of students achieving the NMS. The principal explained:

> *"In 2012, 82% of students achieved NMS…. 2016 was the first year that students in Year 9 had done YDM in Years 8 and 9. Only eight students did not meet NMS, but all were EALD: two attempted the test and the other six were exempt. Students who have lived in Australia for less than 12 months are exempt, which means you are allocated a score that is automatically below the minimum standard. Although these scores are not included in the school mean, they are included in the NMS score. When these eight students are excluded from school data, 100% of students achieved NMS in 2016."*

5.2.3 Catering for students with special needs

Learning support

An additional use of YDM has been to provide learning support for students with special needs. For example, the AIM project included three schools that used an adjusted form of YDM as learning support for students with very low performance in the early years of secondary schooling. At one of these schools, the 2010 Year 8 cohort of 16 students with very low performance were provided additional YDM teaching in Year 8 and half of Year 9. At the end of Year 8, only three remained in the lowest level class. By the end of Year 10, 14 of the 16 students had chosen Mathematics A in Year 11 (not Prevocational Mathematics). According to their teacher, the AIM materials had enabled the students to become confident and resilient and have a good understanding of mathematics. This became known to other secondary schools and two other secondary schools subsequently approached YDC asking for the same program for their schools.

Special schools

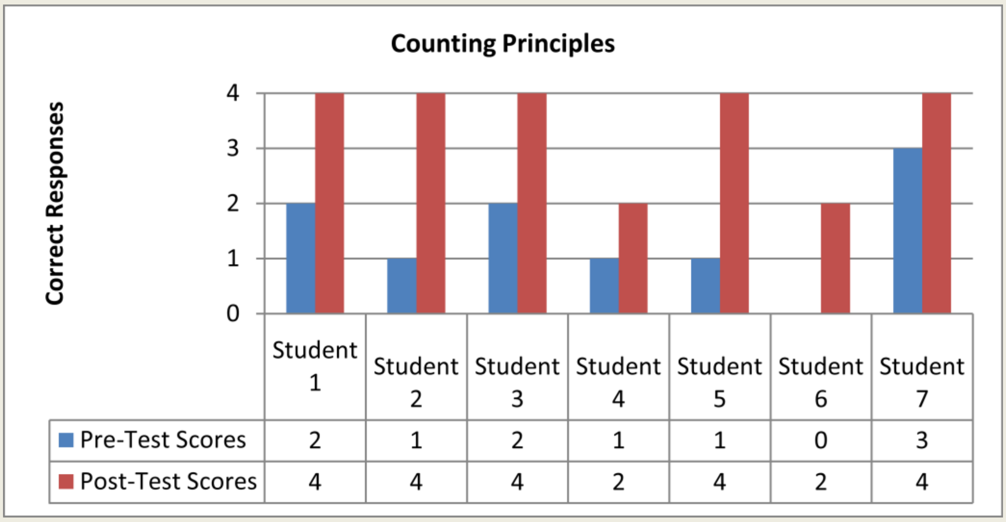
Sixteen special schools have participated, or are currently participating, in YDM projects, with staff from YDC working to adjust the program for these schools by recognising the needs of individual students and centres (for example, by creating new materials that recognise students' tactile and visual needs). A significant issue for any special school or program is the complexity of measuring impact using the assessments and tools that are typically applied in mainstream schools. For this reason, the following vignette from a special school indicates the impact of the program by drawing on a range of qualitative data (e.g., teacher presentations and reflective journals; reflections by YDC staff working with special school teachers and students). Although demonstrating impact using quantitative student achievement data is not possible, it is still possible to evaluate a range of impacts at special schools on students' learning in key areas, most significantly mathematics-related life skills.

YDM at a metropolitan special school (P–12)

There are currently 37 students enrolled in the senior secondary school. Students are generally able to access the Australian Curriculum from the General Capabilities to a Year 2 level.

According to both teachers and YDC practitioners, while mathematics was taught prior to the school becoming involved in YDM, it was often up to the individual teacher. YDC practitioners described that many lessons they observed followed a pattern of students' rote learning; for example, teachers would show an image of a mathematical symbol or algorithm on an electronic whiteboard, and students would duplicate or record it by copying it into a book or tablet while seated at their desks. These tasks sometimes required a significant cognitive load as students worked to refocus their attention between the screen and their individual work (e.g., a worksheet on their desk). Most significantly, the teaching was primarily unrelated to students' everyday realities and lives.

In 2014, when the school began YDM training, staff reported feeling energised and began to plan using the RAMR framework, by aligning it to the General Capabilities embedded in the Australian Curriculum. Teachers began to find ways to link students' learning to their lived realities, for example by teaching counting during meal times and play times. The following graph demonstrates the growth in understanding of counting principles for secondary students in one classroom.



Teachers also reported that, *"with increased engagement for our students, we are seeing fewer problem behaviours during our maths rotation!!"*

The school has continued to embed YDM, and continues to report that students are gaining essential knowledge, connections and life skills that will be important throughout their lives. For example at the 2015 Sharing Summit, the school presented a session on teaching measurement and time in which students were able to demonstrate their knowledge via assessment activities such as creating and using a personalised calendar. According to the school, YDM is now a pivotal part of planning and is strongly related to the school strategic plan.

Vignette 5.9 Impact of YDM at a special school

5.3 Student engagement

5.3.1 Student engagement with mathematics learning

> *"The kids' attitude towards maths has changed. They **want** to see me coming now whereas they used to run the other way when they would see me coming! Now they say, 'Are you coming to our class to do fun maths?' "*
>
> *– Numeracy Coach at a low socio-economic metropolitan primary school*

A significant body of literature demonstrates the importance of student engagement in mathematics education (e.g., Goldin, 2014; Skilling, 2013; Skilling, Bobis, & Martin, 2015). This is especially important for "low-achieving students [who] are particularly at risk in so far as their inappropriate motivation may inhibit their learning opportunities" (Sullivan, 2011, p. 55). Sullivan (2011) describes that "effective [mathematics] teaching … is dependent on presenting to students important and engaging tasks for which they make their own decisions on solving strategies, rather than following procedures" (p. 64). Similarly, ACARA (2009) has argued that "the personal and community advantages of successful mathematics learning can only be realised through successful participation and engagement" (p. 9).

Teachers across the range of YDM projects have described significant improvements in student engagement in their own classrooms. For example, during the first year of the PRIME Futures program, which commenced in late 2015, questionnaires were conducted to ascertain teachers' perceptions of both student outcomes and engagement. Figure 5.12 depicts responses from 73 out of 113 teachers from 25 out of 29 schools (teacher response rate ~65%) in four geographical clusters of schools. After approximately six months of participation, more than 80% of respondents perceived increased student engagement and 63% improved student learning/understanding. Also, some teachers already reported better test results (19.2%) and more interest in STEM subjects/pathways/careers (8.2%). An increase in the percentages of the latter two areas is expected as the program unfolds because these changes are likely to take more time to occur. This, for example, has become evident for the first two school clusters which are one year into the program, and for which a second survey has been conducted (see Figure 5.13). Out of 33 teacher respondents, 30.3% reported better test results and 21.2% an increase in interest in STEM subjects/pathways/ careers. In the most recent survey, only 3% of respondents of the first two school clusters reported that they "had not yet tried the YDM approach" compared to 6.9% in the first survey. Teachers' perceptions of increased student engagement rose to 90.9% and perceptions of improved learning/understanding to 72.7%. This data indicates that there has been an incremental improvement in teacher perceptions of student engagement, motivation and learning over time.

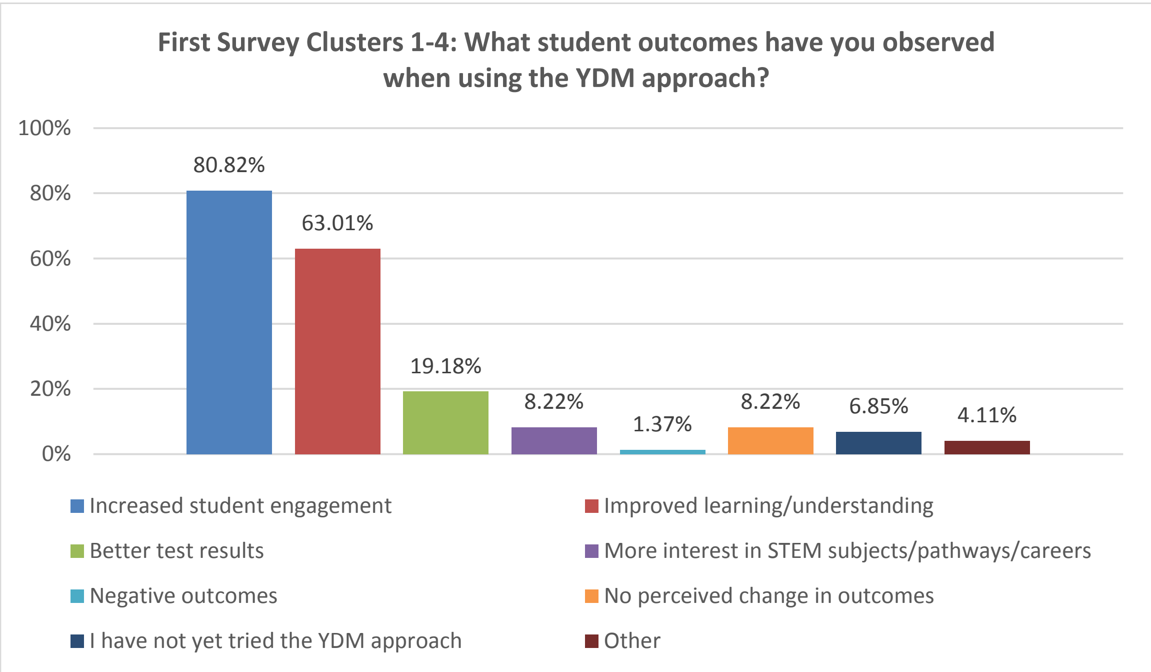


Figure 5.12 PRIME Futures Clusters 1–4 Teacher Opinions Questionnaire 1: Student outcomes

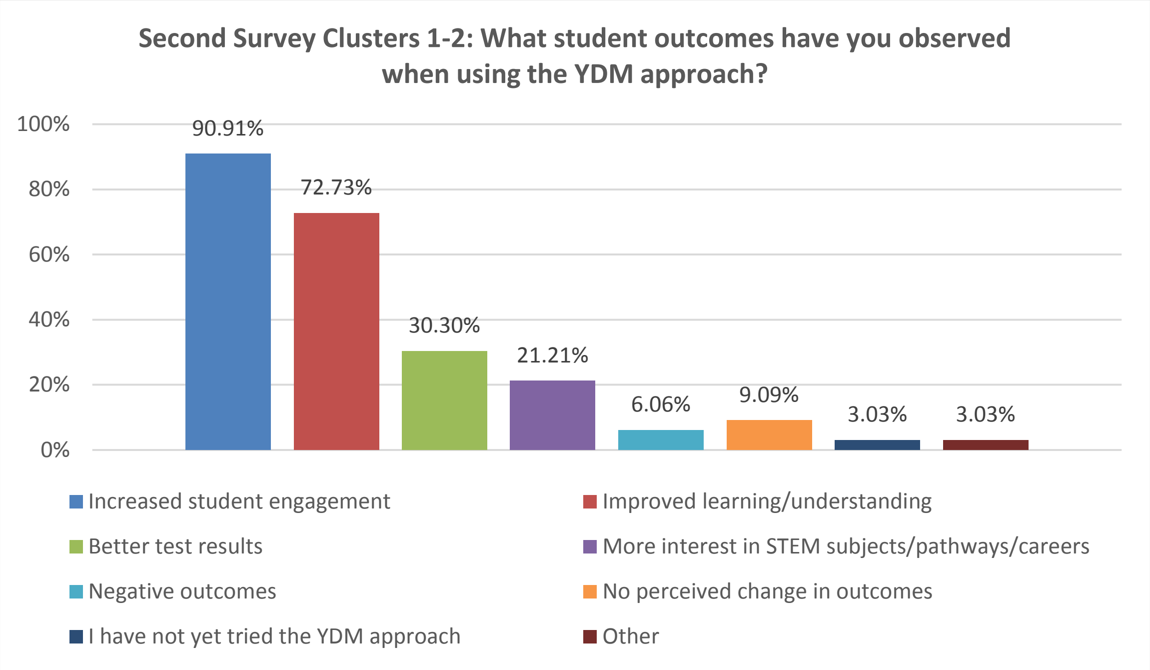
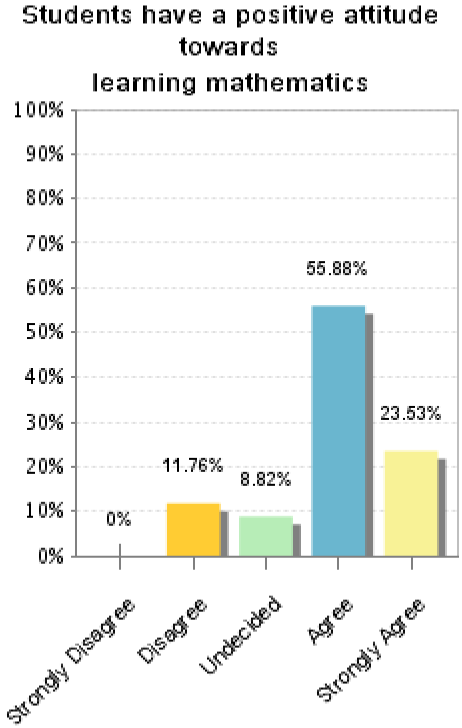
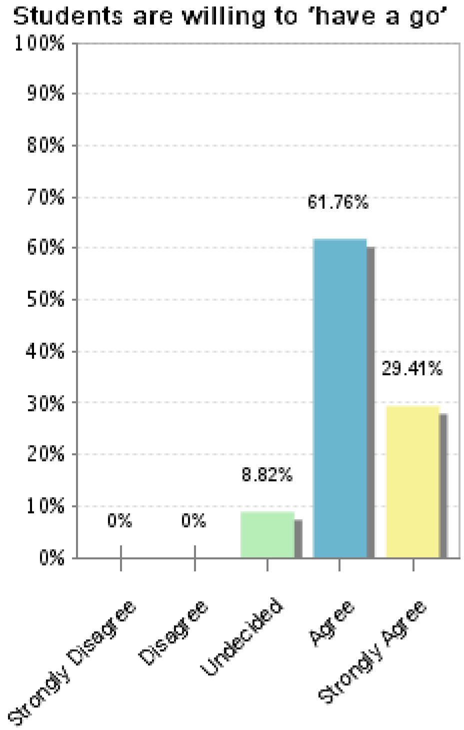
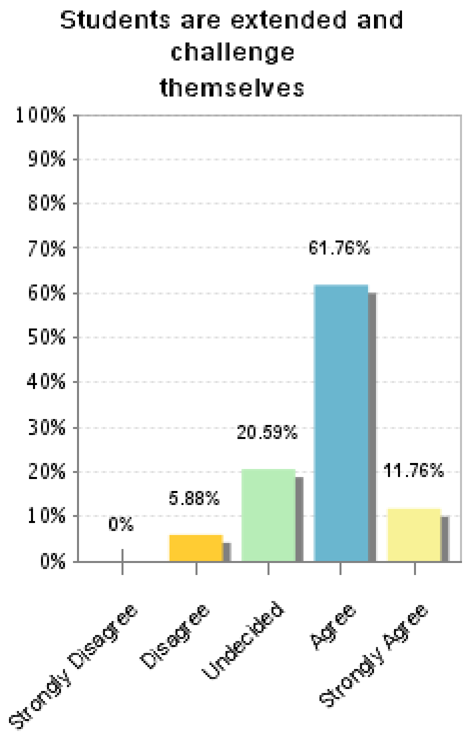


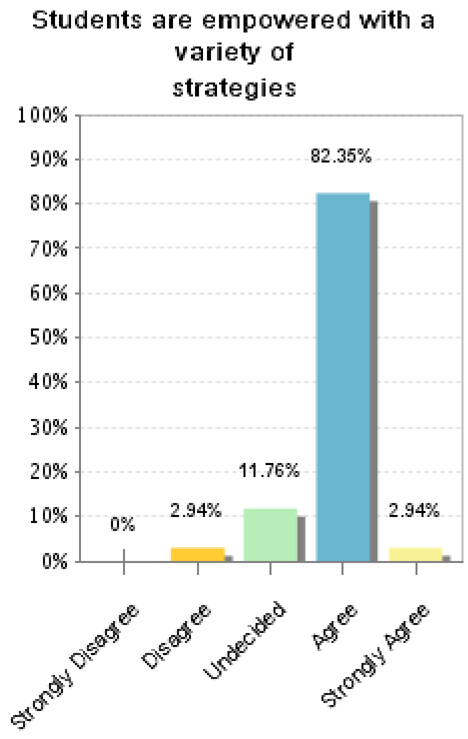
Figure 5.13 PRIME Futures Clusters 1–2 Teacher Opinions Questionnaire 2: Student outcomes

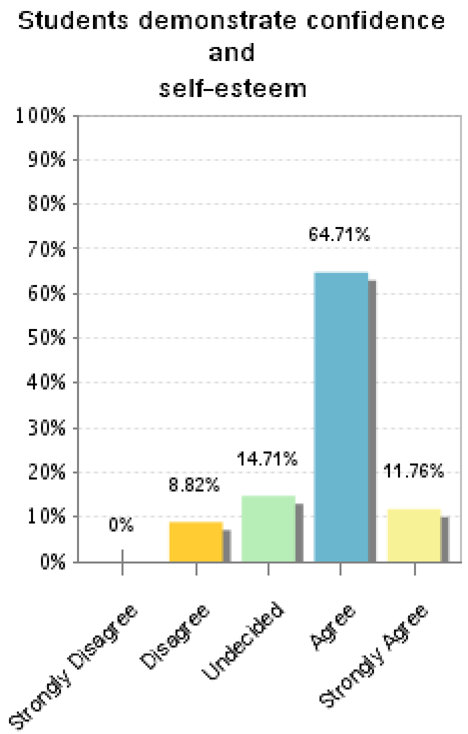
Another indicator of increased student engagement is that between 73.5% and 91.2% of Cluster 1 and 2 teachers agreed or strongly agreed with the following statements after about one year of YDM implementation:

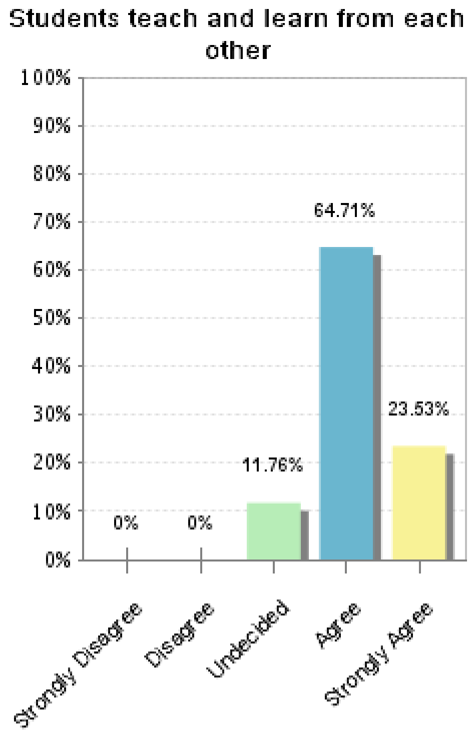





Students are extended and challenge themselves
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0%
5.88%
20.59%
61.76%
11.76%
Strongly Disagree
Disagree
Undecided
Agree
Strongly Agree


Students are empowered with a variety of strategies
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0%
2.94%
11.76%
82.35%
2.94%
Strongly Disagree
Disagree
Undecided
Agree
Strongly Agree


Students demonstrate confidence and self-esteem
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0%
8.82%
14.71%
64.71%
11.76%
Strongly Disagree
Disagree
Undecided
Agree
Strongly Agree


Students teach and learn from each other
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0%
0%
11.76%
64.71%
23.53%
Strongly Disagree
Disagree
Undecided
Agree
Strongly Agree

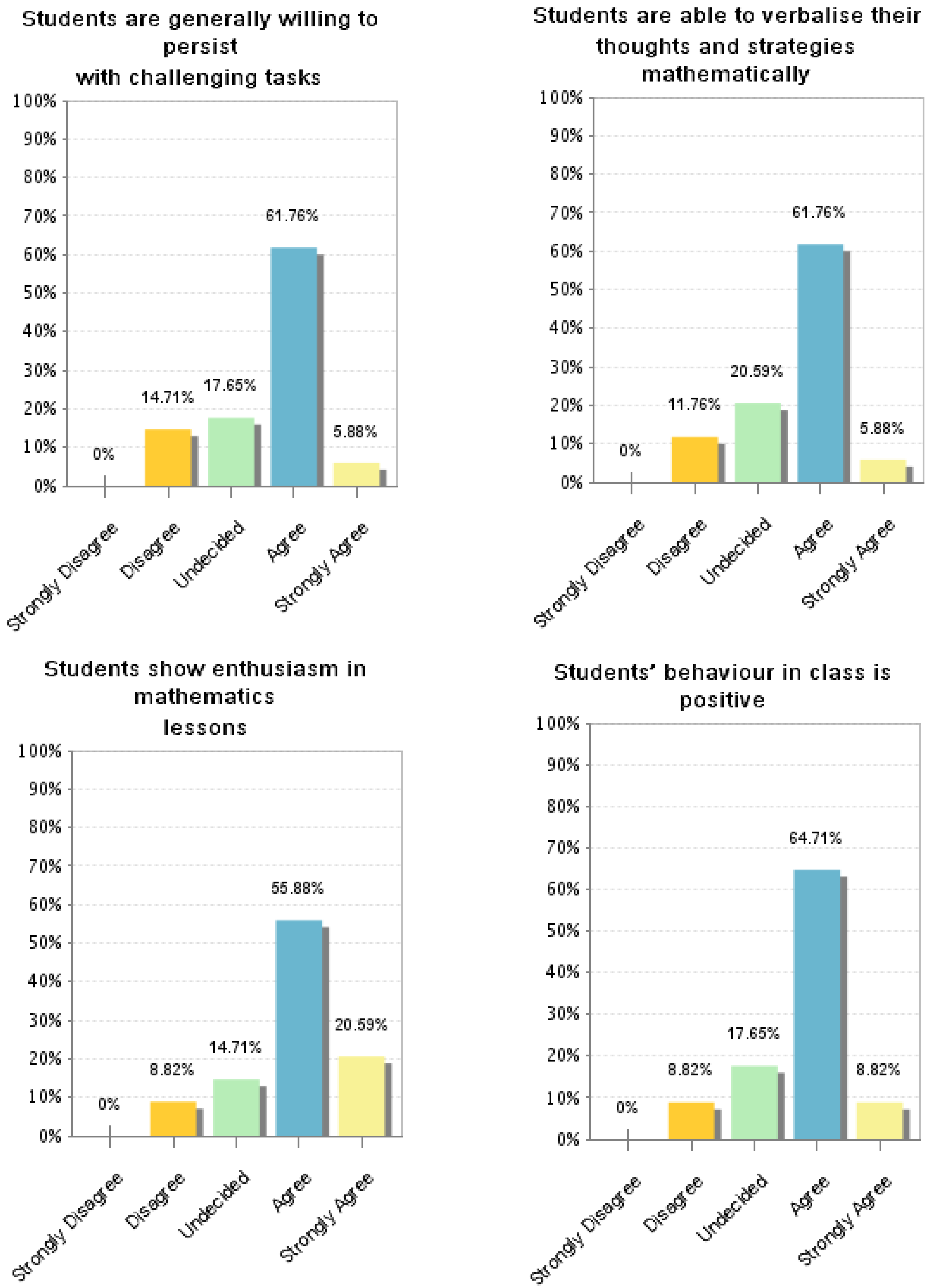


Figure 5.14 PRIME Futures Clusters 1–2 Teacher Opinions Questionnaire 2: Student engagement

Further evidence for improved student engagement in other projects, collected through observations of teachers and students conducted by YDC staff, has been corroborated with data collected in teacher reflective journals and at annual YDC Sharing Summit presentations. A cross-section of comments has been compiled in Table 5.1 below.

Table 5.1 *Teacher beliefs about student engagement*

<table>
<tr><th>Year</th><th>Year level</th><th>Excerpts of comments from teacher reflective journals</th></tr>
<tr><td>2012</td><td>1</td><td>“I have been experimenting by writing a Year 1 lesson on Money following the RAMR framework. I have been amazed at the amount of information the children knew about money – information which would never have come out if I hadn’t exposed the kids to RAMR. The children have been thoroughly engaged in every way and as I gave the kids a pre- and post-test I can actually see what they have learnt. It has been so exciting!”</td></tr>
<tr><td>2016</td><td>2</td><td>“Students are very keen to learn when it comes to YuMi maths. They love the engaging lessons and activities. They also love it because the lessons make sense to them with the links to reality and by ‘doing’ the maths they experience more success.”</td></tr>
<tr><td>2016</td><td>5</td><td>Student engagement has increased. Student comments include:
“I thought it was better because we got to go outside to do work.”
“I found the story about Descartes and the flies on the wall really interesting when learning about Cartesian planes.”
“The activities on the board with negative numbers really helped.”</td></tr>
<tr><td>2016</td><td>5</td><td>Student comments include:
“We do maths by going outside and play maths games to visualise what we are trying to work out. Maths is a lot different now and more exciting and I feel that it is really helping me improve in my maths.”
“I do my maths on my laptop and in my book, I understand maths better now. I look everywhere and link it to different things, I use myself in maths sometimes. I really like maths and I like doing it. Maths is really fun at school.”</td></tr>
<tr><td>2014</td><td>Secondary</td><td>“[Kids respond] amazingly ... to get these kids now to have ‘maths in your hands’, to be able to see it and do it, and to see how it actually affects us and the kids in everyday life, you walk into school to the tuckshop there’s maths. You got to work out how much money you got and how much you want to spend.

Just to be able to physically do it (maths) with the kids is so much better than simply ‘You spent this much, and how much did you get back?’ One activity was to take them to the tuckshop. They bought their lunch and they actually got to see their lunch, and see the changing of money, and say ‘Wow, easy!’ The light-bulb would go on in their head. And we would come back and do a worksheet and it’s done in 2 minutes, instead of a whole lesson.”</td></tr>
</table>

Vignette 5.10 on the following page describes increased student engagement at a remote secondary school.

Increased student engagement at a remote secondary school

A senior secondary teacher describes the effect on student engagement for his students:

"When we used to have foundation maths, kids felt shamed. I think if I was in a foundation maths class I would feel pretty shamed as well. Now that it is Deadly Maths, the shame factor is decreasing. Another indication of that is that kids are ticking that on their subject selection form. And I think that has got something to do with our school culture about Deadly Maths as well. Confidence is something that you can't really [measure] and say 'here's the data to show that they are more confident now'. But being in the classroom with them each day, you can see how their confidence is picking up.

Here's just a little story. The other day, we were throwing out hundreds of old textbooks. And I got my Deadly Maths class and finished 15 minutes early, and I got them to help carry them all down to the skip. When they came back there were four textbooks sitting outside. I said to one of the boys, 'what do you think about these four?' He said, 'Oh, no sir, I was wondering if us four [students] could take them home. We want to see what maths we are doing next year.'

If you knew the kids that wanted to take these textbooks home, there is ***no way*** *at the start of the year, they would have ever asked for such a thing. They had no confidence with maths. And now they are actually looking forward to next year."*

Vignette 5.10 Increased student engagement at a remote secondary school

Similarly, students in a regional primary school described the significant impact on student engagement and achievement of the whole class, in an interview with their school principal (Vignette 5.11 on the following pages).

Such comments from students, as well as those in Vignettes 5.5, 5.8 and 5.10, corroborate teachers' comments (such as those in Table 5.1) that student engagement increases dramatically when YDM is implemented. The data indicates the following:

- Students are more engaged by hands-on activities that are related to their everyday lives (for example, sport) than they were in their previous experiences of maths.
- Students experience mathematics lessons as easier, yet more fun. They report that increased understanding has a flow-on effect to further engagement with mathematics.
- Increased student results (on pre- and post-tests, A to E reporting, etc.) are also a motivating factor for many students.
- Students report feeling more confident in maths, which may be associated with teacher observations that students are more likely to take risks, for example, attempting mathematics and contributing to class discussions (see section 5.1.2 above, section 5.3.2 below, and Figure 5.9).
- Students report being able to apply their knowledge to their everyday lives (for example making purchases).

Increased student engagement at a regional primary school

Two Year 5 students, Charlie and Brooke (pseudonyms), discuss YDM with their school principal: (Full interview is available at Appendix D).

Charlie:	*Everybody contributes with their ideas*
Brooke:	*… No-one just sits and mucks around at their desk*
Charlie:	*Yeah. Everyone has a turn. We get to do it every day during maths. It's lots of fun, and people all get to have a turn. Not just one person.*
Brooke:	*Yeah*
Principal:	*Is that a big change from the way you used to do maths before?*
Both:	*Yeah.*
Principal:	*How is it different?*
Charlie:	*When maths was just on the board, we would just copy it down and write an answer. Whereas when we are outside we all get involved, and it is like a game but its learning at the same time. It's fun…*
Brooke:	*It's not like people are just getting bored and fiddling at their desk…. And lots of the boys don't concentrate….*
Charlie:	*Yes! Most of the boys don't really contribute or anything. But now they are.*
Principal:	*Does it make any difference to what you have learned about maths?*
Both:	*Yeah!*
Brooke:	*I have learned a lot more things.*
Principal:	*Do you see maths in other places now? Before, you were saying that you were doing a lot of writing…*
Both:	*Yeah.*
Brooke:	*So our teacher is going to teach us maths now and we know how it connects to the "out world"… to the outside.*
Charlie:	*Our teacher has been helping us with chance and patterns and stuff. That is going to help us with the things we need to survive in the real world.*
Brooke:	*And it also helps us for tests because we can get higher marks. Because also our results are getting higher. Definitely.*
Principal:	*Have they? For you both?*
Both:	*Yeah.*
Charlie:	*And for the whole class as well. Most people have improved. Since the start of the year. At the start of the year no-one really… well everyone hated maths. But now… with YuMi Deadly Maths, it's just… awesome… it's fun… it's energetic! It's like games and learning!*
Brooke:	*And now people are getting As and Bs!*

Year 4 students were also asked to compare their experiences learning YDM with maths lessons in previous years (continued next page):

Vignette 5.11 Increased student engagement at a regional primary school

Increased student engagement at a regional primary school (continued)

Year 4 students compare YDM with previous maths lessons:

- *I understand maths more now. I find it pretty fun – I like doing maths now because it can be fun.*
- *I do maths on my computer, in my book, outside and everywhere… maths is way easier and much more fun than it was 2 or 3 years ago. My teacher makes maths awesomely fun by letting us get involved in maths and get included in maths games and experiments. Maths gets a lot harder throughout the year but it gets better and more fun throughout the years of school.*
- *We do maths by going outside and play maths games to visualize what we are trying to work out. Maths is a lot different now and more exciting and I feel that it is really helping me to improve in my maths*
- *I think doing maths is really fun now, especially number lines and the giant grid mat you always use. The mat really shows what we're doing and what you're trying to explain. I also love doing chance games. I also loved how you did the coordinates last term for gold digging.*
- *I do maths now in a different way to what I learned in Prep. Now I am confident in doing maths because it is more interesting, fun and I learn while doing it. I do maths outside like digging for gold which connected to our history. I do maths on my computer by doing tables and graphs on word and excel and I do maths in my books with graphs, times tables, addition strategies and much more. I love YuMi maths because it has helped me learn maths in a new fun way.*
- *I do maths when I'm ordering something at the tuckshop and I need to work out the price of something that I am buying, or even when I'm at the shopping centres. (*This is an Indigenous student. According to her teacher, she is now also linking maths to her real-world experiences.)*
- *I like doing math because with chance it is really fun when we get to roll dice and flip coins and spin spinners. And last term how we did gold and coordinates and we had to find our space where we got to dig for gold.*
- *I like maths more now because it is even when you play sport.*
- *I do my maths on my laptop and in my book. I understand maths better now. I look everywhere and link it to different things, I use my self [my body] in maths sometimes. I really like maths and I like doing it. Maths is really fun at school.*
- *Sometimes our class goes outside and uses mathematical tools. We've learned that there are several ways to do math and solving problems in subtraction, addition, multiplication, division, fractions, decimals etc. Since the start of the year to now, math has been a lot easier and a lot more fun to do.*
- *I do maths by working it out by doing an algorithm timetables and strategies. I use maths in sport such as AFL so if I know that I have got 6 goals I will use my times tables to work out how many points that is all up that I've scored. Maths is everywhere such as shops, sport, school and work.*

Vignette 5.11 (cont'd) Increased student engagement at a regional primary school

5.3.2 Student engagement in non-compulsory mathematics: Senior subject selection

Increased student achievement, combined with increased student engagement, also creates new opportunities for students who would have been unlikely to be in a position to consider tertiary strand senior mathematics subjects. Vignette 5.6 provided an illustrative example of an Indigenous student who elected to undertake Maths A in his senior secondary years. What follows in Vignette 5.12 is a reflection from a Head of Department at a metropolitan secondary school.

Increased engagement with non-compulsory maths at a metropolitan secondary school

A maths Head of Department reflects on student engagement in compulsory and non-compulsory maths:

"I've worked at this school for 27 years. I was Maths Head of Department when this happened. We had run AIM [YDM programs] for students in junior secondary. We had big differences in student results. I'll give you an example: We had one girl in Year 7 who was below the national minimum standard [Band 4]. By the time she was in Year 8 she was doing algebra assignments. By the time she got to Year 9 NAPLAN she was Band 8 [similar to or above the national mean]. And I can tell you what her problem was – she didn't understand what a decimal was [before YDM]. Once we did the hands-on activities with YDM she got it and everything fell into place for her. Around half of the Year 9 cohort were recommended to Bridging to Maths A in Year 10. Previously, all of these would have gone to Vocational Maths with no other options.

So, I was at a senior subject selection night, sitting there with everyone else trying to flog my subject to the parents and kids. I had three parents come up to me that night from kids who had come from the YDM class. This is something that has never happened in 27 years. Normally, kids from those lower classes just want to steer clear of the big, bad maths teacher. Suddenly, they had experienced success and wanted to come and find out what their options were for senior maths. The parents said that for the first time ever, their kids were coming home and talking about maths classes."

A YDM maths teacher also reflects on what she saw as typical examples of increased student engagement in senior maths for students who had completed two years of YDM (Years 8 and 9).

"Kai [pseudonym] arrived in high school with attitude (a great way to cover up not understanding things). He had misconceptions… [about] place value and the idea that in order for him to do maths he had to remember each individual lesson (rather than learning problem-solving using skills acquired). [After YDM in Years 8 and 9] he was recommended for Maths A and completed Year 11 on a solid C standard (I would have to check how he went in Year 12 for you). I often saw him at school during his Year 10 and 11 and I believe his behaviour improved dramatically. One comment that he made comes to mind when I asked him how things were going, 'we have already done a lot of this stuff in Year 9, Miss, I can't believe that some people don't know how to do bloody Pythagoras!' He seemed mortified.

Jess [pseudonym] arrived to high school totally disengaged and with a plethora of misconceptions. Some that stand out were: place value, any number system that was not base 10 such as time, measurement... Although she was not recommended for Maths A, she sought me out before she completed Year 12 to thank me for all of my patience and help (she could be quite difficult). The thankyou went like this 'Miss, I just got an overall A grade in PVM, English Communication, Hospitality and Tourism. All my teachers have been wonderful, but you are one I wanted to thank. I always felt dumb because I didn't understand so much about lots of things, but having that time to relearn math and learn it in a different way changed the way I learnt lots of things. I can organise my tasks and my thoughts, I do not feel I am confused anymore.' She smiled and gave me a nod and went to catch her bus. Although this young lady never attempted a higher level maths, I feel the time spent with her in the course helped her achieve grades in high school that will help her gain employment – her confidence and attitude now makes her very employable. I hope the pathway classes that will be implemented over the next three years have the same impact on student understanding ... I will keep you posted."

Vignette 5.12 Engagement with senior secondary non-compulsory mathematics

5.4 Summary

The triangulation of publicly available systemic data (NAPLAN), teacher- and school-collected quantitative student achievement data, and qualitative data such as teacher reflections, survey responses and so on indicates that YDM projects have a significant positive impact on student achievement. This includes improvements in a range of NAPLAN measures at the school level (e.g., percentage of students achieving above the NMS, percentage of students in the lower NAPLAN bands). Section 5.1 provided evidence that YDM-trained and YDM-active schools out-perform their non-YDM trained similar schools, and that schools demonstrate significant improvements in achievement (on a range of measures such as NAPLAN, PAT-M and so on) after commencing YDM.

The evidence shows that YDM has an impact on the achievement of Indigenous students, students from low socio-economic areas and students requiring remedial maths intervention. Data in section 5.2 demonstrated that YDM is able to make significant in-roads in closing these achievement gaps. The significance of this impact is that students who would have previously been unable or unlikely to continue with maths in senior-secondary have demonstrated that they are subsequently willing and able to select and participate in maths in senior secondary.

These improvements in achievement are underpinned by significant improvements in student engagement in maths. Data in section 5.3 demonstrated that students from early primary school through to senior secondary are much more interested, engaged and excited about participating in school mathematics after learning in YDM-active classrooms.

6. Impact on teachers

Section 5 provided evidence of impact on student achievement and learning in mathematics. This section unpacks the impact of YDC projects on teachers. In particular, this section focuses on impacts to both teacher knowledge and pedagogy (6.1), and teacher confidence (6.2). It then turns to examine the impact on specific groups of teachers, namely, out-of-field teachers (6.3), teachers in special schools (6.4), and teacher aides and support workers (6.5).

Because YDC projects follow a train-the-trainer model, the exact number of teachers who have been influenced by YDM is unknown. However, numbers can be estimated based on most projects training four teachers per school. As shown in Appendix B, 249 schools have participated in YDC projects since 2010, meaning the number of teachers who have received YDM training is approximately 1000. This figure could be doubled to reach a conservative estimate of about 2000 teachers indirectly influenced by YDM through in-school training.

6.1 Teacher knowledge and quality pedagogy

> *"We are improving kids' knowledge in maths in a way that I didn't think possible. And I am really passionate about this. And I think anybody who works with YDC and anybody who is teaching it should get out there and tell everybody they can about how wonderful it is.*
> ***Because without doubt, it works. It is the best thing I've done****."*
>
> *– Maths Head of Department in a large metropolitan secondary school, 2015*

From a cognitive perspective, mathematics teaching can be understood as occurring on a spectrum from procedural teaching, where the focus is on rote learning of instrumental mathematics content, to structural teaching, which requires students to focus on acquiring relational mathematics content as rich schema. So-called "direct instruction" projects that rely on rehearsal, rote learning and student retention of facts have gained both popular and political support in recent decades, and have been trialled both in Australia and internationally as a means of closing the gap between Indigenous and non-Indigenous students (e.g., Ewing, 2011). International evidence (e.g., Lipman, 2004; Smith, Lee, & Newmann, 2001) indicates that, while students from high socio-economic backgrounds are more likely to receive structural teaching, students from lower achieving and poor backgrounds are more likely to be exposed to "didactic" (Smith, Lee, & Newmann, 2001, p. 15), procedural teaching with teacher-focused lessons, emphasis on the acquisition of basic numeracy skills and teacher reliance on worksheets, textbooks, practice tests and the like as teaching methods.

In contrast, YDC's model for teaching mathematics requires teachers to develop deep knowledge of mathematics and mathematics learning in order to focus on enabling students to develop deep schematic understandings of mathematics concepts. As described in section 2, YDC uses the RAMR model to focus on engaging teachers in deep learning of mathematics concepts, and in learning how to help students develop deep understandings of mathematics concepts, rather than relying on worksheets and didactic teaching strategies.

Teachers' accounts of increases in understanding and improvements in practice were assembled by drawing on multiple datasets (e.g., teacher reflective journals, YDC Sharing Summit presentations, feedback from YDC evaluations). Teachers commonly described significant increases in their ability to enact engaging and effective pedagogies when teaching mathematics. Teachers also described increases in their own knowledge and understanding. For example, one experienced primary school teacher in a provincial school described this as follows:

> *"Up until my first session of YuMi, I thought I had a pretty good grip on maths. Probably my own personal biggest misconception was around algorithms – teach the algorithm – follow the process and you will always get the right answer – easy? No way… It's so empowering… I always thought I knew maths, but by golly! Number lines have a whole new dimension to me and maths. I feel that everyone should be embracing the YuMi philosophy. It gives you that 'ahhh' [relaxed and happy] feeling."*

Similarly, a secondary maths teacher at a remote college explained that he had:

> *"… aha moments while teaching and learning it [YDM]. Things that I knew how to do, but didn't know why we had to do it that way, now we get into that deep understanding and getting it done practically makes you see it differently, and then you go 'Ah, okay, now I know why we got to do this and this, now I know why it'll help us do that.' Then tell the kids and help direct them in the same path."*

Teacher comments at the conclusion of a YDM workshop in North Queensland in 2015 included:

> *"I always knew there was a better way of teaching maths, and now I feel I understand. I am confident to plan units of work and my knowledge of how we learn mathematical concepts has developed greatly."*
>
> *"[YDM] has given me a greater depth of understanding on the sequence of maths teaching…"*
>
> *"I find the big ideas outlined in each strand's booklets very helpful with my cohort of students – we struggle to get through the ACARA content each year, so connecting teaching to big ideas really helps."*

The following reflection from the 2015 YDC Sharing Summit (Vignette 6.1) is from a mathematics Head of Department at a large metropolitan secondary school. The teacher has an extensive teaching history across the secondary school. The school is located in a mid–low socio-economic (ICSEA ≈ 960), outer metropolitan area. After being trained in YDM in 2014, and experiencing success with younger classes, he began to look for opportunities to use YDM's RAMR model in senior maths. This reflection demonstrates the impact of YDM on experienced teachers as well as beginning teachers.

YDM pedagogy in senior secondary mathematics

"The thing that was really great about it was that every time I would [attend PD], I was learning a lot of stuff. A lot of what I was learning, I was doing over and over again – but every time I looked at it I would find there was more depth to it, and it made me understand it more. And then when I got into the situation with [training] the staff, there were questions… I don't know if you work with guys who teach Maths C, but they don't think like normal people. They don't! They find it hard to dumb stuff down. So when you have a Maths C teacher who says, 'the kids aren't getting this, how do I teach it?' And you show them a really simple strategy, and he picks it up and runs with it. And then you see him bringing up things in a Year 12 Maths B or Maths C class where he's doing real-life applications using a RAMR model, you really do realise – there is something in this stuff.

And it is because [YDC staff] are dedicated to demystifying mathematics. I say that on purpose because as I tell my Year 8 and 7 kids, Voldemort did not think out how to multiply numbers. It's logical: 2 times 2 will be 4 and it doesn't matter if you do it today or if you do it in 20 years' time. And the kids get into it, and they understand it. And it is because of the passion of these people [YDM] that we are able to now do the job that we do. And we are improving kids' knowledge in maths in a way that I didn't think possible. And I am really passionate about this. And I think anybody who works with YDC and anybody who is teaching it should get out there and tell everybody they can about how wonderful it is. Because without doubt, it works. It is the best thing I've done.

The other thing that happened was I started integrating the RAMR model into my senior curriculum. Because I was teaching Year 11 and 12 Maths A. And some of this stuff, I thought, this would work really really well. So I started using the RAMR model, and looking at models that my Maths A students had, and then teaching them using techniques that I had gained using my YDM training. So here is an example of the stuff I actually did with my Year 12s. This is a real-life example (from the unit: Spending Money). [Shows onscreen a money problem related to the price of vacuum cleaners.] Straight away [I know that] the RAMR model is a good one.

This is straight out of the textbook – vacuum cleaners. So, how many teenagers buy vacuum cleaners?! I don't know any teenager who has actually bought a vacuum cleaner. So … I turned this into the model where I have Culture Kings [caps from Culture Kings]. It is the same sort of question, but I put it into something they could relate to and understand. I made sure I grabbed all these real-life scenarios for them.

Next one – I had to teach Pythagoras Theorem. Because I have been teaching Maths A for a long time, I thought, 'what is the main issue that students have with Pythagoras?' And the main issue was that they didn't understand square numbers… and so they couldn't understand the way Pythagoras worked. So I spent a lot of time on the multiplication models. I got down and started talking to these Year 11 kids and Year 12 kids about multiplication models. I started showing examples of the line model, and how it works in relays (e.g., swimming and running), and getting them to think about how it worked. Then we started talking about sets. How things are in sets (like a crate of milk cartons). We talked about that and multiplication. We talked about trains and if a train carriage weighed 10 tonne, how many sets are there?

Then we had to get into arrays, because these are the square numbers. (e.g., using the seats in a stadium as an array). Then we talked about how these all fit together… We talked about square numbers and I got them to make square numbers [using Lego]. They actually got the blocks and made the square numbers. Then I got them to draw a triangle. I asked them what the length of the sides were. Once they figured out that it was the square root, they all had that moment. AHA!!! 'Ohhhh! That's what a square root is, Sir!' Yes! 'Oh, why is this so easy!?' Now these are students who have been doing Pythagoras Theorem since Year 8! They've been doing it for years and now all of a sudden they get to understand it!

Managing money. I went back to the big idea of part-part-whole. Students had issues with changing things by proportions. So I went into double number lines. I had the price of the Samsung Tablet that had been discounted. Once they started seeing that on the double number line, they were able to figure out the proportions and how to get back to the original price. They started to understand the maths on how this works. And of course they start to understand one of the other big ideas – inverse operations…"

Vignette 6.1 YDM pedagogy in senior secondary mathematics

Across the range of YDC projects, it is clear that while most teachers want to help their students to understand mathematics concepts, they sometimes struggle to find practical and motivating activities that will do so. The following reflection from an early years teacher was typical of teachers looking for alternatives to commonly used pedagogical approaches towards mathematics.

Teacher reflection on YDM at a remote P–10 school

The following reflections were provided by an early years teacher at a P–10 remote school in late 2016. The school commenced with YDM in 2014. In early 2016, the teacher reported that she had “a light-bulb moment” in which she questioned the value of her practices, and her impact on student learning in mathematics. In her words, “I knew I needed to do more YuMi, and I knew my approach needed to change”. Over 2016, she began to engage more deeply with YDM concepts, and reflects that:

“Having first been introduced to YDM three years ago, I have since been asking myself with each new math concept – how can I YuMi that? How can I engage my students through the use of their bodies, hands and minds and how can I, as their teacher, look outside the square and traditional worksheets and cut-and-paste approaches?”

In addition to the teacher’s reports that her changed pedagogical approach has shifted her students’ engagement in and knowledge about mathematics, it is also worth noting that the school has achieved significant gains in NAPLAN achievement since 2014. In 2013, the school was performing below the national mean in Year 3 and substantially below in Year 5. In 2015, Year 3 achieved above the national mean for the first time, and Year 5 achieved at a level similar to the national mean. (Data obtained from My School).

Vignette 6.2 Teacher reflection on YDM pedagogies at a remote P–10 school

In the PRIME Futures program, principals are observing teacher change in mathematics knowledge and pedagogy. After either one or two PD workshops and only about six months into the two-year project, over 60% of principals from 18 schools reported a moderate to extensive improvement in the mathematical and Indigenous knowledge of teachers. Over 70% of principals reported improved pedagogical skills as well as an increase of teacher expectations of students (see Figure 6.1).

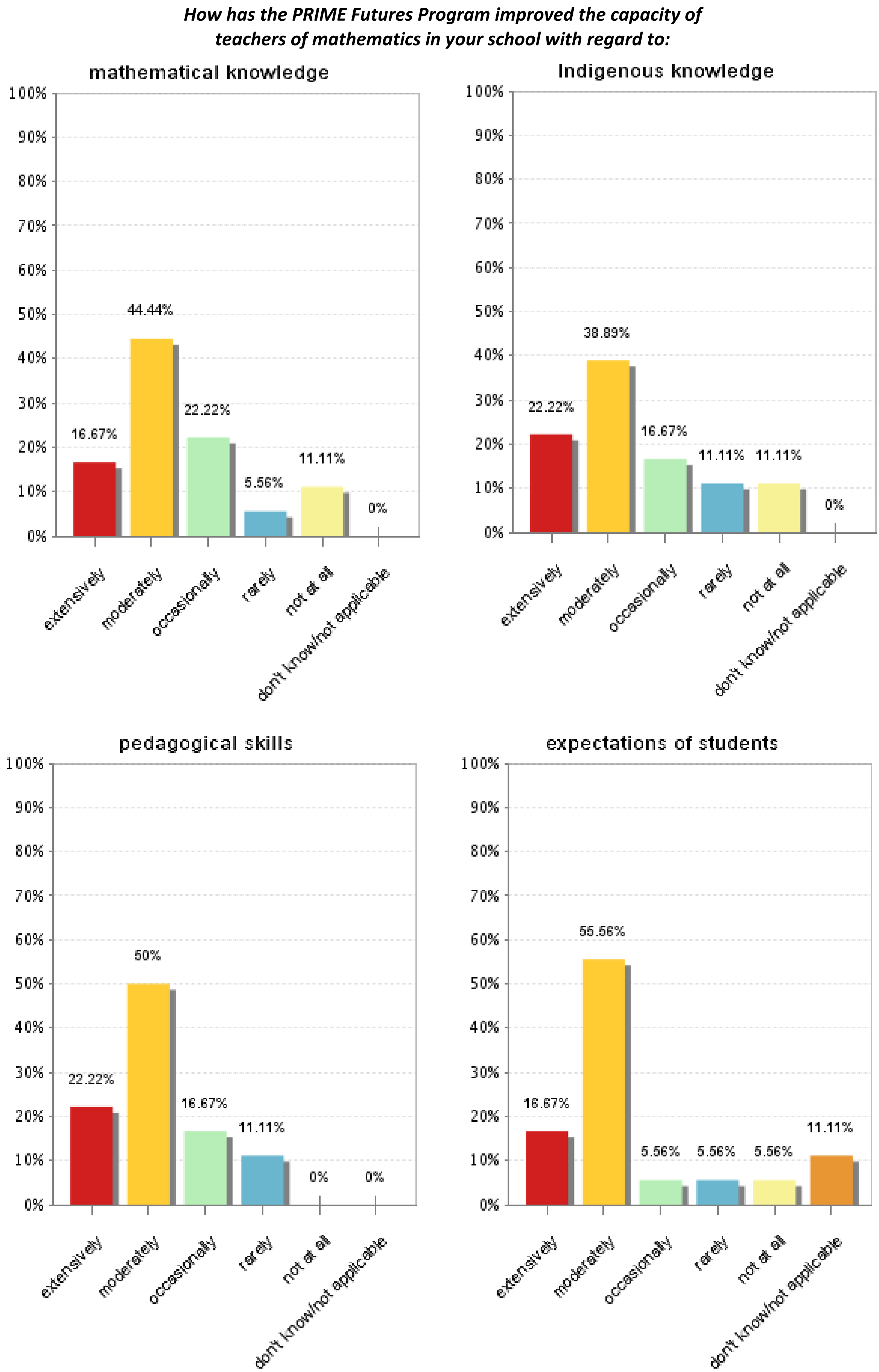


Figure 6.1 PRIME Futures Clusters 1–4: Principal observations on improved teacher capacity

6.2 Teacher confidence and engagement with mathematics teaching

In addition to building on teacher knowledge and providing teachers with a new repertoire of pedagogical practices, YDM also improves teachers' confidence and engagement with mathematics teaching. Twelve out of 18 principals in the PRIME Futures program, for example, reported moderate to extensive improvement in teachers' confidence in teaching mathematics just six months into the program.

How has the PRIME Futures Program improved the capacity of teachers of mathematics in your school with regard to:

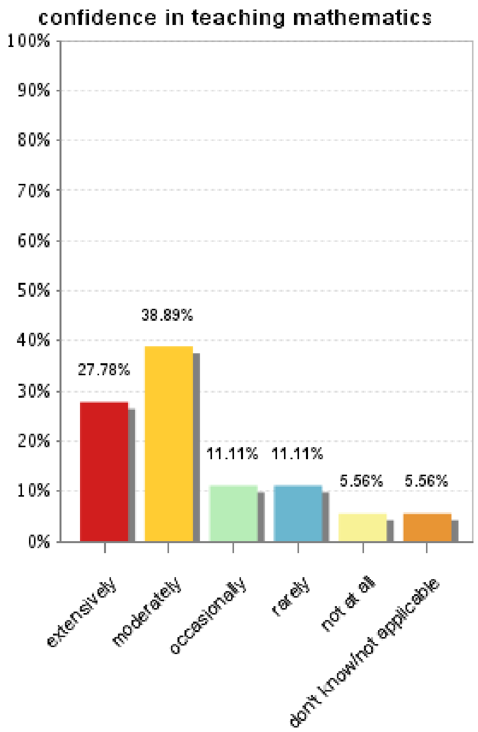


Figure 6.2 PRIME Futures Clusters 1–4: Principal observations on improved teacher confidence in teaching mathematics

Anecdotes from teachers in other projects similarly reflect a perceived improvement in confidence and enjoyment in mathematics teaching which in turn resulted in improved student results.

A Year 3 teacher at a provincial primary school explained that:

> *"Initially, for myself, accepting YDM… I was teaching Year 3 and I did not like teaching maths before I started YDM. It reinvigorated me in enjoying teaching maths, which then of course, the children were enjoying maths. Which then makes results grow. Because if you enjoy something, you actually can improve. So teachers could see that, if I could implement it in my classroom, they could see that they could implement it in their classrooms as well."*

For some, YDM helped build confidence, while for others it reinvigorated their enthusiasm for mathematics teaching. On completing a YDM workshop in 2015, participating teachers were asked to share their journey in one sentence, and made comments such as:

> *"[YDM] has taken the fear out of being a teacher. I now know where to go and how to get there with students."*
>
> *"One word: passion. YuMi has given me back a passion for maths, for teaching maths and for working with all students to love learning maths."*
>
> *"It has reinvigorated my professionalism, as a colleague and a staff member, to teach maths.*
>
> *"It has taken the fear out of teaching maths for me. So much rich pedagogy in this workshop."*

> *"My students are excited when I go to a YuMi workshop. They are anticipating me bringing back ideas for more maths enjoyment and learning."*
>
> *"My confidence has grown in dealing with C2C. I now have confidence in our practice: sequencing, what comes before and after, what to streamline."*

Similar responses have been received from other workshops, in which teachers identify decreased fear of teaching maths, increased content knowledge, increased student engagement and an increased repertoire of engaging and effective pedagogical practices.

6.3 Impact on out-of-field teachers

In 2013, the Queensland Audit Office (QAO) published a report to parliament that investigated the supply of specialist subject teachers in secondary schools. As described in section 3, there is currently a lack of qualified secondary mathematics teachers in Australia. At the local level, the short supply of qualified mathematics teachers has resulted in increasing numbers of "out-of-field" teachers who "have not formally demonstrated specific content knowledge and teaching techniques" to teach mathematics (QAO, 2013, p. 3). Supporting out-of-field teachers is particularly important given that analysis of TIMSS 2011 data (Mullis, Martin, Foy, & Arora, 2012) demonstrates that Year 8 students whose teacher specialises in mathematics achieve better results. According to the QAO report, although all teachers must meet requirements for teacher registration, in 2010, 24% of permanent secondary teachers reported that they were teaching at least one subject out-of-field. Worryingly, the QAO's analysis of the Queensland Education Department's database OneSchool revealed that in 2013:

- At least 18% of Mathematics B teachers were teaching out-of-field.
- At least 46% of junior mathematics teachers were teaching out-of-field.

Similarly, Weldon (2015, 2016) reported that 30% of Australian secondary mathematics teachers can be considered out-of-field. The negative effect on systems with large numbers of out-of-field teachers has been documented both in Australia (e.g., Ingvarson, Beavis, Bishop, Peck, & Elsworth, 2004) and internationally (e.g., Darling-Hammond, 1996) for some decades, yet remains a significant issue.

The QAO (2013) report noted that, while supporting out-of-field teachers was important, it was also a "drain on school resources and increased teacher workloads" (p. 20) as well as being a significant source of teacher stress and lack of confidence. During field visits, QAO researchers visited a YDM school participating in the AIM project, and reported the case study as a "model of professional learning" (p. 22).

In the YDM AIM project, approximately 85% of participating teachers were teaching out-of-field. This figure alone indicates the importance of providing practical support, as was provided by YDC staff. The following vignette is an excerpt of an interview conducted by a YDC practitioner and an out-of-field (secondary maths) teacher at a remote P–12 college. This vignette is also indicative of the increased confidence gained in the teaching of mathematics across time as observed in out-of-field teacher participants.

Impact of YDM on an out-of-field teacher from a remote P–12 College (2012–14)

Interviewer: *Being non-maths background, how has your understanding of maths changed after being involved in YDM?*

Teacher: *Because I'm not maths-trained, it makes it a lot easier for me to teach it (maths) because it's more hands-on and practical, I can get the kids to sit down and figure it out for themselves instead of sitting there and just trying to feed them information. So it gives them the opportunity to learn it themselves and to discover it instead of being spoon fed, and it gives me the opportunity for me to create fun maths lessons.*

Interviewer: *Not being from a maths background, have you ever thought of teaching maths, with the Deadly way, have you ever thought of teaching maths as a hindrance?*

Teacher: *No, no. I actually find teaching this maths now easier than teaching PE, which is my subject. Because PE you have to do theory and then practical, whereas this maths is all practical and theory all at once. [Students] don't realise they are doing [maths] until they get their worksheet and realise 'Oh, I can actually write this down'. And for them it's good and for me it's so much easier.*

Interviewer: *It has taken away some fear you used to have [of teaching mathematics]?*

Teacher: *Yes, definitely. And just worrying I was sort of giving the wrong ideas and pathway. We need one [Deadly] for science now.*

Interviewer: *How would you prepare certain lessons that you may have found difficult but you would have to teach it?*

Teacher: *For this just following the RAMR cycle just helps, and I have started using it in PE as well. Just to have that flow-on effect and going from the first activity to the next one, to the next one... the kids that struggle, they know the cycle as well. So they know once we've gone through the first phase and they are on the next phase, they see 'Wow, we've done the first one, right, we're on to the next one'. Gives them the confidence, which allows me to sit back and let them flow along.*

Interviewer: *So your experience as a student learning maths being not good experience, and the fact that now you have this opportunity to teach them (students) in a way that your teacher never taught you, and having YDM with the Hand-Body movement together with your physical education background, just brings everything together. So it's never a disadvantage not being a maths background?*

Teacher: *The whole way it's set up, and for me looking back when I was teaching [maths] last year, like the C2C maths program I could have done things differently, but I didn't have that image in my head for maths and the ability to deconstruct things, to be able to break it down like that and make the connectivity's. This [YDM] basically gives you that lens to look through 'Oh, we can do this, we can do that'. And then going on the PDs and actually seeing you doing it, 'cause for me seeing it on paper is a waste of time, but if I actually see it done, 'Aww okay, I can change this, I can do that.'*

Vignette 6.3 Impact of YDM on an out-of-field teacher from a remote P–12 college

6.4 Raising teachers' expectations in special schools

According to YDC practitioners who have worked in special schools, an important impact in special schools was raising teachers' understandings of how mathematics might relate to the real world for students with disabilities, and raising teachers' expectations for student learning. Data from both YDC practitioners and special school staff indicates that significant changes have occurred in special schools as teachers have made pedagogical changes, including:

- Less reliance on didactic pedagogies such as worksheets, and maths activities on interactive whiteboards that are unengaging and unrelated to students' everyday lives.
- Less reliance on lessons in which students copy and interpret (for example, copying a basic algorithm from the whiteboard into a computer/tablet).
- An increase in pedagogies that allow students to create and demonstrate mathematical knowledge.
- An increase in the breadth of mathematics taught at special schools, in particular, knowledge that is related to students' everyday lives.
- An increase in the use of whole body and kinaesthetic learning, which leads to better understanding and retention of concepts.
- An increase in hands-on pedagogies that engage students and allow them to experience success in maths (for example, drawing on knowledge from their lives such as eating and travelling to school).

A teacher at a small metropolitan special school described the impact of YDM:

> *"We [teachers] all feel that YDM has had a positive impact on our staff. It has reminded many of us of the mathematical elements of each and every day. It has prompted teachers to make more connections and cross-curricular links. Most of all, it draws out and names mathematics as part of our daily program, and part of our routines. This is really important for the students that we teach at a special school. It has formalised an ongoing kinaesthetic and real-world approach to mathematics that we all know is really beneficial for our students as well … it has helped our staff to be more creative and more confident when teaching mathematics."*

What follows (Vignette 6.4) are the reflections of a school principal and Head of Curriculum (HOC) on changes to teacher practice in their school.

Leadership team reflections on YDM at a metropolitan special school

Principal:	*I want to share with you some of our achievements. I can now say that maths is happening in all of our classrooms. I don't know that I could have said that confidently before our YuMi journey… The students are engaged. We see teachers outside with kids. Our groundsman might not like it! Our concrete is full of chalk and writing everywhere! We're seeing engagement. We're seeing staff engage with students, and students engage with each other. We're seeing clapping and counting…*
HOC:	*I'll tell you a story about a teacher. Now this is something she wouldn't traditionally have done. But I saw her outside my office with her class, with their backs up against the wall, measuring their shadows. And every hour, they appeared again! And I was like, 'wow! They are all on task and together.' And I made the mistake of coming out and they measured my shadow. And then the next hour one young lady pointed to me and said 'ooo, ooo', [you, you] so I had to come and be measured again too. And it was just great! This was a student who is often off-task! And there she was... it was really good.*
Principal:	*Teachers are talking about maths and their pedagogy more… and teachers' professional knowledge is growing. And they are seeking more. The more that they have started to realise what they don't know – some of the deeper stuff – they are seeking it out now… that is really exciting for us, as a special school, that ten years ago didn't have a curriculum journey.*
HOC:	*We often talk about student data, but my role as HOC is to work with teachers… It is so exciting! **Students are off the worksheet and out of the classroom!***

Vignette 6.4 Leadership team reflections on YDM at a metropolitan special school

6.5 Role of teacher aides and Indigenous support workers

Early on in the development of YDM, field visits revealed that teacher aides and support workers such as Indigenous Education Workers and Aboriginal Education Workers were a vital part of mathematics teaching in regional and remote schools (e.g., Baturo, Cooper, & Doyle, 2007; Kidman, Cooper, & Sandhu, 2012; Warren, Baturo, & Cooper, 2010). For example, while non-Indigenous mathematics teachers may have little experience or knowledge in Indigenous education, support workers may have important knowledge, skills and experience working in the community but may have limited training in the teaching of mathematics. Teacher and teacher aide partnerships have been encouraged, with teacher aides often attending PD and contributing to YDM in the classroom.

Involving teacher aides in supporting Indigenous Year 9 students with mathematics learning

A remote school sent its Years 8 and 9 teachers and teacher aides to AIM training. Because knowledge about how to teach each of the modules was made available to both teacher and teacher aide, there were changes in how teachers and aides worked together to teach mathematics. For example, in one Year 8 class, the teacher aide, who had tended to be in the class as an observer and assistant, began to work alongside the teacher as a teaching partner. The partnership changed classroom dynamics and led to a remarkable improvement in mathematics outcomes in the class. As a consequence, the teacher aide presented collaboratively at a national conference.

The following vignette was written collaboratively between teachers and YDC staff, and presented at a national conference run by the Australian Association of Mathematics Teachers in 2012.

"The teacher used masking tape to create a large clock on the floor. The Year 9 students were struggling to tell time on an analogue clock. The students also had difficulty understanding the concept of passage of time (e.g., What time will it be in 10 minutes?). It was from this large clock that the teacher recapped 'o'clock' time, and half past… but there was a lot of confusion. The teacher decided to focus on the 'half past' notion of time. She explained it was half way round the clock, half way between two o'clocks, or 30 minutes of the 60 minutes. Still a few students were confused.

The teacher was at a loss until the Teacher Aide stepped in and modelled the passing of time from 6 o'clock to 7 o'clock. She held down the two hands of the clock and moved the long minute hand. Simultaneously the short hour hand turned. A pausing at approximately 28 past 6 was used to ensure students were focused on what was happening to the relationship between the hands on the clock.

With keen interest the students watched as the short hand moved past 6 and the long hand moved to the six. One boy said 'its past six!'. This resulted in a short discussion of what 'half past 6' meant – that the short hour hand would be half way between the 6 and 7, it was past 6. The students were amazed at the simplicity and were quickly able to transfer their new understandings to quarter to and quarter past.

Throughout the lesson, the students compared the times on their carpet clock with that depicted on a wall clock. They initiated comparisons. The teacher and teacher aide did not instigate or lead the discussions. The students naturally linked their learnings on the floor with the real-life familiarity of a clock – which although they were familiar with the device, [they] had little ability to read prior to the lesson.

***It is** the **interactions of the students, the teacher aide and the teacher, and the notion of creating a kinaesthetic representation of familiar devices – in this case a clock – that assisted in the students wanting to engage in mathematics and develop deep understandings.** Following on from the lesson, the teacher, teacher aide and students were able to take ownership of the mathematics. The students were able to explore 12 and 24 hour time and determine arrival and departure times."*

(Sorenson, Kidman, & McNeill, 2012, pp. 3–4).

Vignette 6.5 Teacher aides working with YDM to support Year 9 Indigenous students

6.6 Summary

The data presented in this section has demonstrated the significant impact YDM training has had on improving teacher knowledge and pedagogy. Principals and teachers from across a range of diverse school types (geolocation, socioeconomic status, primary/secondary, etc.) have indicated that YDM training has had a major impact on teachers' knowledge and confidence in teaching mathematics. Teachers have reported that students are excited when teachers attend YDM training, because they anticipate teachers will return to the classroom with new and engaging strategies and ideas for teaching. A number of teachers reported that YDM training took the "fear" out of teaching maths. Increasing the knowledge and confidence of out-of-field teachers is particularly important given the large number of out-of-field maths teachers in the teaching workforce. YDM raises the expectations of teachers in special schools and has made an important impact in improving the quality of pedagogy delivered in YDM-trained special schools. Finally, YDM-trained teacher aides and support workers are better able to support maths learning in the classroom. This is particularly important in remote, regional and remedial classrooms where support workers are a vital part of classroom activity.

7. Impact on schools, systems, partnerships and communities

This section outlines the impact of YDM on school systems and other stakeholders. Section 7.1 details the reach of YDM's impact by charting the number of schools that have participated in YDC projects and the impact on different cohorts of students. Section 7.2 describes the impact of YDM on community engagement. Section 7.3 describes the impact of YDM on school and education system partnerships. Section 7.4 outlines the role of industry and philanthropic partnerships.

7.1 Reach

7.1.1 Number, location and type of schools and funding

Sections 5 and 6 have detailed the impact of YDM on students and teachers. The reach of this impact is significant given that YDC has now worked with 216 schools located across all education regions of Queensland, 12 from Victoria, 15 from South Australia and 6 from Thailand, as shown in Figure 7.1. In Term 2 of 2017 at least 26 more schools will begin YDM training through the PRIME Futures program, including 16 from Western Australia.

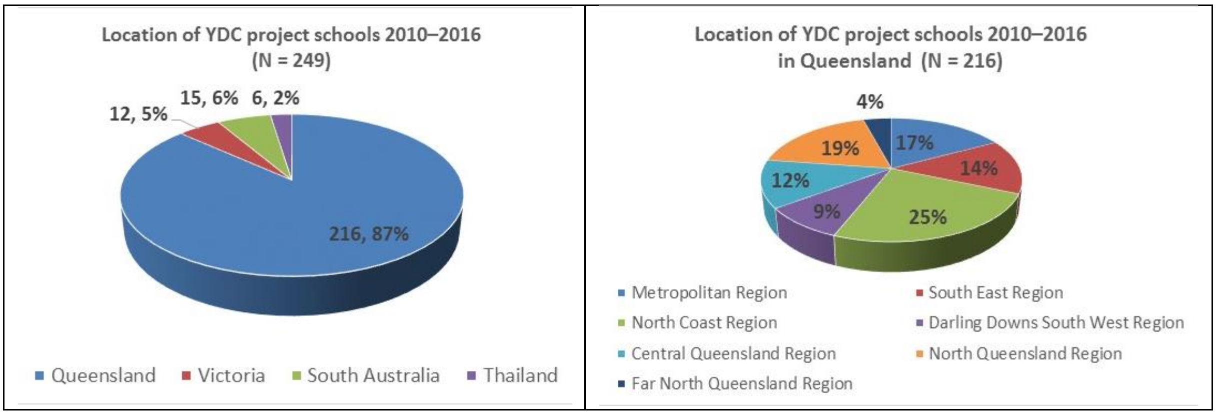
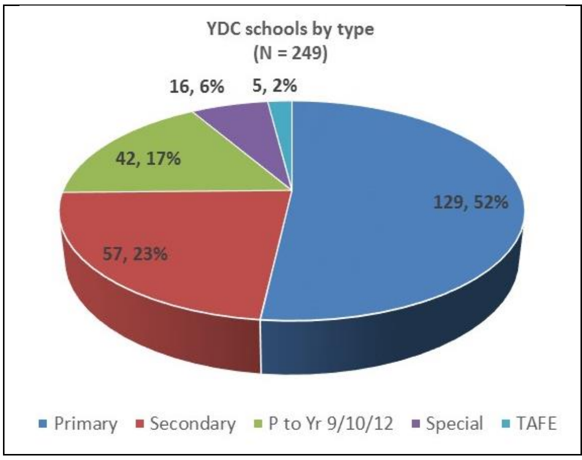


Figure 7.1 Location of YDC project schools 2010–2016

In terms of types of schools and project funding, YDC projects have worked with 129 primary schools; 57 secondary schools; 42 Prep to Year 9, 10 or 12 schools; 16 special schools; and 5 TAFEs, as shown in Figure 7.2. Schools have predominantly been from the state government sector, but have also included catholic and independent schools.



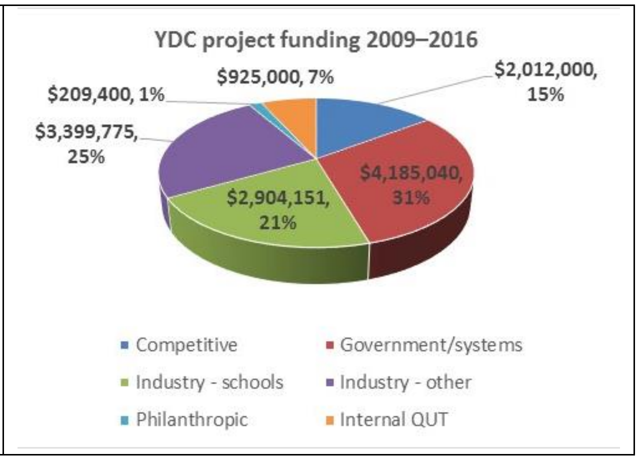


Figure 7.2 YDC project schools by type

Figure 7.3 YDC project funding 2009–2016

YDC has received project funding from a range of sources as shown in Figure 7.3. Significantly, $2,904,151 or 21% of YDC's total funding has been sourced through schools self-funding their participation in YDM training. YDM is a well-known program across Queensland, particularly in Indigenous and low socio-economic schools, and those with significant refugee and migrant student populations. For example:

- 109 schools participated in the TIME project from 2010 to 2012.
- 31 schools participated in Partnering for Enhanced Mathematics Outcomes (PEMO) from 2012 to 2014.
- 81 schools have participated in self-funded YDM training since 2012.

The high number of schools willing to self-fund YDM training is evidence of the impact and success of the program.

7.1.2 Cohorts of students

In terms of reaching different cohorts of students, recent results of the PRIME Futures program after about six months of implementation in 29 schools are promising. Most teachers reported a moderate to extensive increase of engagement not only in Indigenous students but also in both boys and girls as well as in students in the upper and lower ability range (see Figure 7.4).

How have different groups in your class(es) increased their engagement in mathematics?

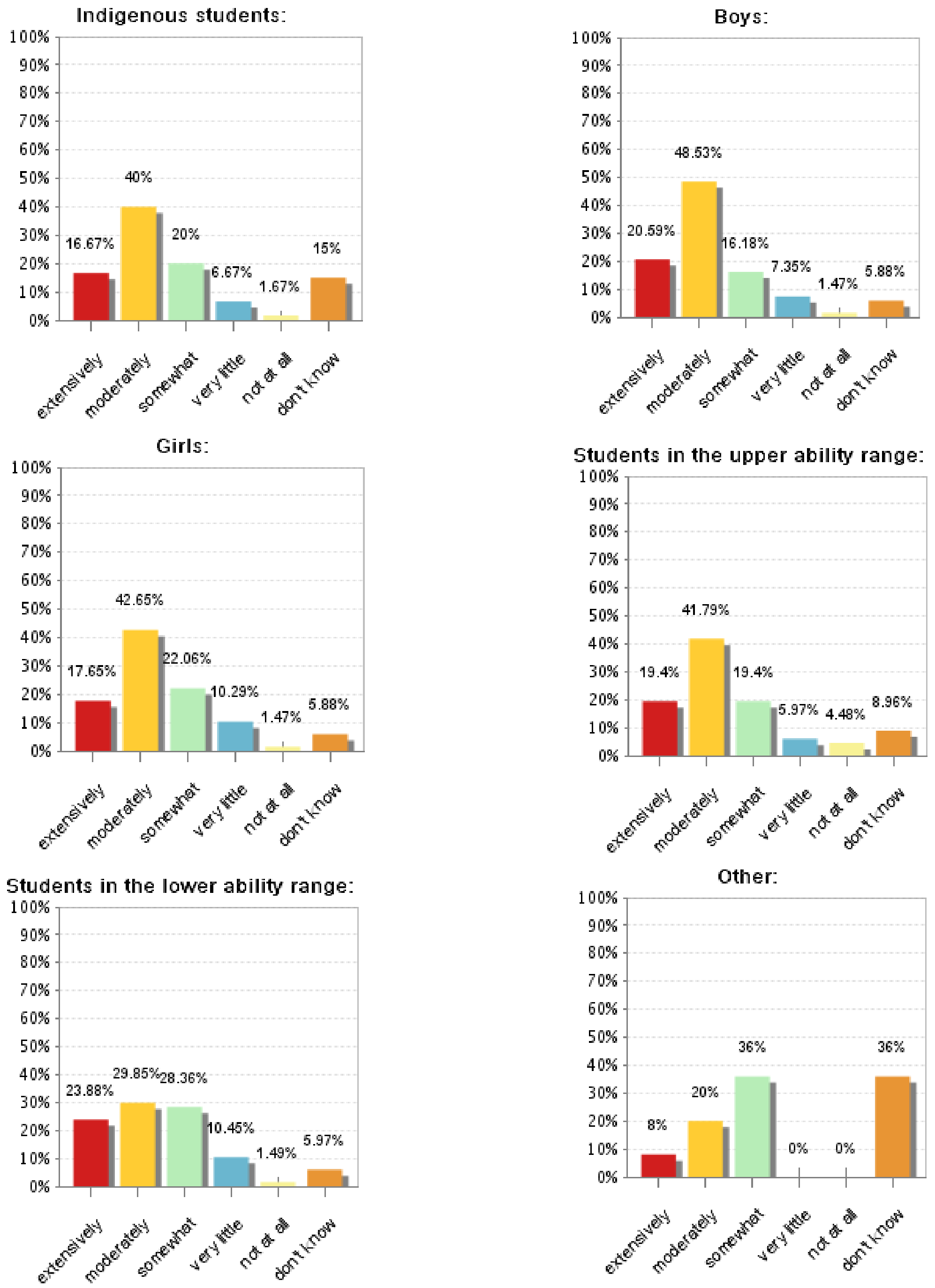


Figure 7.4 PRIME Futures Clusters 1–4 Teacher Opinions Questionnaire 1: Level of increased engagement in mathematics in different groups of students

Examples for the "other" student group included:

- "Reluctant maths students"
- "Average students"
- "Student at pointy end of behaviour triangle"
- "[Students] from another country ... students who don't attend regularly"

7.1.3 Teachers and whole school

The PRIME Futures program also suggests that through the train-the-trainer approach YDM reaches many more teachers than those trained by YDC and therefore has the potential to improve the teaching of mathematics in the whole school. YDC-trained teachers are asked to share the YDM approach with their colleagues and survey data indicates that they do this increasingly as the program progresses, most likely after they have gained more confidence in their own use of YDM. While in the first PRIME Futures survey teachers tended to share YDM mainly with one or two colleagues (see Figure 7.5, Clusters 1–4), the results of the second survey suggest that YDM has reached many more teachers in the school due to increased sharing over time (Figure 7.6, Clusters 1–2).

How many colleagues have you shared YuMi Deadly ideas with?

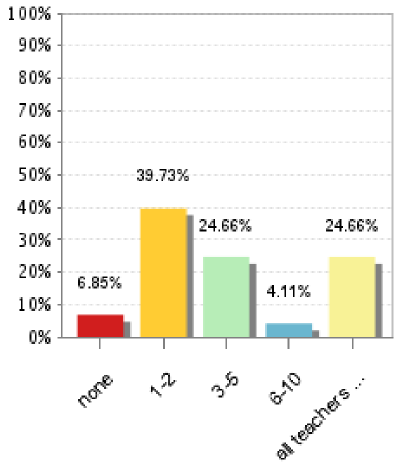


Figure 7.5 PRIME Futures Clusters 1–4 Teacher Opinions Questionnaire 1: Extent of training

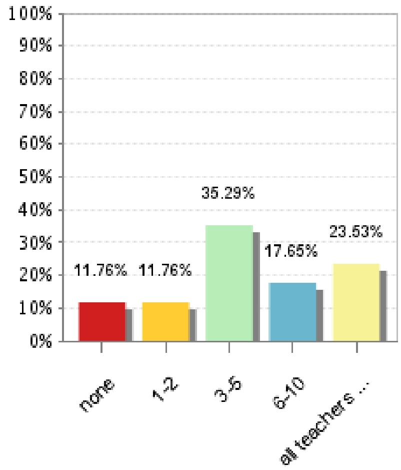


Figure 7.6 PRIME Futures Clusters 1–2 Teacher Opinions Questionnaire 2: Extent of training

When YDC-trained teachers were asked about the year levels of the colleagues they have trained, it also became evident that YDM has spread across all different year levels (see Figure 7.7), which is another indicator of the reach of this program across schools.

What year levels do these [trained] colleagues teach mathematics to? (select all that apply)

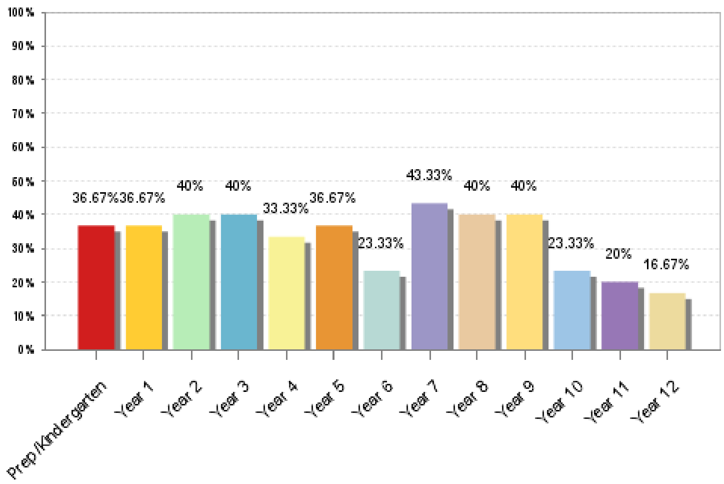


Figure 7.7 PRIME Futures Clusters 1–2 Teacher Opinions Questionnaire 2: Year levels of trained teachers

As a preliminary result of the PRIME Futures train-the-trainer approach (approximately one year into the program) over 90% of YDC-trained teachers reported that some of their colleagues have already accessed/used YDM materials. More than 6% reported that all or most of their colleagues have accessed/used YDM materials (see Figure 7.8).

How many of your colleagues have accessed/used YDM materials (for example YDM books, exemplar lesson plans) – either directly or by sharing materials obtained by another teacher?

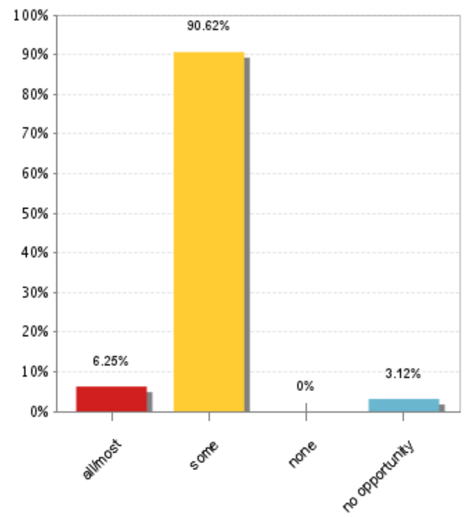


Figure 7.8 PRIME Futures Clusters 1–2 Teacher Opinions Questionnaire 2: Extent of accessed/used YDM material by trained colleagues

The above results of the reach of the YDC PRIME Futures train-the-trainer approach are corroborated by principals' responses with regard to the YDM training happening in their schools. After just one year into the program all responding principals reported that YDC-trained teachers supported their colleagues in YDM (see Figure 7.9).

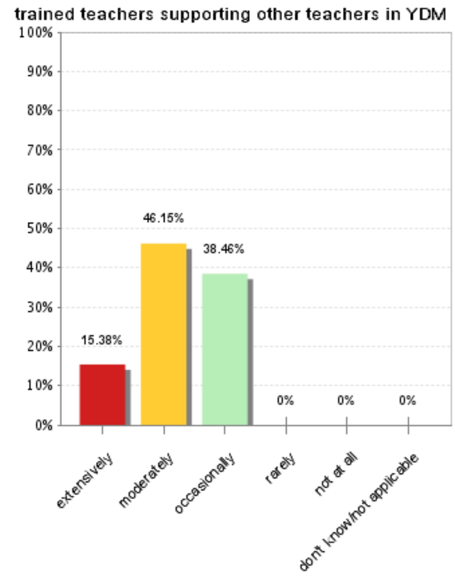


Figure 7.9 PRIME Futures Clusters 1–2 Teacher Opinions Questionnaire 2: Extent of YDM-trained teachers supporting their colleagues

As a result of the train-the-trainer approach all responding principals reported that YDM is already used in different year levels with varying degrees; 67% reported a moderate to extensive use of YDM across the whole school (see Figure 7.10).

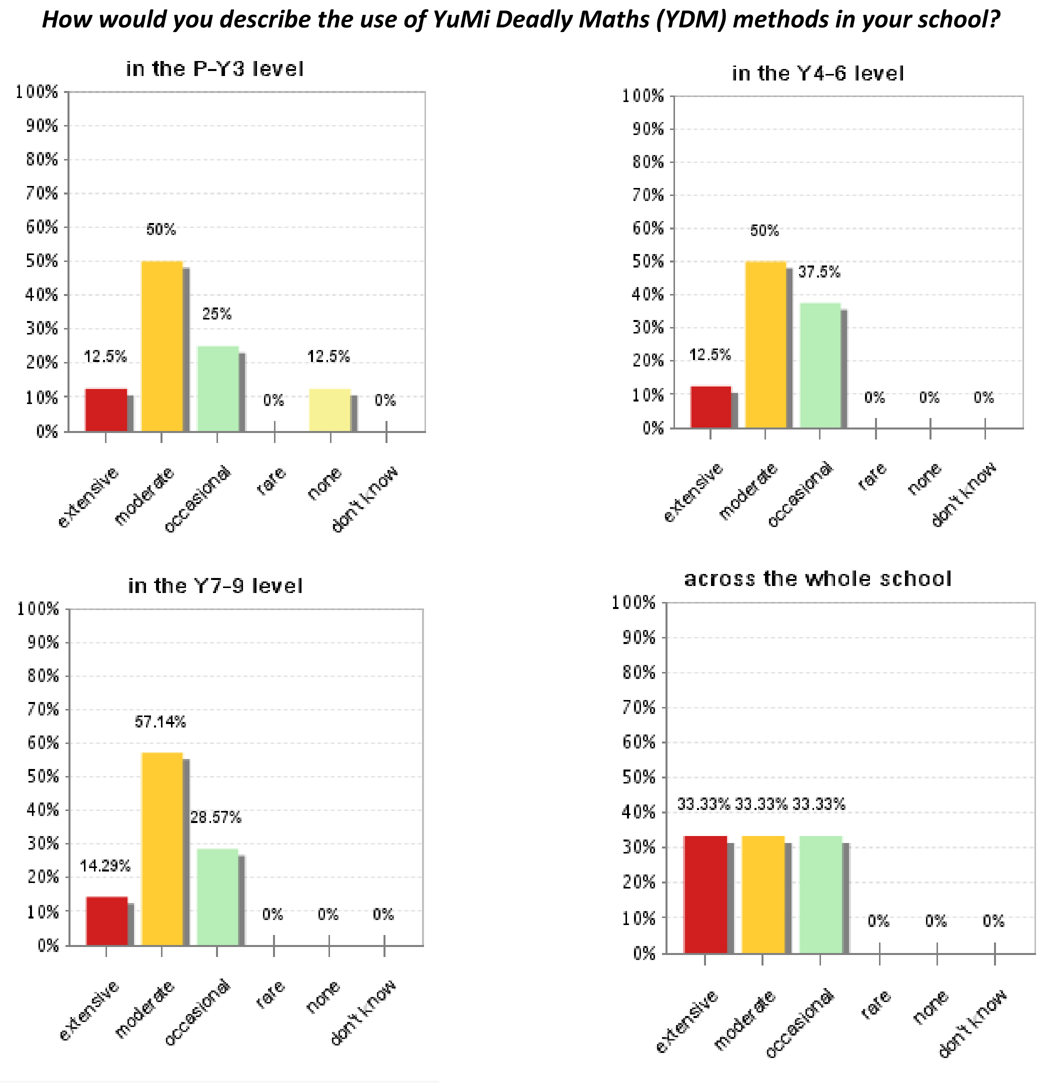


Figure 7.10 PRIME Futures Clusters 1–2 Principal Questionnaire 2: Extent of YDM usage in the school

7.1.4 Training for out-of-field teachers

Further evidence of the reach and significance of YDM is that in 2016, YDC led a successful QUT Faculty of Education application for Queensland Government funding to provide training to up to 400 out-of-field junior secondary mathematics teachers. The Junior Secondary Mathematics Program (JSMP) provides online targeted professional development to develop confidence in teachers to deliver junior secondary mathematics relevant to their year level and their local context. The program is being delivered online to two cohorts of teachers from mid-2016 to mid-2017. Feedback from these teachers about the course to date has been very positive.

7.2 Community engagement

All YDC projects encourage schools to involve communities in their YDM journey, for example by holding parent information sessions and by inviting members of the local Indigenous community to in-school activities and events. In projects that were developed specifically for Indigenous students (such as AIM), YDC staff communicated with Indigenous councils and community organisations to show respect, and to inform the community of progress, when YDC staff visited local schools. The AIM project maintained contact with Aboriginal and Torres Strait Islander people associated with the schools in two ways:

- informally, through the school, particularly through the contacts of the principal and the local Indigenous teacher aides; and
- formally, through organising to visit the local Indigenous council or committee each time the school was visited.

In addition to direct work with communities, a number of YDM schools have included communities by:

- Holding “numeracy games nights” for families.
- Inviting parents to celebrations of YDM, where parents can participate in maths activities and celebrate increases in student achievement.
- Holding information sessions (that are sometimes also attended by YDC practitioners).
- Inviting Indigenous councillors and Elders to provide materials and attend community-YDM celebrations. (For example, one councillor created a yarning circle in the centre of a “Maths Fiesta” attended by students and community.)

One of the schools that holds family games nights makes showbags for families that contain YDM activities that parents and children can play at home. The showbag includes games that teachers believe will be relevant and accessible for students and families, for example games that use mobile phone apps. As one teacher explained, *“This is important to appeal to families who may not have a deck of cards but may have an iPad or iPhone. The showbag tries to accommodate all types of families.”* Another teacher explained the reasoning for the showbag, saying, *“A lot of our families don’t have a lot of games, and access to the things that we would have had when we were growing up. So we are trying to provide those things for families.”*

The following vignette details how a regional primary school celebrated and shared their YDM journey with the local community.

Inviting community to learn and celebrate YDM success at a regional primary school

A regional primary school undertook a range of activities to engage with parents and the local community, including:

- Holding parent information sessions, presented by YDC practitioners and school staff.
- Including information in newsletters outlining student engagement and celebrating student successes.
- Holding school annual celebration days. The 2014 theme was "We are deadly!" Parents were invited to attend the school and see students engaged in YDM. Local business people were also invited to come into the school and talk about the reality of how maths was a part of their world. Classes broke into year-level groups, with every teacher in the school having prepared different RAMR activities to cover a range of maths strands (e.g., every Prep teacher planned to cover a different maths strand so children could rotate through activities and work in all strands over the day).

The principal explained, *"Not only did we empower our colleagues, we also wanted to connect with our wider community, being our parent base."*

Parent information sessions were held, and YDC practitioners presented alongside school champions. The school newsletter showcased student engagement and success. The principal explained the importance of school staff working in partnership with YDC staff and parents: *"It allows parents and carers to learn about YDM from a YDC staff member, as well as the school staff. That gives credibility. They would check with [the YDC practitioner] when she would come: 'What are they doing? Is this ok?' It allowed [parents] to check independently what the school was doing."*

After one parent information session, the principal received an email from a parent saying, *"Thanks very much for forwarding us the materials. We are keen to learn more about the method in order to provide support for our sons in their learning. We are grateful to the school for taking up such an interesting and forward-looking initiative."*

Both parents and teachers described the positive impact of the "We are Deadly" celebration day. For example. Teacher reflections included that:

- *"The day was a HUGE success."*
- *"The day was literally buzzing with excitement. [We, the champions] had the privilege of taking photos. We have thousands – literally thousands of photos because the kids were so engaged."*
- *"This young lady [Year 4 student] was disengaged, but she was given a task to create 3 shapes. As you can see [from the photos] she got engaged, got on task, had success and thoroughly enjoyed the activity."*

In addition to positive feedback from parents on the day, a parent emailed the school principal to say: *"The maths activities that I saw the students participating in were fun and engaging (which is the idea behind YDM). The teachers had gone to a lot of trouble to prepare the activities, and I think the students enjoyed them immensely. As a mathematics teacher, I see so much benefit in what our school is doing to engender a love of learning maths into the students. Well done!"*

Another parent (of a Year 3 student) subsequently emailed to explain: *"My daughter participated in the NAPLAN test this year. Her results, especially in maths were well above our expectations. This result did not happen overnight and I directly contribute [sic] it to the support and encouragement provided to my daughter whilst at this school last year. The teachers helped her all year to achieve and maintain a high standard in maths, and didn't allow her to become complacent as they believed in her skills and abilities."*

Vignette 7.1 Engaging parents and the community in YDM

Engagement with the Indigenous community appears to have had an impact on Indigenous community support for increased school attendance, for the school's mathematics program, and for teaching Aboriginal and Torres Strait Islander knowledge to students, as found in principal survey results in the early stages of the PRIME Futures program (see Figure 7.11).

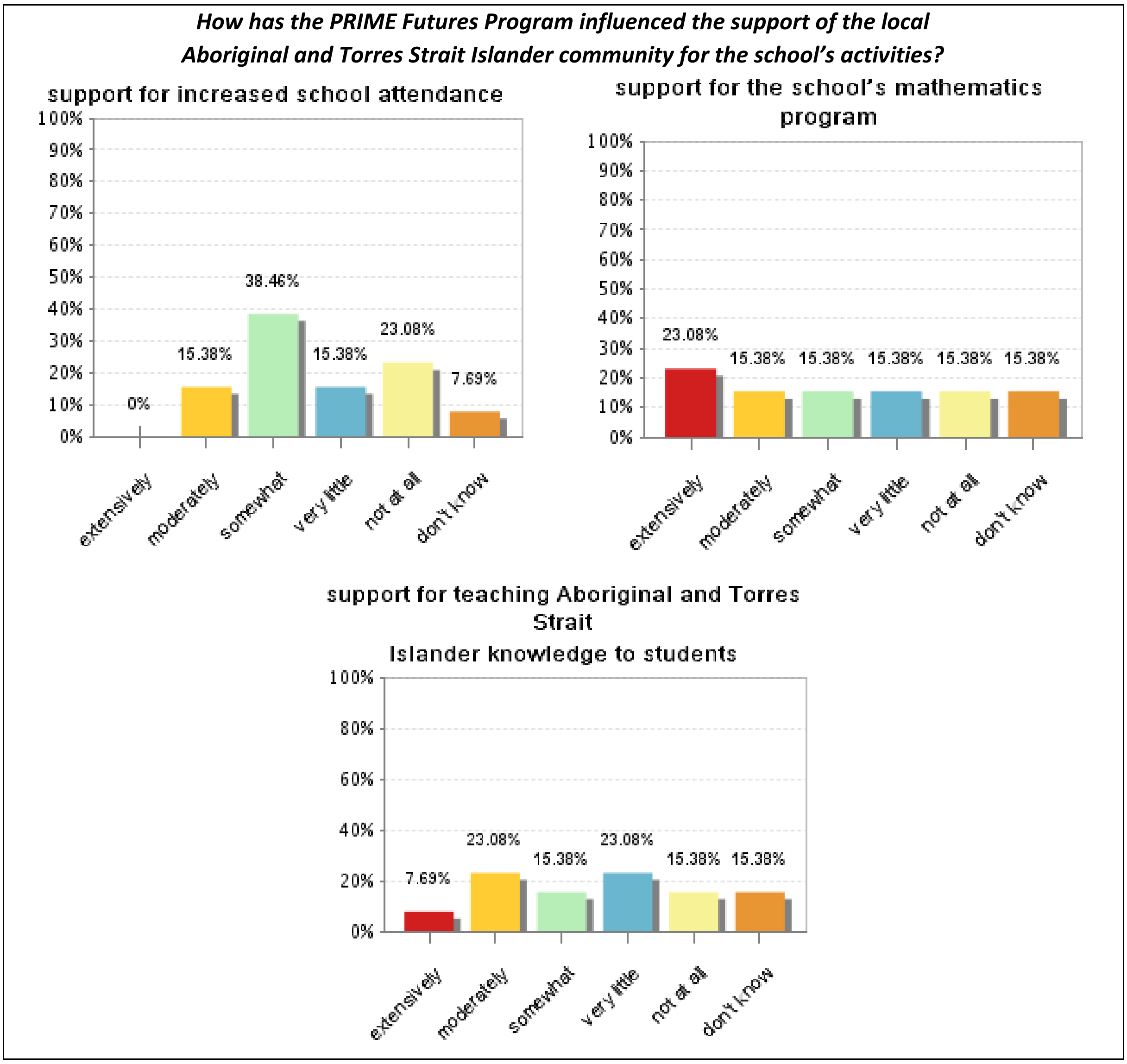


Figure 7.11 PRIME Futures Clusters 1–2 Principal Questionnaire 2: Support of the local Aboriginal and Torres Strait Islander community for the school's activities

7.3 School and education system partnerships

Collaborative research is increasingly recognised as important in both academic literature and departmental policy. For example, a key principle in the Queensland Department of Education's Research Planning Guidelines is that "research is collaborative and involves an open, respectful relationship between all participants, researchers, and partners" (DET, 2016, p. 5). For YDC, working collaboratively with schools not only provides opportunities for schools to improve knowledge, practice and outcomes through ongoing development, but also provides important contributions to knowledge. YDC has worked collaboratively with schools, education systems and philanthropic organisations since its inception.

Sharing knowledge within and between schools has been acknowledged globally as an important means of bringing about systemic change (e.g., Ainscow, 2015; Ainscow, Harris, & Carrington, 2017). Key policy documents such as the *Every student succeeding: State Schools Strategy 2016–2020* (Department of Education, Training and Employment, 2014) and the Australian Institute for Teaching and School Leadership's (AITSL) Professional Standards for Teachers (AITSL, n.d.-b) and Professional Standards for Principals (AITSL, n.d.-a) both acknowledge the importance of collaboration within, between and beyond schools (for example with parents and community members). Participating in YDM projects has provided educators with the opportunity to work collaboratively with colleagues within their own schools. Many participants have also had opportunity to work with other participating schools at PD sessions, and at the annual YDC Sharing Summit, which has now run for six years.

The YDC Sharing Summits have an important impact on teacher knowledge. A number of teachers have described that participating in the Sharing Summits was both inspiring and useful (for example, in terms of gaining practical knowledge and building support networks). Teacher reports indicate that YDM's train-the-trainer model and the Sharing Summits increase the movement of knowledge across schools and education systems, and increase collaboration within (and sometimes between) schools, creating "communities of practice". Participant feedback about the Sharing Summit has been collected each year. Analysis of participant feedback from 2016 reveals that both experienced and new YDM-trained teachers and leaders were overwhelmingly satisfied with the opportunity to learn from each other at the summit. Comments included:

> *"I realise I can't wait for others to invoke change – I need to be prepared to stand up and lead it. Thank you for organising and encouraging schools to participate."*
>
> *"I wish more of our staff attended, so it is not just the teaching of maths. Set up a network of summit participants so we could visit other schools. Really enjoyed this! Learned a lot."*
>
> *"It's very good to share knowledge across schools."*

Many teachers and principals have described that both working collaboratively with YDC staff and networking with other YDM schools have had a positive impact on teacher knowledge, engagement and confidence. For example, a provincial primary school principal said:

> *"We did need support. Pedagogical change always requires support and encouragement. A key feature of the agreement with QUT YDC was that for one week each term for two years, a mentor, coach, and critical friend visits the school to work with all the staff. This allowed the champions to explore issues and their understanding, and it allowed other teachers to access their expertise in the familiarity of their classroom."*

Working collaboratively with university YDC staff and sharing learning within, between and beyond schools helps to ensure that participants in YDC projects remain focused on successful implementation of the YDM program. The following excerpt from a presentation given by a principal of a P–12 remote college exemplifies the importance of collaboration between university researchers and schools.

> ***Sharing Summit 2015: Excerpt from a presentation given by a principal of a remote P–12 college***
>
> *"The model of QUT was very supportive. The instructional sessions each term ensured that staff were very clear on the content and the delivery model. As well as the instructional content of these sessions my staff were given the opportunity to network with other staff, from other schools, to learn from their implementation successes and challenges.*
>
> *I must say that overwhelmingly my staff returned from these sessions feeling empowered and valued. Like all teachers, they enjoyed sharing their stories and receiving the positive feedback from other teams and the presenters about their work.*
>
> *These sessions were then further supported by regular visits to our school. I believe that the importance of these was to keep the full team focused on the results that the program could deliver for students. The connection between the university staff and teachers ensures that the program remains practical and relevant to the classroom."*

Vignette 7.2 Excerpt from a 2015 Sharing Summit presentation given by a principal of a remote P–12 college

7.4 Industry partnerships and philanthropic funding

A Skills and Research Capacity report (Commonwealth of Australia, 2011) published by the Federal Department of Industry, Innovation and Science included YDC as a case study (p. 34) to illustrate the important role that higher education institutions such as universities play in the national innovation and capacity building agenda (https://industry.gov.au/Office-of-the-Chief-Economist/Publications/Policy/AustralianInnovationSystemReport/AISR2011/wp-content/uploads/2011/07/Case-Study-Compendium-Skills-and-Research-Capacity.pdf).

YDC has continued to work with research organisations, government departments and philanthropic funders as a means of generating and sharing knowledge. This is exemplified by YDC being awarded the $3.4 million in funding from CSIRO in partnership with the BHP Billiton Foundation in 2015 to deliver YDM training to a minimum of 60 schools, 120 teachers and 1500 Indigenous students through the PRIME Futures program.

7.5 Summary

The data presented in this section demonstrates YDC's reach of impact. The centre has worked with more than 240 schools in Australia across a range of:

- sectors (catholic, government and independent);
- states (Queensland, Victoria, South Australia and, from 2017, Western Australia);
- geolocations (remote, regional and metropolitan);
- levels of socio-economic advantage (from low to high SES schools); and
- mathematics teaching experience (from experienced maths heads of department to out-of-field teachers).

Data from the PRIME Futures program demonstrates both the reach and significance of impact as the aggregated data from the 29 participating schools in the first year demonstrates YDM has improved student engagement and increased sharing and collegiality among teachers. Further, evidence from a number of schools shows that YDM has been used to engage families and communities in children's maths education. This has been particularly important for Indigenous students. The PRIME Futures data from 29 schools indicates the impact on Indigenous students' attendance and communities' support for school maths programs.

8. Contribution to knowledge

This section details the impact of YDC in terms of the generation of professional knowledge (section 8.1), scholarly knowledge (section 8.2) and public knowledge (section 8.3).

8.1 Professional knowledge

A central principle for YDC has been a strong commitment to building teacher professional knowledge. Through its collaborative work with multiple schools, regions and communities, YDC has contributed to the generation of professional knowledge about the teaching of mathematics. It has produced a large number of resource books, exemplar lesson plans, teaching guides and other materials that are used in schools across the country (see section 7.1.1), and has contributed to the national "Teach Learn Share" website.

8.1.1 Production of resource books and exemplar materials

A large number of project resource books and exemplar teaching materials have been developed collaboratively between YDC staff and schools. For example, over 80 exemplar RAMR lessons were commissioned by the Queensland Department of Education following the TIME project. These lessons incorporated both Australian Curriculum Mathematics content descriptors and cross-curriculum priorities (as at the time of their production). Similarly, the TIME project led to the development of seven teacher resource books for Prep to Year 9, including six that detail how to teach number, operations, algebra, geometry, measurement, and statistics and probability. The AIM project developed 24 sequenced modules for accelerating mathematics learning of underperforming Years 7 to 9 students. The MITI project developed 45 extension tasks covering all mathematics content in the Australian Curriculum for Years 7 to 9. A complete list of materials generated by YDC is included at Appendix E.

8.1.2 Contribution to Teach Learn Share: The National Literacy and Numeracy Evidence Base

YDC has contributed to the "Teach Learn Share" website, which was a Federal Government initiative enabling "educators and education systems to share their most effective approaches to literacy and numeracy teaching and learning in Australia" (Curriculum & Leadership Journal, 2013), overseen by DEEWR as part of the Smarter Schools Literacy and Numeracy National Partnership. The site, which has now been incorporated into the Scootle website (as of 2014), is an online database of strategies and approaches for improving literacy and numeracy, submitted by teachers, professional associations, academics and education authorities in order to provide access to evidence-based research, as well as strategies shown to be successful in improving student outcomes in Australian schools and school systems. A video about YDC's AIM project and its effectiveness was developed by Teach Learn Share in collaboration with YDC. The video is available on the Scootle website:
http://www.scootle.edu.au/ec/viewing/S7089/index.html

8.2 Scholarly knowledge

Besides contributing to teacher professional knowledge, YDC has also worked to disseminate knowledge to a broader professional audience through publication in professional journals and at conferences. YDC staff and HDR students have published a range of scholarly material. Some publications have been in collaboration with teachers (e.g., Sorensen, Kidman, & McNeill, 2012), and others were written in collaboration with external academic authors (e.g., Cooper & Warren, 2011). A list of publications and conference presentations by members of YDC is provided in Appendix F.

YDC staff have also supervised a number of higher degree research students. A list of PhD and Masters students supervised by YDC staff since 2010 is provided in Appendix G.

8.3 Public knowledge

YDC staff's commitment to emancipatory pedagogies and breaking down deficit discourses around mathematics education and Indigenous education is also reflected in their efforts to educate the wider community. YDC has worked to help break down negative perceptions about Indigenous students' ability to learn mathematics, through contribution to media reporting and public debates (see Figure 8.1). For example, in 2016 YDC staff Professor Tom Cooper and Mr Jim Lowe contributed their knowledge at a round table discussion on mathematics education for the Standing Committee on Indigenous Affairs, Educational opportunities for Aboriginal and Torres Strait Islander students (http://parlinfo.aph.gov.au/parlInfo/search/display/display.w3p;query=Id%3A%22committees%2Fcommrep%2F074678d2-0be1-42a6-af24-897683b3e9ae%2F0003%22).

NEWS

http://www.abc.net.au/news/2016-04-28/yumi-maths-a-hit-in-hughenden/7364078

YuMi Deadly Maths a hit in Hughenden for students at different levels

ABC North West Qld By Kathleen Calderwood

Posted 28 Apr 2016, 9:30am

PHOTO: The year 4/5 class at Hughenden State School creates a column graph using their bodies in a YuMi maths lesson with teacher Karlee Bowtell. (ABC North Queensland: Kathleen Calderwood)

A small school in outback Queensland is having great success using a unique teaching program to help students learn maths and numeracy.

RELATED STORY: Internship gives new teachers a taste for school life

MAP: Hughenden 4821

YuMi Deadly Maths is a professional development program for teachers to help them teach maths in a more interactive and engaging way.

Figure 8.1 Excerpt from a media story covering YDM in a regional community

A list of media contributions is provided in Appendix H.

8.4 Summary

YDC has contributed to the generation of professional knowledge about the teaching of mathematics through its extensive corpus of project resources and to scholarly knowledge through academic publications. Further, YDC staff have contributed to public knowledge by appearing in a range of public forums such as parliamentary proceedings and media reporting. Developing teachers' professional knowledge and improving public perceptions of mathematics teaching and learning through such contributions is a significant impact, particularly given the context outlined in section 3 of this report.

9. Evaluation of impact

The preceding sections have demonstrated both the reach and significance of YDM in a wide range of areas, most significantly:

- Improving student achievement and knowledge, including NAPLAN performance in the numeracy domain.
- Improving student engagement in mathematics, from the early years through to senior secondary schooling.
- Improving equity by closing the gap between Indigenous and non-Indigenous student achievement, as well as boosting the achievement of students at low-SES and remote schools.
- Making rapid improvements in achievement for students who enter junior secondary school with results that are significantly below their peers (e.g., students who commence high school with a Year 2–3 level knowledge in maths and who, after participating in YDM, become willing and able to participate in non-compulsory maths subjects such as Maths A in senior secondary).
- Increasing teacher knowledge and confidence to teach maths; this was especially significant for the large number of out-of-field teachers who are currently teaching maths.
- Raising the expectations and knowledge of teachers in special schools.

In some cases, the significance of impact for individual students or schools was highlighted in the report. Other data, such as the PRIME Futures data and NAPLAN trend analysis, indicates the significant reach of YDM over more than 240 schools.

YDC has received funding totalling $13,635,366 over the last eight years (2009–2016) to support its projects. This funding has come from competitive, government, industry, internal QUT and philanthropic grants, and directly from schools through self-funding. In particular, the high number of schools willing to self-fund YDM training ($2,904,151 or 21% of total funding, from 81 schools) is evidence of the impact and success of the program, as is YDC's successful 2015 bid for $3.4 million in funding from CSIRO in partnership with the BHP Billiton Foundation to deliver the PRIME Futures program, which is YDC's largest single grant to date.

In conclusion, as can be seen throughout the report, YDC projects have had both short and longer term impacts, and YuMi Deadly Maths has had a positive effect on all stakeholders. With continued funding, YuMi Deadly Maths has the potential to grow both nationally and internationally.

> *"The best thing about my YuMi PD experience has been sharing ideas with other teachers and building a professional group that I can turn to when stuck planning. The Blackboard site has been pivotal to resourcing my planning and the discussion list has great potential."*
>
> *– Teacher*
>
> *"YuMi makes maths learning so purposeful, the activities each have a specific purpose but allow students freedom to create their solutions and methods. I walk into maths classes now and everybody is busy and on task enjoying their maths."*
>
> *– Curriculum leader*
>
> *"The result is that YDM has been implemented effectively into our school and our data confirms that our students' understanding of maths is improving. Thank you to YuMi Deadly Maths staff for your support and patience which has allowed us together to achieve such successful outcomes for our students."*
>
> *– Principal*

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Appendices

Appendix A: YDC history and pedagogical approach

QUT researchers have been working collaboratively with schools, TAFEs and community groups since the mid-1980s. From 2000 to 2009, researchers who are now part of YDC collaborated with principals and teachers predominantly from Aboriginal and Torres Strait Islander schools and occasionally from low-SES schools in a series of small projects to enhance student learning of mathematics. These projects tended to focus on a specific mathematics strand (e.g., whole-number numeration, operations, algebra, measurement) or on a particular part of schooling (e.g., middle school teachers, teacher aides, parents). They resulted in the development of specialist materials but at that stage did not form a comprehensive mathematics program.

In October 2009, QUT received funding from the Queensland Department of Education and Training (DET) to develop a train-the-trainer project, which aimed to enhance the capacity of schools in Central and Southern Queensland Indigenous and low-SES communities to teach mathematics effectively. The project focused on Years P to 3 in 2010, Years 4 to 7 in 2011 and Years 7 to 9 in 2012 and covered all aspects of school mathematics. This work facilitated the development of YDM as a cohesive mathematics pedagogical framework covering all content strands of the Australian Curriculum: Mathematics (ACARA, 2016b) and now underpins all YDC projects.

The receipt of grants for the DET project and for two other large projects funded by the Australian Department of Education, Employment and Workplace Relations (DEEWR), and the Australian Research Council (ARC), resulted in the establishment of YDC in 2010. These grants allowed YDC researchers to refine YDM and develop comprehensive PD programs for teachers. On completion of these projects, YDC began collaborating directly with schools in the delivery and refinement of the PD for teachers. In doing this, it was found that YDM pedagogy was as effective for all students as it was for Indigenous and low-SES students. To date, YDC staff have worked with teachers in more than 200 schools.

More recently, YDC has been contracted to deliver the PRIME Futures Program, the mathematics element of the wider Indigenous STEM Education Project managed by CSIRO in partnership with the BHP Billiton Foundation. Over four years from 2015, this program will reach a minimum of 60 schools, 120 teachers and 1500 Indigenous students in 10 geographic clusters. Another current project is the preparation and delivery of a 24-week online program of PD in Years 7 to 9 mathematics content and pedagogy for up to 400 out-of-field teachers employed by DET.

YDC operates under the leadership of Professor Tom Cooper and currently employs researchers whose work underpins the continued development and refinement of YDC programs and who also contribute to the delivery of the PD to teachers. YDC employs experienced teachers of primary and secondary mathematics to undertake the detailed program development, delivery and support of schools; and administrators who manage and support the day-to-day work of YDC. YDM now underlies three types of projects available to schools: YDM general pedagogy projects which provide basic training in the YDM pedagogy; YDM accelerated learning projects which provide training in remedial pedagogy to accelerate learning; and YDM enrichment and extension projects which provide training in pedagogy to build deep learning of powerful maths and increase participation in post-compulsory and tertiary mathematics.

Approach to teacher resources YDC resources are distributed to PD participants in hard copy form at PD workshops and electronically through password-protected access to the relevant part of the YDC website or QUT Blackboard site.

Research basis of YDC

The mission of YDC is to enhance the teaching and learning of mathematics to improve employment and life chances, particularly for Indigenous and low-SES students. As part of this mission, YDC is committed to ongoing research. Each year researchers and practitioners from YDC present research papers and workshops at several academic and professional conferences in Australia and internationally. They also regularly contribute articles for publication in scholarly and professional journals. This work is detailed in Appendix F.

The aim of YDC research is to:

- ensure that YDM continues to represent best practice in mathematics education, particularly for Indigenous and low-SES students;
- investigate and monitor emerging issues in mathematics education;
- refine the methods used for teacher PD in a scaled-up environment using the train-the-trainer model; and
- monitor, evaluate, and report on YDC projects.

The proven record of YDC in research has led to the development of the YDM pedagogy and associated materials. The YDM programs and materials are continually refined, upgraded, and expanded based on ongoing work of YDC researchers and practitioners (e.g., the recent XLR8 Mathematics Project funded by ARC) and others (e.g., the development of a new teacher resource booklet on literacy in mathematics).

The focus of YDM is the delivery of mathematics programs to school students ranging from the pre-school/reception/kindergarten years to Year 12, both content (what is taught) and pedagogy (how it is taught). This requires that YDC researchers and practitioners research effective practices, stay abreast of current research by others in the area, and maintain familiarity with technological advances affecting mathematics education.

An integral part of the work of YDC is the provision of PD to teachers in a manner that is cost effective, yet sustainable. Action research methods are used, based on a train-the-trainer approach. This approach allows the “scaling up” of the PD from key teachers in schools trained by YDC to the other teachers of mathematics in those schools. The effectiveness of the YDC approach is continually evaluated, leading to enhancements and refinements, and the work of others in Australia and overseas is monitored. For example, YDC researchers are currently preparing a paper about the YDC experience of scaling up PD for possible future publication in a scholarly journal.

In conducting this research YDC uses the following approaches.

1. **Decolonising**. YDC research is decolonising (Tuhiwai Smith, 2012; Denzin, Lincoln, & Tuhiwai Smith, 2008) and follows the empowering outcomes approach advocated by Tuhiwai Smith where, in collaboration with the community, research is designed so that it is of immediate benefit to the researched. The arguments raised by Tuhiwai Smith for this approach in Indigenous contexts are equally valid for low-SES contexts.
2. **Design experiment**. To be decolonising, YDC research follows the design experiment methodology (Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003), which is an extension of the teaching experiment methodology (Vygotsky, 1978). Within continuous thesis, antithesis and synthesis cycles:

   (a) resources are developed for professional learning of teachers and classroom learning of students based on best available theories of professional and student learning;

   (b) the professional learning resources are trialled, in a practical context, by the researchers with the teachers, and the classroom learning resources by the teachers with students, and these trials are observed and data gathered with respect to practices and outcomes; and

   (c) the datasets are analysed in terms of the interaction between researcher action and teacher response and teacher action and student response, and in terms of the effectiveness of the resources.

   This enables researchers to:

   (a) construct deeper explanatory theories on the interaction between researchers and teachers and between teachers and students that leads to deeper understanding of effective professional learning of teachers and content learning of students within the practical context; and

   (b) construct more innovative and effective resources from the evaluations of the applications of the professional learning and student instructional strategies within the studies and in terms of the theories.
3. **Action research**. YDC research follows the action research methodology (Koshy, 2009; McNiff, 2013) to improve the practices of researchers and teachers through a cycle of plan, act, observe and reflect. The action research and design experiment research reinforce each other. Researchers gather data on the effectiveness of their professional learning in terms of teachers’ practices, and teachers are encouraged to gather data on their classroom trials, use action research practices to evaluate their effectiveness, and share

this with researchers. Because of the action research approach, teaching and learning improves, benefiting the subjects of the research (schools, teachers and students), consistent with the decolonising approach.

4. **Mixed method, case study and longitudinal**. YDC research is mixed method (e.g., Creswell & Plano Clark, 2011) because it uses a mix of qualitative and quantitative approaches. It is qualitative in that it uses observation, interviews and the gathering of artefacts (e.g., reflective journals, lesson plans, students' work) to describe what is happening. It is also quantitative in that it uses feedback sheets, surveys, and pre- and post-tests to identify change (and, in some cases, test for significance). Second, YDC research is case study (e.g., Yin, 2009) because it focuses on classrooms, schools, cohorts of schools, teachers and groups of teachers as cases and provides rich descriptions of their involvement. These become part of the data and assist in developing explanation of change, or lack of change, that is the basis of theory. Last, YDC research is longitudinal in that it follows schools, teachers and students across a period of time while they are involved in professional learning and classroom trials.

   It should be noted that YDC research is based on the view that data gathering must be undertaken by experts in teaching and learning so that important components are identified.

5. **Emerging, contingent and cumulative**. YDC research is emerging because, although operating from theories of teaching and learning, it allows theory to emerge from the data (using the thesis, antithesis and synthesis dialectic). It also is contingent in that the results of previous data gatherings are used to determine future parts it studies. Finally, it is cumulative in that data is combined and analysed at the end of projects, linking patterns that emerge across parts of the studies.

Looking at the five characteristics of YDC research described above, it is apparent that YDC research meets the Higher Education Research Data Collection (HERDC) criteria for research.

1. **Creation of new knowledge**. YDC research easily meets this criterion as the structure and final aim of all YDC research is to create explanatory theory for PD and classroom teaching and learning and innovative PD and student learning resources. In particular, ongoing YDC research is directed at developing innovative approaches to teaching and learning by developing theory about how structuring learning into vertically sequenced components enables acceleration of learning.

2. **Creative and systematic**. YDC research also meets these criteria of research. By focusing on interactions in real-life contexts, YDC research is forced to involve a wide variety of perspectives and to unpack a broad number of factors to explain behaviour observed and measured. This often requires creative analysis of rich datasets and attention to complexity within specific contexts, using cross-disciplinary techniques. YDC is also systematic in that its longitudinal aspect requires repeated data gatherings that enable factors to be followed across the life of the projects.

3. **Form of research**. YDC research is most obviously directed towards strategic basic and applied research. However, some studies have an experimental approach and many have experimental aspects in that some data is subjected to statistical analysis to test significance of results (this because of the mixed method approach). Also, YDC research has a strong pure research basis; this does not happen *within* funded projects but rather *across* funded projects. Because the research compares different (but similar) projects, researchers are able to identify and construct new theoretical frameworks, for example, relating to the acceleration theory described earlier.

Appendix B: Overview of YDC projects, schools and funding by type (2009–16)

Table B1 and Figure B1 summarise YDC project funding from late 2009 to 2016 categorised by sources of funding and type of project. Tables B2 to B4 on the following pages provide details and brief descriptions of individual projects in each category, with the number of schools participating in each project. Because many schools have participated in more than one project, the total number of schools shown in Tables B2 to B4 adds to more than 300. The actual number of different schools that have participated or are currently participating in YDC project is 249.

Table B1 *Summary of YDC project funding 2009–2016 by type of project*

Source of funding	YDM general pedagogy projects	YDM accelerated learning, enrichment-extension and integrated projects	YDM vocational and context-based projects	Total
Competitive	$0	$855,000	$1,157,000	$2,012,000
Government/systems	$2,081,040	$2,000,000	$104,000	$4,185,040
Industry – schools/systems	$2,104,625	$799,526	$0	$2,904,151
Industry – other	$3,399,775	$0	$0	$3,399,775
Philanthropic	$0	$0	$209,400	$209,400
Internal QUT	$450,000	$450,000	$25,000	$925,000
Totals	**$8,035,440**	**$4,104,526**	**$1,495,400**	**$13,635,366**
No. of projects	**17**	**9**	**6**	**32**

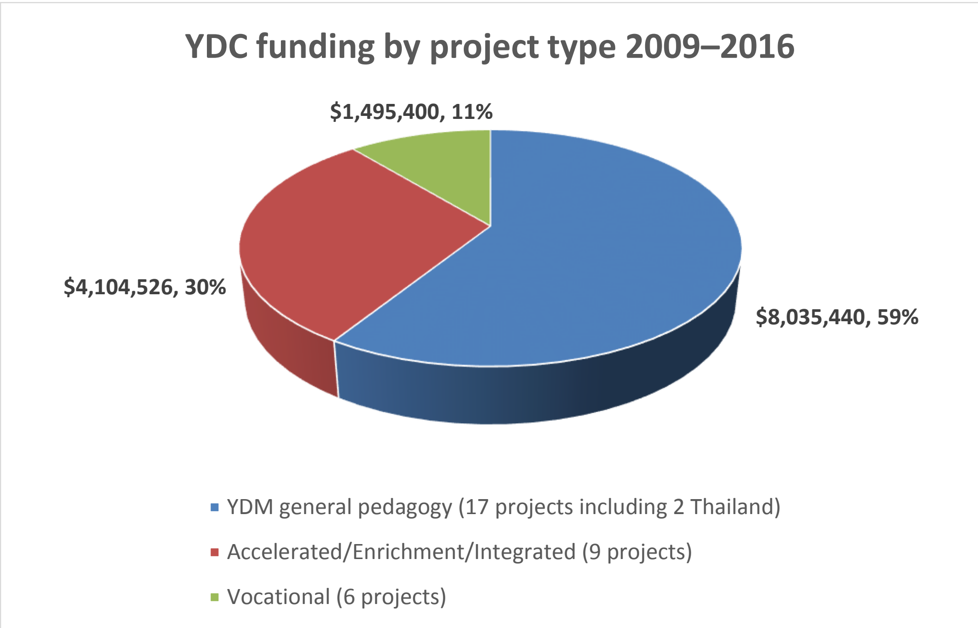


Figure B1 YDC funding by project type 2009–2016

Table B2 *YDM general pedagogy projects (2010–2016)*

Project title	Year(s)	No. of schools	Funding	Description
Teaching Indigenous Mathematics Education (TIME)	2010–12	109	$1,500,000 Qld DET	Delivered PD at QUT for key teachers from the schools, together with resources, using an action-research approach. Developed the YDM pedagogical approach, resources and PD program.
Sustainable Access to Mathematics (SAM)	2011	4	$119,200 ISQ	Worked with Year 4 teachers, focusing on whole numbers and common fractions. Training was a combination of PD and school visits. Diagnostic testing was included.
YDM-WMR Victoria*	2012–13	12	$360,000 WMR	Delivered YDM training at a central location in the Western Metropolitan Region of Victoria, together with resources, website access, and online support, using an action-research approach.
Sustainable Numeracy Academy Project (SNAP)	2012–13	21	$360,000 ISQ	Worked with numeracy coaches to enable them to lead their schools in using numeracy assessment, analysis, planning, teaching and reflection to enhance students' numeracy learning outcomes. Training was a combination of PD in a central location and visits to schools.
Partnering for Enhanced Mathematics Outcomes (PEMO)	2012–14	31	$450,000 QUT/HEPPP	Delivered YDM training to low socio-economic primary and secondary schools in the Caboolture area of north Brisbane, via a combination of central PD days and twilight sessions (funding also covered accelerated learning and enrichment/extension projects).
YDM Next Steps*	2012–14	9	$370,000	Delivered YDM training at central locations (Brisbane and Central Queensland); included visits to schools.
YDM North Queensland*	2013–17	8	$452,809	Training was/is a combination of central delivery in North Queensland and visits to schools. Some schools are having new teachers trained each year.
YDM TIMEX*	2013–14	4	$20,000	Provided school visits and PD to improve implementation of the YDM program following the TIME project.
LongTIME	2013	-	$50,000	Funding from DET ISSU for longitudinal case studies of schools involved in TIME project.
YDM Remote*	2013–15	4	$274,236	Delivered YDM training through online methods and visits to schools.
Australian Thai Mathematics Education (ATME) Private Educational Administrators Project (PEAP)	2013 2014–15	 6	$13,200 $38,640	The ATME project was funded by the Australia-Thailand Institute, DFAT, to establish and promote professional learning networks between educators in Thailand and Australia. The PEAP project was funded by an Australia Endeavour Research Fellowship and worked with six private schools in the Chiang Mai district, delivering 5 days of PD covering YDM pedagogy including RAMR and big ideas for Year 4 Thai curriculum topics.
YDM Central Queensland*	2014–15	8	$180,000	Training was a combination of central delivery in Central Queensland and online support.
YDM Metropolitan*	2014–15	4	$136,480	Training was tailored to individual schools and was a combination of central delivery at QUT and visits to schools.
YDM Special Schools*	2014–16 2015–17	14	$260,000	Training was/is a combination of central delivery at QUT and visits to schools.
YDM Toowoomba*	2015–17	1	$51,100	Training is a combination of central delivery at QUT and visits to the school.
PRIME Futures	2015–19	43	$3,399,775	Training is a combination of central delivery for the cluster and visits to schools.
Total schools/funding		**278**	**$8,035,440**	

Note. DET = Department of Education and Training; DFAT = Department of Foreign Affairs and Trade; ISQ = Independent Schools Queensland; ISSU = Indigenous Schooling Support Unit; WMR = Western Metropolitan Region (Victoria); HEPPP = Higher Education Participation and Partnership Program. * = self-funded by schools or regional partnerships.

Table B3 *YDM accelerated learning, enrichment-extension and integrated projects (2010–2016)*

Project title	Year(s)	No. of schools	Funding	Description
Accelerated Indigenous Mathematics (AIM)	2010–13	9	$2,000,000 DEEWR	Worked with Years 8–10 teachers, teacher aides, students, and community in nine Queensland regional schools with cohorts of Aboriginal and Torres Strait Islander students to develop a mathematics program to accelerate the students' learning to where they could access mathematics subjects in Years 11–12 and therefore enhance their employment and life chances. Developed modules, sequenced over three years, that are vertical sequences of learning to take students from their ability level to their age level in mathematics.
XLR8 Maths Pilot*	2010–11	6	$70,000	Provided PD workshops and maths resource booklets based around the teaching of mathematics to accelerate underperforming Years 8–9 students, with the aim of improving their access to Years 10–12 mathematics and beyond.
ARC Linkage XLR8 Maths (LP120200591)	2012–16	4	$855,000 ARC	An adaptation of AIM to low socio-economic schools with a low percentage of Indigenous students and across two years rather than three. Provided a special program for students working approximately four years below the level of their peers in junior secondary cohorts to enable access to mainstream Year 10 classes. Developed modules for Years 7 to 9 and included diagnostic and summative assessment.
PEMO Partnering to Accelerate Mathematics (PAM)	2013–14	12	$225,000 QUT/HEPPP	An adaptation of AIM to non-Indigenous schools and across two years rather than three. Scaffolded the accelerated learning of mathematics by underperforming Years 8–9 secondary students. Provided PD and resources.
PEMO Mathematicians in Training Initiative (MITI) Pilot	2013–14	7	$225,000 QUT/HEPPP	Developed approaches that increase Mathematics B and C uptake in high schools, including activity across all years of high school to identify potential students and provide them with instruction that enables easy progress to higher level post-compulsory mathematics.
MITI Metropolitan*	2014–15	5	$50,000	Delivered PD and a collection of 45 Enrichment and Extension tasks for Years 7–9 enabling schools to design a course covering the Australian Curriculum: Mathematics for these year levels using only the 45 tasks.
AIM Reflection Project*	2015	1	$14,850	Provided PD, school visits and resources to train school staff in YDM and AIM using the AIM vertical curriculum modules designed to enable underperforming students to reach Year 9 level and access Years 10–12 subjects.
YDM Integrated projects (ISS/ISM)*	2014–16	5	$572,776	Integration of two or three YDM projects (YDM TDT, AIM and/or MITI), tailored to the needs and objectives of each school. Provided PD and school visits to develop programs to meet the needs of the students.
Accelerated Inclusive Mathematics Early Understandings (AIM EU)*	2015–17	1	$91,900	Developing a new set of nine AIM-style modules covering Prep to Year 2 material to improve Year 3 outcomes and delivering PD on their implementation in the classroom.
Total schools/funding		**50**	**$4,104,526**	

Note. DEEWR = Department of Education, Employment and Workplace Relations; ARC = Australian Research Council; HEPPP = Higher Education Participation and Partnership Program. * = self-funded by schools.

Table B4 *YDM vocational and context-based projects (2010–2016)*

Project title	Year(s)	No. of schools	Funding	Description
ARC Linkage VET Skilling Indigenous Australia (LP0989663)	2010–13	4	$1,157,000 ARC	The project developed, evaluated and refined mathematics teaching and assessment resources for a variety of VET courses, particularly those associated with mining and construction. The project aimed to address concerns about both Indigenous unemployment and Indigenous skills shortages at the same time by making VET certification and employment attainable for Indigenous students.
Get Into Vocational Education (GIVE)	2010 2011	2	$86,400 Rio Tinto Alcan Community Fund $100,000 The John Villiers Trust	GIVE developed and studied the effectiveness of an integrated literacy, mathematics, science and trades program for students in Years 4–9. The trades context was later expanded to include other motivating contexts such as robotics. The GIVE project was one of three State Finalists in the Middle Phase of Learning category of the 2011 Education Queensland Showcase Awards.
Footprints to Pathways: Sustaining Indigenous Employment in Queensland	2013–14		$104,000 Dept of Transport & Main Roads	This project aimed to develop practical knowledge and understandings about the attraction, recruitment, training, retention and tenure of Indigenous people in Queensland. This project was a pilot for an (unsuccessful) ARC Linkage application submitted for 2014–17.
JAMATH: Engaging with music industry and school staff and students through research on music and mathematics.	2011–12	4	$25,000 QUT Engagement Innovation	A collaboration between YDC and music group Join Australian Music (JAM) that integrated music and mathematics in order to motivate and engage students to improve learning. JAM provided workshop days of music experiences and activities for students. YDC provided mathematics teaching before and after the JAM workshop days that used music contexts to look at the maths topics of number, fraction, patterning, measurement and shape. YDC also provided PD sessions to prepare teachers for the music day.
JAMATHS Central Highlands	2014	1	$23,000 Kestrel Aboriginal Community Development Fund	As above
Total schools/funding		**11**	**$1,495,400**	

Note. ARC = Australian Research Council; VET = Vocational Education and Training.

Appendix C: Methodology for NAPLAN analysis

The analysis was based on data obtained from two sources:

- school NAPLAN data published annually in the My School website (ACARA, 2016c), for YDM schools (mainly located in Queensland) and their similar schools (as at May 1, 2016); and
- NAPLAN data for all students across Australia published in the annual national reports of the NAPLAN program (e.g., ACARA, 2015a).

For any particular school, the average gain over two years is calculated as the difference (usually increase) in the mean scale score (MSS) achieved in the NAPLAN numeracy test(s) by a cohort of students in that school with the MSS of the same cohort in that school two years later. The MSS is based on the raw score achieved in the NAPLAN tests in a particular domain (for example, numeracy) that has been:

- normalised across Australia to allow for variations in raw test results from one year to the next (for example, the difficulty of the tests may vary); and
- vertically equated so that a result in a NAPLAN domain in one year (e.g., Year 3 in 2014) can be compared with a result in the same domain two years later (e.g., Year 5 in 2016).

Nationally, the average gain is calculated as the difference in the MSS achieved in the NAPLAN numeracy test(s) by all students in Australia with that of the same cohort two years later.

Similar schools are defined in relation to a particular school (called the selected school). They are a group of up to 60 schools with students from statistically similar backgrounds to the students from the selected school. Statistically similar backgrounds are determined by reference to the Index of Community Socio-educational Advantage (ICSEA; ACARA, 2015b) that takes account of students' socio-economic advantage, the school's remoteness and the percentage of Indigenous students enrolled. An average NAPLAN result is calculated for these 60 similar schools to enable comparison with the NAPLAN results of the selected school. The group of schools that are similar to the selected school will vary from year to year as the ICSEA status of the various schools changes.

The analysis was completed by YDC during 2016 and consequently does not include secondary school (Years 7–9) data because most Queensland state secondary schools only accepted their first cohort of Year 7 students in 2015. For the same reason, the Years 5–7 data comparison ends in 2014. Secondary school results will be analysed by YDC during 2017.

In analysing the data, the use of data from My School required the following assumptions:

- Given that YDM focuses on mathematics, only the data in the NAPLAN domain of numeracy was considered.
- The calculations of the mean gain over two years for YDM schools and for similar schools were based on the average gain for each school, with the result that a small school had the same impact on the mean as a large school. Drawing conclusions based on the mean of data that has already been averaged can be misleading. However, to allow for school size would require data on the number of students in the relevant cohorts in each school. While this data is available in the My School website for individual schools, it is not available for their similar schools.
- In contrast, the Australia-wide data on average gain (labelled *all schools*) is calculated by averaging the result for each student, not for each school. This means that a small school would have a lesser contribution to the mean gain than a large school. Accordingly, the all-schools data is useful for analysing trends in the data, but not for direct comparisons. For example, differences in the way that the mean gain is calculated in these two instances would prevent a claim that YDM schools are showing a greater mean gain than schools throughout Australia.

These assumptions have an impact on the validity and reliability of the conclusions. However, given the nature of the data that is available through the My School website, it is not possible to improve on the analysis.

Appendix D: Interviews conducted by a school principal of a regional primary school

Interview with two Year 5 students

Principal: So, you've been doing something different in maths – can you tell me about that?

Charlie: We've been going outside and doing activities. It's more fun than sitting inside. Everybody contributes with their ideas.

Brooke: No-one just sits and mucks around at their desk.

Charlie: Yeah. Everyone has a turn. We get to do it every day during maths. It's lots of fun, and people all get to have a turn. Not just one person.

Brooke: Yeah

Principal: Is that a big change from the way you used to do maths before?

Both: Yeah.

Principal: How is it different?

Charlie: When maths was just on the board, we would just copy it down and write an answer. Whereas when we are outside we all get involved, and it is like a game but it's learning at the same time. It's fun…

Brooke: It's not like people are just getting bored and fiddling at their desk… And lots of the boys don't concentrate…

Charlie: Yes! Most of the boys don't really contribute or anything. But now they are.

Principal: Does it make any difference to what you have learned about maths?

Both: Yeah!

Brooke: I have learned a lot more things.

Charlie: Yeah. Like with mapping if you have to go to [a coordinate] A3, I thought you always thought you just go up and then go to the side. And now … there are some ways of going … like with degree angles. And I've learnt what an acute angle is … and how big degrees are. And it's more fun than usual.

Principal: And does it make more sense?

Both: Yeah.

Brooke: Yeah, it does. Because people don't just sit there being bored. They get more interested in it.

Charlie: Most people [used to] get bored and just sit around during maths class.

Principal: Do you see maths in other places now? Before, you were saying that you were doing a lot of writing…

Both: Yeah.

Brooke: So our teacher is going to teach us maths now and we know how it connects to the "out world" … to the outside.

Charlie: Our teacher has been helping us with chance and patterns and stuff. That is going to help us with the things we need to survive in the real world.

Brooke: And it also helps us for tests because we can get higher marks. Because also our results are getting higher. Definitely.

Principal: Have they? For you both?

Both: Yeah.

Charlie: And for the whole class as well. Most people have improved. Since the start of the year. At the start of the year no-one really… well everyone hated maths. But now… with YuMi Deadly Maths, it's just… awesome… it's fun… it's energetic! It's like games and learning!

Brooke: And now people are getting As and Bs!

Principal: Do your parents know that you are doing this kind of maths?

Brooke: Yeah, and Mum is like, "oh I didn't know that!" (imitates someone learning a new maths concept)

Charlie: My parents are really happy I am doing better in my maths.

Brooke: Yeah… because I'm getting better grades. I'm understanding it more.

Principal: So if someone hadn't done this kind of maths before, what could you tell them?

Charlie: Well we could tell them if we could have something more than just sums on the board for us to just copy down.

Brooke: Tell them it can be more fun, energetic and that people all get to have a go. And that they would probably concentrate more.

Principal: In this kind of maths, you do a lot of things that are hands on. Do you come up with any of those ideas?

Charlie: Usually… well recently we've done… well we're working on chance. We had a number line and some people had a card and it has "likely", "possible", or "definite", then two people would hold a string and you would have to peg up where you think your card would go. That helped us because…

Brooke: Yeah, like people would say, "oh I didn't know where that would go. I thought it went higher…" And then they started to understand it.

Charlie: Some people didn't understand what "possible" meant.

Principal: So it helped you understand the language you were using because you could see it…

Both: Yeah…

Brooke: And then when people started understanding the language, placing it on the number line, they'd know exactly where it goes, and how the number line continues on… all that kind of stuff.

Principal: How do you think this has set you up for Year 6 maths?

Charlie: I think it is going to help me improve. As I said, at the start of the year I hated it. I wasn't really good at it. So now that I'm higher in my grades, I'm actually enjoying it. So I think I will do much better.

Brooke: Yeah, and then also you can get higher marks. And you understand a lot more of it because you've really gone over it – you've put your hands on it. So you won't be confused, not like when you are on the board and not learning about it doing YuMi Deadly. And then it would be like… you wouldn't listen as much.

Charlie: It would be boring! (Both laugh).

Principal: Thank you for sharing your ideas with us. I'm glad you are doing so well!

Interview with two Prep students

Principal: Do you write down what you have done?

Georgia: Yes. We write down the numbers… like if we are doing equals and plus.

Principal: Is it easier to write down after you've been doing it with your body?

Georgia: Yes! Because you know it.

Principal: What is your favourite subject? Reading? Maths?

Georgia: I think YuMi Deadly Maths.

Principal: Why?

Georgia: It's more funner. And we get to use counters and draw stuff and make numbers and…

Chris: … and tally marks and number tracks…

Georgia: and new knowledge. And pictures. The work. Tally marks and lots of different stuff.

Chris: And you know the number of something. And you can use the tens frame….

Principal: Well thank you very much for sharing!

Appendix E: List of project materials and resources developed by YDC

Figure E1 summarises the corpus of professional resources developed by YDC since 2010. Tables E1 and E2 on the following pages list the print resources in more detail.

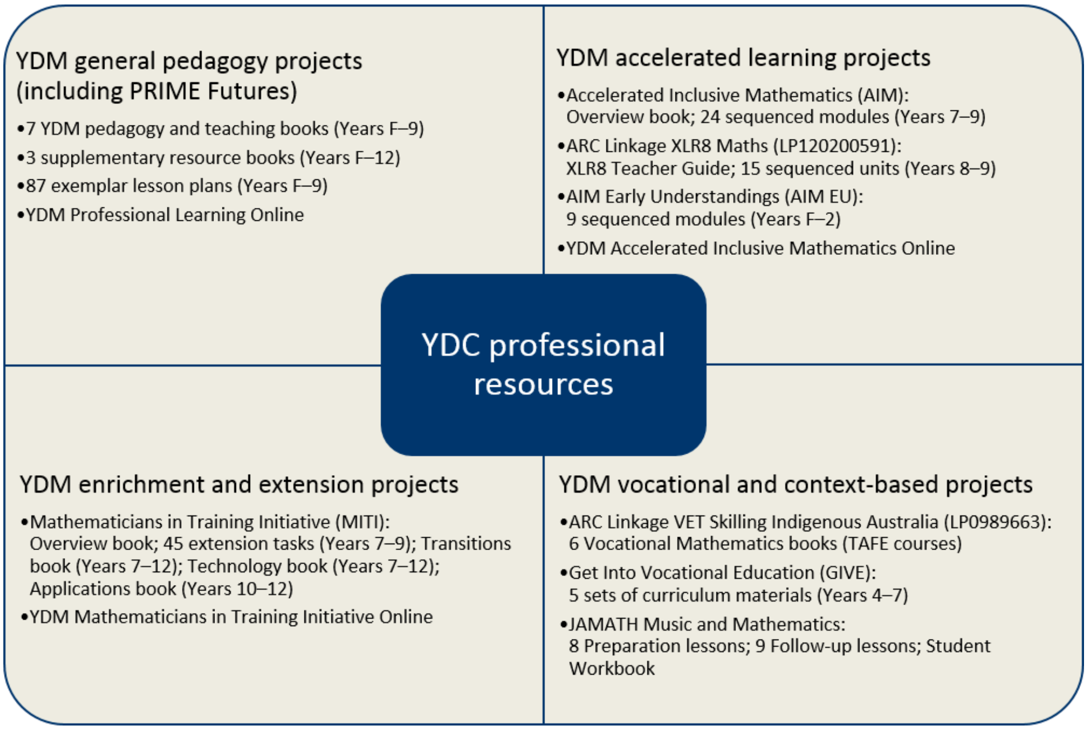
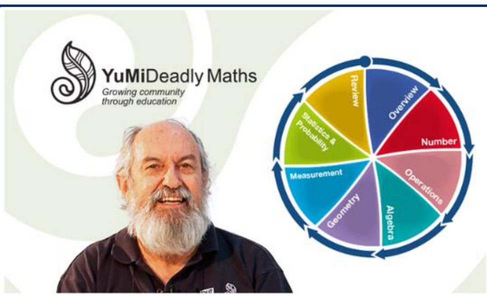


Figure E1 YDC print and online professional resources

YDM Professional Learning Online is a QUT Blackboard Community site for participants in YDC projects. It includes online learning modules which align with the 7 YDM pedagogy and teaching books covering mathematics for Years F to 9, plus a Review section (Figure E2). The modules are made up of PowerPoint slides and short video segments presented by YDC practitioners.



- **Overview**
  Introduction 65 mins
- **Number**
  Introduction 75 mins
  Session One 30 mins
  Session Two 45 mins
- **Operations**
  Session One 45 mins
  Session Two 60 mins
- **Algebra**
  Session One 65 mins
  Session Two 65 mins
- **Geometry**
  Session One 60 mins
  Session Two 75 mins
- **Measurement**
  Session One 65 mins
  Session Two 65 mins
- **Statistics and Probability**
  Session One 45 mins
  Session Two 45 mins
- **Review**
  Links to YDM-CCP Teacher Resources (lesson plans) by year level or topic

Figure E2 YDM Professional Learning Online modules

Table E1 *YDM project materials*

YDM general pedagogy projects

YuMi Deadly Maths (YDM) general pedagogy projects including PRIME Futures

7 YDM pedagogy and teaching books (Years F to 9):
Overview
Number
Operations
Measurement
Algebra
Geometry
Statistics and Probability

3 supplementary resource books:
Big Ideas for Mathematics
Problem Solving
Literacy in Mathematics

Sustainable Numeracy Academy Project (SNAP)

5 PD modules—Maths and My World series:
Module 1: Maths and My World Overview
Module 2: Numbers and My World
Module 3: Operating and Calculating in My World
Module 4: Algebra and Patterns in My World
Module 5: Solving Problems in My World

YDM accelerated learning projects

Accelerated Inclusive Mathematics (AIM)

- Overview book
- 24 modules (Years 7–9):

8 Year A modules (Year 7):
N1 Whole Number Numeration
N2 Decimal Number Numeration
O1 Addition and Subtraction for Whole Numbers
M1 Basic Measurement (Length, Mass and Capacity)
O2 Multiplication and Division for Whole Numbers
M2 Relationship Measurement (Perimeter, Area and Volume)
G1 Shape (3D, 2D, Line and Angle)
SP1 Tables and Graphs

8 Year B modules (Year 8):
M3 Extension Measurement (Time, Money, Angle and Temperature)
N3 Common Fractions
G2 Euclidean Transformations (Flips, Slides and Turns)
O3 Common and Decimal Fraction Operations
A1 Equivalence and Equations
N4 Percent, Rate and Ratio
SP2 Probability
G3 Coordinates and Graphing

8 Year C modules (Year 9):
A2 Patterns and Linear Relationships
N5 Directed Number, Indices and Systems
A3 Change and Functions
G4 Projective and Topology
O4 Arithmetic and Algebra Principles
SP3 Statistical Inference
A4 Algebraic Computation
O5 Financial Mathematics

ARC Linkage XLR8 Maths (LP120200591)

- Teacher Guide
- 15 units (Years 8–9):

7 Year A units (Year 8):
Unit 01 Comparing, counting and representing quantity
Unit 02 Additive change of quantities
Unit 03 Multiplicative change of quantities
Unit 04 Investigating, measuring and changing shapes
Unit 05 Dealing with remainders
Unit 06 Operations with fractions and decimals
Unit 07 Percentages

8 Year B units (Year 9):
Unit 08 Calculating coverage
Unit 09 Measuring and maintaining ratios of quantities
Unit 10 Summarising data with statistics
Unit 11 Describing location and movement
Unit 12 Enlarging maps and plans
Unit 13 Modelling with linear relationships
Unit 14 Volume of 3D objects
Unit 15 Probability

Accelerated Inclusive Mathematics Early Understandings (AIM EU)

9 modules (Years F to 2):

Module N1 Counting
Module A1 Patterning
Module A2 Functions and Equations
Module N2 Place Value
Module N3 Quantity
Module O1 Thinking and Solving
Module O2 Meaning and Operating
Module O3 Calculating
Module N4 Fractions

YDM enrichment and extension projects

Mathematicians in Training Initiative (MITI)

- Overview book
- Transitions book (Years 7–12)
- Technology book (Years 7–12)
- Applications book (Years 10–12)
- 45 Extension tasks (Years 7–9):

15 Year 7 tasks:

7A1 Reflecting on Rotations
7A2 Connected Expressions
7G1 Flippin' Congruence
7G2 Finding the Winning Strategy
7M1 Rocking Around the World
7M2 Cheap Houses
7N1 Tangled Fractions
7N2 Directing Numbers
7N3 What Are You Worth?
7N4 How Tall is the Criminal?
7N5 Rating Our World
7P1 Dice Doubles
7P2 Fair Game
7S1 Are Older Actors Better?
PS1 Assuming Too Much

15 Year 8 tasks:

8A1 Growing Patterns and Growing Graphs
8A2 Algebraic Caterpillars
8A3 Building a Mathematics Structure
8G1 Maths in a Box
8M1 Accuracy and Precision
8M2 Designing a Kitchen
8M3 Crazy Bird Boxes
8N1 Diminishing Fractions
8N2 Challenging Fractions
8N3 Square Percentages
8N4 Consecutive Sums
8P1 The Lucky Prince
8P2 And Not Or
8S1 Distributing Distributions
PS2 Topological Oddities

15 Year 9 tasks:

9A1 Dividing Diagonals
9A2 Taking the Guesswork Out of Maths
9G1 Constructive Constructions
9M1 Look Out for the Baby!
9M2 Square Angles
9M3 Three-Fact Triangles
9M4 How High is that Tree?
9N1 Power-ful Mathematics
9N2 It's All Greek to Me
9N3 Which Card?
9P1 Is Greed Good?
9P2 Monopolising Monopoly
9S1 How to Lie with Statistics
9S2 A vs B
PS3 Investigating Investigations

YDM vocational learning and context-based projects

ARC Linkage VET Skilling Indigenous Australia (LP0989663)

6 Vocational Mathematics books:

Certificate II in Horticulture
Certificate III in Children's Services
Civil Construction and Numeracy
Manual Arts and Mathematics
Remote Area Teacher Education Program (RATEP) and Mathematics
Diagnostic Assessment (covering a range of mathematics strands)

Get Into Vocational Education (GIVE)

Curriculum materials:

Year 4 Construction
Year 5 Horticulture
Year 6 Hospitality
Year 7 Design and Engineering (billy carts)
Year 5/6 (composite class) Service Industry

JAMATH Music and Mathematics

8 Preparation lessons:

Lessons 1 and 2: Patterns and Music
Lessons 3 and 4: Fraction, Ratio, Shape and Pitch
Lessons 5 and 6: Shape, Volume and Loudness
Lessons 7 and 8: Time, Notes and Beat

9 Follow-up lessons:

Lessons 1 to 4: Patterns in Music:
Lessons 5 to 7: Equivalence/Fractions in Music:
Lessons 8 to 9: Measurement in Music
Student Workbook

Key: A = Algebra; G = Geometry; M = Measurement; N = Number; O = Operations; P = Probability; PS = Problem Solving; S = Statistics; SP = Statistics and Probability

Table E2 *YDM exemplar lesson plans – Years F/P to 9*

Number and Algebra	Measurement and Geometry	Statistics and Probability
Foundation/Prep (9 lessons)		
Bits and pieces Let's go hunting Partners Pattern hunt Spot the number	Guess where? How long does it take? My drink bottle Sensational shape hunt	
Year 1 (9 lessons)		
Big steps in growing Pattern pursuit Put them together The teen game When I'm a teenager	Dare to compare My special time	Deadly data What's the chance?
Year 2 (10 lessons)		
The animals went in two by two Patterns How many clumps?	Clever calendars Which is the longest? Out and about Shape search Tracking triangles	Favourites Today's traffic tale
Year 3 (9 lessons)		
Hundreds and thousands School challenge Flying high Wholes and parts Cutting it up	Angle it Fill it up	Come in spinner Lucky dip
Year 4 (10 lessons)		
Act it out How many quads? Left overs Spending the Lotto millions Tuckshop orders Walking the rope	How long is a foot? Make your own ruler My town Symmetry hunt	
Year 5 (8 lessons)		
Bright budgeting Crack the code Pizza for lunch	Packaging Patrolling the perimeter Skateboard skills Supersize it	Chances are
Year 6 (8 lessons)		
An equal share Ups and downs Smart shopping	Angle strength Change course Covert me Fencing the yard	Loaded dice
Year 7 (8 lessons)		
Form one family How much is this part? What's the link? What's the overlap?	Allied shapes Angle connections	Give it your best shot What are the odds?
Year 8 (8 lessons)		
Between the waterholes Common connections Maths magic Best buys	How many layers? Transfigure the shape	How fair is this? One word changes it all
Year 9 (8 lessons)		
Exponential change How does my garden grow? Time exploration	How much does it hold? Look alikes Terrific triangles	A two-way street Family tree

Appendix F: List of publications and presentations by members of the YDC team (2010–2016 only)

Book chapters

Sarra, G., Matthews, C, Ewing, B., & Cooper, T. (2011). Indigenous mathematics: Creating an equitable learning environment. In N. Purdie, G. Milgate, & H. R. Bell (eds.), *Two way teaching and learning: Toward culturally reflective and relevant education* (pp. 173–185). Camberwell, Vic: ACER Press.

Cooper, T. J., & Warren, E. (2011). Years 2 to 6 students' ability to generalise: Models, representations and theory for teaching and learning. In J. Cai & E. Knuth (eds.), *Early algebraization: A global dialogue from multiple perspectives* (pp. 187–214), Advances in Mathematics Education. doi:10.1007/978-3-642-17735-4_12

Warren, E., Baturo, A. R., & Cooper, T. J. (2010). Power and authority in school and community: Interactions between non-Indigenous teachers and Indigenous teacher assistants in remote Australian schools. In J. Zadja & M. A. Geo-JaJa (Eds.), *Globalisation, Comparative Education and Policy Research, 9: The Politics of Education Reforms* (pp. 193–207). Dordrecht, Netherlands: Springer.

Warren, E., Cooper, T. J., & Baturo, A. R. (2010). Pedagogies to support Indigenous students' mathematics learning in rural and remote Queensland classrooms. In J. Zadja (Ed.), *Globalisation, Comparative Education and Policy Research 10: Globalisation, Education and Social Justice* (pp. 161–184). Dordrecht, Netherlands: Springer.

Journal articles

Chalmers, C., Carter, M., Cooper, T., & Nason, R. (in press). Implementing "big ideas" to advance the teaching and learning of science, technology, engineering, and mathematics (STEM). *International Journal of Science and Mathematics Education*.

Rioux, J., Ewing, B. F., & Cooper, T. J. (in press). Embedding Aboriginal perspectives and knowledge in the biology curriculum: The little porky. *Australian Journal of Indigenous Studies*.

Ewing, B. F. (2014). Rich and purposeful mathematical knowledge of mothers and children in a Torres Strait Islander community. *SpringerPlus*, *3*(42). doi:10.1186/2193-1801-3-42

Sarra, G. & Ewing, B. (2014). Indigenous students transitioning to school: Responses to pre-foundational mathematics. *SpringerPlus*, *3*(685). doi:10.1186/2193-1801-3-685

Ewing, B. F., Sarra, G., & Cooper, T. J. (2013). YuMi Deadly Maths program: Efficacy and collaboration. *Education Today, 13*(1), 28–30.

Warren, E., Miller, J., & Cooper, T. J. (2013). Exploring young students' functional thinking. *PNA, 7*(2), 75–84.

Ewing, B. F. (2012). Funds of knowledge of sorting and patterning: Networks of exchange in a Torres Strait Island community. *Australian Journal for Indigenous Education*, *41*(2), 131–138.

Ewing, B. (2012). YuMi Deadly Maths getting great results. *Australian Teacher Magazine*, *8*(5), 29.

Warren, E., Miller, J., & Cooper, T. J. (2012). Repeating patterns: Strategies to assist young students to generalise the mathematical structure. *Australasian Journal of Early Childhood, 37*(3), 111–120.

Ewing, B. (2011). Direct instruction in mathematics: Issues for schools with high Indigenous enrolments: A literature review. *Australian Journal of Teacher Education, 36*(5). doi:10.14221/ajte.2011v36n5.5

Ewing B. F., Cooper, T. J., Baturo, A. R., Matthews, C., & Sun, V. (2010). Contextualising the Teaching and learning of measurement within Torres Strait Islander schools. *Australian Journal of Indigenous Education, 39,* 11–23.

Conference papers

Carter, M. G., Cooper, T., & Anderson, R. (2016). Teachers' use of a pedagogical framework for improvement in mathematics teaching: Case studies from YuMi Deadly Maths. In *Opening up mathematics education research: Proceedings of the 39th annual conference of the Mathematics Education Research Group of Australasia*. Adelaide, SA: MERGA.

Cooper, T. J., & Carter, M. G. (2016). Large-scale professional development towards emancipatory mathematics: The genesis of YuMi Deadly Maths. In *Opening up mathematics education research: Proceedings of the 39th annual conference of the Mathematics Education Research Group of Australasia*. Adelaide, SA: MERGA.

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Nutchey, D., Grant, E., Cooper, T., & English, L. (2015a). A continuum to characterise and support teacher interpretation of an innovative curriculum. In K. Beswick, T. Muir, & J. Wells (Eds.), *Proceedings of the 39th conference of the International Group for the Psychology of Mathematics Education* (pp. 297–304). Hobart, TAS: PME.

Nutchey, D., Grant, E., Cooper, T., & English, L. (2015b). Introducing the multi-faceted teaching experiment. In *Proceedings of the CAR Symposia: Contemporary approaches to research in mathematics, science, health and environmental education.* Melbourne, VIC: Deakin University.

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Grant, E., Nutchey, D., Cooper, T., & English, L. (2014). Language and literacy in mathematics: Stepping stones or stumbling blocks in accelerating junior-secondary students. In *Science, Technology, Engineering and Mathematics (STEM) in Education Conference.* Vancouver, Canada: University of British Columbia.

Nutchey, D., Grant, E., & Cooper, T. (2014). Use of genetic decompositions to scaffold the development of a structurally sequenced curriculum for mathematics acceleration. In *Science, Technology, Engineering and Mathematics (STEM) in Education Conference.* Vancouver, Canada: University of British Columbia.

Cooper, T., Nutchey, D., & Grant, E. (2013). Accelerating the mathematics learning of low socio-economic status junior secondary students: An early report. In V. Steinle, L. Ball, & C. Bardini (Eds.), *Mathematics Education: Yesterday, Today and Tomorrow (Proceedings of the 36th annual conference of the Mathematics Education Research Group of Australasia)* (pp. 202–209). University of Melbourne, VIC: MERGA.

Kidman, G., Cooper, T. J., & Sandhu, S. (2013). The pedagogical contribution of the teacher aide in Indigenous classrooms. In A. M. Lindmeier & A. Heinze (Eds.), *Proceedings of the 37th conference of the International Group for the Psychology of Mathematics Education* (Vol. 3, pp. 161–168). Kiel, Germany: PME.

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Sandhu, S., Kidman, G., & Cooper, T. (2013). Overcoming challenges of being an in-field mathematics teacher in indigenous secondary school classrooms. In V. Steinle, L. Ball, & C. Bardini (Eds.), *Mathematics education: Yesterday, today and tomorrow, proceedings of the 36th annual conference of the Mathematics Education Research Group of Australasia* (pp. 594-601). Melbourne, VIC: MERGA.

Kidman, G., Cooper, T. J., & Nutchey, D. J. (2012). Get Into Vocational Education (GIVE): Motivating underperforming students. In J. Dindyal, L. P. Cheng, & S. F. Ng (Eds.), *Mathematics education: Expanding* *horizons, proceedings of the 35th annual conference of the Mathematics Education Research Group of Australasia* (pp. 401–408). Singapore: MERGA.

Kidman, G., Cooper, T., & Sandhu, S. (2012). Teacher aides and their pedagogical contributions in the underachieving Indigenous mathematics classroom. In *Proceedings of the 2nd International STEM in Education conference*. Beijing, China: Beijing Normal University. Retrieved from http://stem2012.bnu.edu.cn/stem/paper.html

Sorensen, D., Kidman, G., & McNeill, D. (2012). 'Wanna do more math': Engaging underachieving Indigenous learners the YuMi Deadly way. In *Proceedings of the Numeracy, Mathematics & Indigenous Learners national conference, Australian Association of Mathematics Teachers*. Adelaide, SA: AAMT. Retrieved from https://eprints.qut.edu.au/56072/2/56072.pdf

Ewing, B. F., Cooper, T. J., Baturo, A. R., Sun, V., & Matthews, C. (2011). Contextualising the teaching and learning of measurement in Torres Strait Islander schools. In Hudson, Peter B., Chandra, Vinesh, King, Donna T., & Lee, Kar-Tin (Eds.) *Proceedings of the 1st international conference of STEM in Education 2010*, STEM – Science, Technology, Engineering and Mathematics in Education. Brisbane, Qld: Queensland University of Technology.

Warren, E., Miller, J., & Cooper, T. J. (2011). An exploration of young students' ability to generalise function tasks. In J. Clark, B. Kissane, J. Mousley, T. Spencer, & S. Thornton (Eds.), *Mathematics: Traditions and [new] practices: Proceedings of the 34th annual conference of the Mathematics Education Research* group *of Australasia and the 23rd biennial conference of the Australian Association of Mathematics Teachers* (pp. 752–759). Adelaide, SA: AAMT & MERGA.

Ewing, B. F., Cooper, T. J., Baturo, A. R., Sun, V., & Matthews, C. J. (2010). Contextualising the teaching and learning of measurement in Torres Strait Islander schools. *Proceedings of the 1st International STEM in Education Conference, Queensland University of Technology, Brisbane, Australia, November 26–27, 2010*. Retrieved from http://stem.ed.qut.edu.au/index.php/conference-proceedings.html#c

Other conference presentations, workshops and expos

In addition to the above conference presentations, YDC staff have presented sessions and workshops or staffed information booths at the following conferences, expos and summits:

- Aboriginal and Torres Strait Islander Mathematics Alliance (ATSIMA) national conferences, Adelaide, SA (2014), and Wollongong, NSW (2016)
- Association of Independent Schools New South Wales (AISNSW) Aboriginal and Torres Strait Islander Education Conference, Sydney (2016)
- Australian Universities Community Engagement Alliance (AUCEA) conference, QUT, Brisbane (2012)
- Down Syndrome Association of Queensland education conference, Brisbane (2017)
- "Learn, Engage, Connect" one-day PD event focusing on the use of technology in the teaching of mathematics, Melbourne (2016)
- Maths Association of Victoria (MAV) annual conferences, Melbourne (2010–16)
- National Indigenous Engineering Summit, hosted by the Melbourne School of Engineering at the University of Melbourne (2015)
- Queensland Association of Mathematics Teachers (QAMT) annual conferences (2010–16)
- Queensland Education Resources Expo (QUEDREX), Brisbane (2015)
- STEM Education Brainstorming Workshop, hosted by The Royal Society of Queensland, Brisbane (2015)
- Stronger Smarter Summit, Brisbane (2012)
- Teachers Teaching with Technology T^3 International Conference, Fort Worth, Texas, USA (2015)

Appendix G: Higher Degree Research theses (supervised by YDC staff 2010–Present)

Boyd, N. (Current student). *Numerate rich realities: Providing the cultural interface for accelerated mathematics education.* Masters by Research thesis, Queensland University of Technology. Supervisors: B. Ewing & T. Cooper.

Lyons, A. R. (2013). *Co-constructing decimal number knowledge.* PhD thesis, Queensland University of Technology. Supervisors: T. Cooper & G. Kidman.

Phillips, T. (2012). *Cultural factors affecting tertiary education access for Bundjalung men.* Masters by Research thesis, Queensland University of Technology. Supervisors: B. Ewing & T. Cooper.

Rioux, J. (2015). *Two-way strong: A study of vertebrates using Queensland Indigenous knowledges and Montessori Linnaean materials to engage Indigenous secondary school students.* PhD thesis, Queensland University of Technology. Supervisors: B. Ewing, T. Cooper & G. Kidman.

Roberts, J. (2012). *Behavioural beliefs concerning gender and high-risk sexual behaviours in the context of HIV/AIDS in PNG: Views from within teacher education.* PhD thesis, Queensland University of Technology. Supervisors: T. Cooper, R. Elliott & J. Lampert.

Traise, A. K. (2015). *Mathematics knowledge for teaching and the classroom environment.* Masters by Research thesis, Queensland University of Technology. Supervisors: D. Nutchey & T. Cooper.

Appendix H: Media appearances and contributions of YDC staff

Adey, R. (2008). Life matters program: Deadly maths. [Interview with Professor Tom Cooper and Associate Professor Annette Baturo]. *ABC Radio National: Life Matters.* Available at http://www.abc.net.au/rn/lifematters/stories/2008/2341760.htm

Calderwood, K. (2016). YuMi Deadly Maths a hit in Hughenden for students at different levels. *ABC News.* Available at http://www.abc.net.au/news/2016-04-28/yumi-maths-a-hit-in-hughenden/7364078

Cumming, S. (2012). On the map. Dalby: Deadly maths. *Toowoomba Chronicle.*

DeVerteuil, K. (2012). Playing with numbers. *Albert & Logan News.*

Ferrari, J. (2008). 'Education apartheid' failing kids. *The Australian.*

Ghidella, S. (2012). Channel Seven Weekend News. Interview with Dr Bronwyn Ewing, Professor Tom Cooper, Bev Laidlaw and Loreta Dedaj (student). *Seven Weekend News. 16 June, 2012, 6.12pm*

Mackay, J. (2014). Making maths fun while making ukeleles! *ABC Capricornia.* Available at: http://blogs.abc.net.au/queensland/2014/12/making-maths-fun-while-making-ukeleles.html?site=capricornia&program=capricornia_breakfast

Rebgetz, L. (2015). Maths program to help Queensland children with a disability gain employment. *ABC News.* Available at http://www.abc.net.au/news/2015-06-08/math-program-to-help-children-with-a-disability-gain-employment/6519592

Rowbotham, J. (2008). Indigenous students find maths is a good yarn. *The Australian.*

Salleh, A. (2016). Maths, story and dance: An Indigenous approach to teaching. *ABC News.* Available at http://www.abc.net.au/news/2016-08-15/closing-the-maths-gap-with-story-and-dance/7700656

Schalch, J. (2012). Deadly jobs are adding up. *North West Star, Mt. Isa.*

(2012). Burnside's street math. *Sunshine Coast Daily.*

(2012). ABC North Queensland (Townsville) radio interview with Dr Bronwyn Ewing. *ABC North Queensland local radio.* (19 July, 2012, 8.03am).

(2012). ABC North Queensland (Townsville) radio interview with Dr Bronwyn Ewing. *ABC North Queensland local radio.* (20 July, 2012, 12.33pm).

(2012). Booze buster: City looks to minister for alcohol solution*. The North West Star.* Available at http://www.northweststar.com.au/story/305249/booze-buster-city-looks-to-minister-for-alcohol-solution/

(2013). Real-world approach makes maths teaching deadly, *Education Views.* Available at http://education.qld.gov.au/projects/educationviews/talking-point/2013/may/maths-090513.html

(2014). Pitching maths through music at Emerald. *QUT News.* Available at https://www.qut.edu.au/education/about/news/news?news-id=82716

(2014). Radio interview [with Alexander Stuetz]. *4BC Brisbane.* December 2014.

(2015). New project adds up. *Koori Mail: The voice of Indigenous Australia.* Available at http://koorimail.com/wp-content/uploads/610-66.pdf

(2015). 'Deadly' maths program sees prime future for Indigenous students. *EurekAlert: Global source for science news.* Available at https://www.eurekalert.org/pub_releases/2015-09/quot-mp091515.php