Nothing left to chance:

characteristics of schools successful in mathematics

Report of the building an evidence base for best practice in mathematics education project

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Glossary and Abbreviations

A to E reporting	The mandated grading system used by all schools for reporting to parents
AAMT	Australian Association of Mathematics Teachers
AAS	Australian Academy of Science
ACARA	Australian Curriculum, Assessment and Reporting Authority
AC-M	Australian Curriculum: Mathematics
AusVELS	AusVELS was the Foundation to year 10 curriculum (2013–2016) for Victorian government and Catholic schools at the time of this study, and from 1 January 2017 has been replaced by the Victorian Curriculum F–10
C2C	Curriculum to Classroom, an approach to the National Curriculum used in Queensland
Combined school	A school providing education across primary and secondary school years
Concrete materials	Concrete materials, also referred to as manipulatives, are objects designed to represent concretely mathematical ideas that are essentially abstract. Examples of concrete materials commonly used in mathematics include counters, ten-frames, base-10 blocks and pattern blocks
DAP	Developmentally Appropriate Practice
Direct instruction model	A model of teaching in which the teacher explains a concept or demonstrates a skill directly to students
Ecological systems theory	Theory that suggests that development of an individual is nested within a series of interacting environmental influences, from the immediate environment in which the individual exists, through localised influences (micro-level), broader influences (meso-level) to overarching influences macro-level). In schools, for example, students (individuals) exist within classrooms (micro-level), within schools (meso-level), within systems (macro-level)
Explicit teaching	An approach to teaching which has a focus on curriculum content, including having clear goals for every lesson, making connections within and between concepts and monitoring student progress. Explicit teaching can occur with whole class, small groups or individuals as the teacher changes the approach in response to students' feedback

Flexible grouping	The practice of allocating students to classes or teaching groups based on frequent diagnostic assessments, and for particular purposes, such as learning a specific topic or undertaking a particular learning task. Flexible groupings can occur in classrooms that are mixed ability or grouped by ability, within year groups or across year groups
IB	International Baccalaureate
IBPYP	International Baccalaureate Primary Years Programme
ICSEA	Index of Community Socio-Educational Advantage
ICT	Information and communications technology
LMS	Learning Management System. A software application used to track educational progress
Mastery learning environment	A learning environment or classroom where the emphasis is on developing deep understanding of the mathematics rather than emphasising acquisition of particular skills
MCK	Mathematics Content Knowledge
Mixed ability class	A class in which students are placed using criteria other than measured ability
Metro/provincial/remote geolocation	In 2015, the schools' geographic location classification system was based on the locality of individual schools and was used to disaggregate data according to metropolitan, provincial, remote and very remote. The classifications used in this study were provided by ACARA. The geolocation categorisation was changed in 2016 after this study had concluded
MfT	Mathematics for Teaching
NAPLAN	National Assessment Program – Literacy And Numeracy
NCEE	National Center on Education and the Economy
NTWD	National Teaching Workforce Dataset
NumPA	Numeracy Project Assessment – a diagnostic interview tool developed in New Zealand
OCS	Office of the Chief Scientist
OECD	Organisation for Economic Cooperation and Development
Other school	Any school that does not meet the criteria as a *successful school* or as a *superior gain school*

PaLM	Principals as Leaders of Mathematics
PAT-Maths (ACER)	Progressive Achievement Test – Mathematics from the Australian Council for Educational Research
PCK	Pedagogical Content Knowledge
Performance learning environment	A learning environment or classroom where the emphasis is on demonstrating competence, achievement and competition rather than developing understanding
PISA	Programme of International Student Assessment
Primary school	A school that provides education from Foundation to year 6 or year 7 (QLD, SA, WA at the time of this study)
Professional learning communities	A group of teachers that has a focus on '(1) professional learning; (2) within the context of a cohesive group; (3) that focuses on collective knowledge, and (4) occurs within an ethic of interpersonal caring that permeates the life of teachers, students and school leaders' (Stoll & Louis, 2007, p. 3)
Secondary school	A school that provides education beyond the primary years, usually year 7 or year 8 (QLD, SA, WA at the time of this study) to year 10 or year 12
SD	Standard deviation
School vignette	A short story taken from a particular school site visit that exemplifies a particular point within the broader school context
SCM	Students' perceptions of a Classroom Mastery goal orientation
SCP	Students' perceptions of a Classroom Performance goal orientation
SNMY	Supporting Numeracy in the Middle Years project
STE	Students' perceptions of Teachers' Enthusiasm for teaching mathematics
Streaming	The practice of allocating students to classes for a full year with little or no movement between classes based on some assessment process or test

Student-centred teaching	An approach to teaching in which students are provided with opportunities to become active in their learning by engaging in discussion, following their own interests and problem solving. The focus of instruction shifts from teachers to students
Successful school	A school that has achieved growth or performance +1 standard deviation (*SD*) above the mean growth or performance for Australian schools. *Successful schools* include *superior gain schools* but also include some High Performance Schools where gain scores were not available
Superior gain school	A school that has achieved growth from years 3 to 5 or years 7 to 9 of +1 *SD* above the mean growth for Australian schools in the time periods 2011–2013, or 2012–2014
System	For the purpose of this study, 'system' is used to mean Government, Catholic, and Independent sectors working within a state or territory jurisdiction
TCM	Teachers' perceptions of a Classroom Mastery goal orientation. See 'Mastery learning environment'
TCP	Teachers' perceptions of a Classroom Performance goal orientation. See 'Performance learning environment'
TEMPEST	Towards Educating Mathematics Professionals Encompassing Science and Technology
TIMSS	Trends in International Mathematics and Science Study
TSE	Teachers' perceptions of their Subject Enthusiasm for mathematics

1 Executive summary

1.1 Goal

The *Developing an Evidence Base for Best Practice in Mathematics Education* project aimed to identify factors that influence the learning and teaching of mathematics in Australian schools.

The purpose of the project was to build a compelling evidence base for national best practice in mathematics education. This goal was achieved through examining mathematics education practices in schools (termed *successful schools*) that achieved superior gains or high performance in the numeracy component of The National Assessment Program – Literacy and Numeracy (NAPLAN).

This study was commissioned by the Office of the Chief Scientist (OCS), and the research team was led by Associate Professor Rosemary Callingham from the University of Tasmania.

1.2 Summary of findings

The study considered the impacts of practices at the classroom, school and system levels, using desktop research, surveys and case studies. Section 1.5 provides an explanation of the survey, case studies and the desktop review, as well as a definition of *successful schools*.

1.2.1 Schools and classrooms

Case studies were conducted in 52 of 619 Australian schools identified as successful (28 primary, 17 secondary and 7 combined schools). In s*uccessful schools*, there was a strong commitment at all levels to improving mathematics learning and teaching. *Successful schools* were typified by an emphasis on 'mastery learning', which aims to develop deep understanding in mathematics classrooms; and had teachers who were knowledgeable about mathematics and how students learn it. Teachers in these schools were enthusiastic about teaching mathematics, and the schools had policies that supported mathematics explicitly.

100% of case study schools — had senior leadership, who understood and valued mathematics; and a mathematics leader who had input into school policy decisions.

90% of case study schools — had teachers who *liked* mathematics, and were enthusiastic about teaching mathematics (as perceived by student groups that were interviewed).
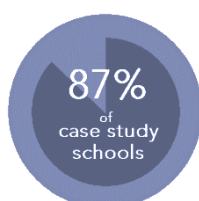
87% of case study schools — used data to monitor individual students' progress; and had a classroom focus on mastery (i.e. developing understanding) rather than procedural fluency.

94% of case study schools — had 'in-school' professional learning communities, and 73% had had formal, in-school professional learning.

Teaching practices informed by research have resulted in superior outcomes for *case study schools* (for example the development of mastery classrooms), and provide good starting points for *other schools* looking to improve.

In addition to the case studies, surveys were distributed to schools across Australia. Surveys revealed that classrooms in *successful schools* were more likely to have a mastery goal orientation, not a performance goal orientation. Mastery goal oriented classrooms were highly associated with teacher enthusiasm for teaching mathematics, and evoked higher emotional and cognitive interest in students than did classrooms with a performance goal orientation.

1.2.2   Systems

The desktop review revealed three key findings for different state and territory, and education systems around Australia. Firstly, there was duplication across jurisdictions in the nature and type of resources that are developed for teachers. Secondly, there was a lack of resources that direct schools and teachers how best to analyse and respond to datasets of different types (e.g. classroom, year cohort, NAPLAN). Thirdly, numeracy was a dominant theme across Australian schools, and the Number and Algebra strand of the curriculum predominates.

1.3   Key findings

The research from this study informed several key findings from the perspectives of policy, school leadership and classroom teaching:

Key finding 1

Schools where mathematics leaders were involved in school policy development and supported by senior leadership had teaching and learning cultures that improved student outcomes.

Key finding 2

Data can be used to monitor and improve student outcomes and progress in mathematics. Sharing best practice models for using data would benefit all schools.

Key finding 3

Across jurisdictions there is duplication and inefficiencies in the development of resources to assist teachers, with varying levels of quality and evaluation.

Key finding for policymakers 1

There is no nationally consistent approach to the implementation of the mathematics curriculum, and the A to E reporting system often does not adequately support and reflect student learning.

Key finding for policymakers 2

Evidence-based professional development tailored to the teaching and pedagogy of mathematics leads to better student outcomes.

Key finding for policymakers 3

Teachers of upper primary and lower secondary years undertake the lowest levels of professional development and may benefit from numeracy and/or mathematics coaches.

Key finding for school leaders 1

Student outcomes were improved in schools with staff members who had responsibility for mathematics and school level policy making input.

Key finding for school leaders 2

Schools with a culture of in-house, discipline specific professional development create collegial and non-judgemental environments for both teachers and students.

Key finding for school leaders 3

Targeted, data-driven approaches for planning and delivering mathematics learning and teaching leads to improved student outcomes.

Key finding for classroom teachers 1

Mathematics taught with enthusiasm, and classrooms focussed on the deep understanding of mathematical concepts and ideas leads to increased student engagement.

Key finding for classroom teachers 2

Students develop better understanding when provided with the opportunity to talk about their mathematics, and to articulate their mathematical thinking and solution strategies.

The first three key findings straddle all three perspectives of policy, school leadership and classroom teaching, and these are discussed in this executive summary. Chapter 7 details additional evidence for all of the key findings for further consideration.

1.3.1   Key finding 1

Schools where mathematics leaders were involved in school policy development and supported by senior leadership had teaching and learning cultures that improved student outcomes.

All *case study schools* had a leader of mathematics (for example principals or heads of mathematics) who had input into school policy decisions and received support from senior leadership who understood and valued mathematics. This value was reflected by the amount of formal in-school professional development (also called professional learning) (73% of *case study schools*) and the prevalence of in-school professional learning communities (94% of *case study schools*). It is important that principals understand how they can build a culture that improves students' mathematics outcomes.

There is currently a *Principals as Literacy Leaders* program, which was developed in 2009, and has been widely successful in different jurisdictions and education systems. A *Principals as Leaders of Mathematics* program could follow a similar model. Western Australia piloted a *Principals as Numeracy Leaders* project in 2012, and it received positive feedback.

1.3.2   Key finding 2

Data can be used to monitor and improve student outcomes and progress in mathematics. Sharing best practice models for using data would benefit all schools.

In 87% of *case study schools*, data were used to monitor student progress and change teaching practices, however, the desktop research indicated that there was a lack of examples in numeracy of how to use data. If data can be used to improve student outcomes, then teachers should have access to best practice examples.

Next steps

The *Dimensions* online portal, which is scheduled to go public in 2017, will include evidence-based resources and professional development programs for mathematics teachers. The portal is partly funded by the Australian Government Department of Education, and led by the Australian Association of Mathematics Teachers (AAMT). Resources for data-use could be developed as part of *Dimensions*.

1.3.3   Key finding 3

Across jurisdictions there is duplication and inefficiencies in the development of resources to assist teachers, with varying levels of quality and evaluation.

The desktop review revealed that there is duplication across jurisdictions in the nature and type of resources that are developed for teachers. Although a number of resources were reported to be used in schools, neither the case studies nor the surveys uncovered particular resources that were associated with *successful schools*. A national plan and communication between education systems within and across jurisdictions could help to increase efficiency and deliver quality information to teachers nationwide.

Next steps

Dissemination of mathematics teaching research, resources and programs could be built into *Dimensions* (an online portal for mathematics teachers, which is scheduled to go public in 2017, as discussed in Finding 1). A national program for communication between education systems could be implemented through the Australian Government Department of Education and Training. These findings could be implemented as a part of the National STEM School Education Strategy from the Education Council (Education Council, 2015).

1.4   Terms of reference

The goal of the project was to build a compelling evidence base for national best practice in mathematics education, and included the following objectives:

1. To identify state and territory level, system level, school level, and teacher practices that achieve superior gain in NAPLAN numeracy test performance between 2011 and 2013, for years 3 and 5, and years 7 and 9.

2. To identify defined practices in primary and secondary schools that result in superior gain at the state and territory, educational system and school levels.

3. To identify schools with superior gain where students:

    a. are confident to use mathematics in routine and non-routine ways to solve real world and mathematical problems;

    b. feel positive about what they are doing in mathematics; and

    c. have the cognitive skills to think deeply and meaningfully about application of mathematics to problems, and communicate these thoughts.

4. To identify the levels and types of mathematics teacher qualifications in these schools.

5. To identify the levels and types of professional development available to and undertaken by mathematics teachers in these schools.

6. To describe the teaching resources used by mathematics teachers in these schools.

7. To describe the practices, teaching philosophies and pedagogies used by mathematics teachers in these schools.

8. To understand the principal's and the school approach to mathematics teaching in these schools.

9. To determine the number of hours and lesson configurations for mathematics lessons in these schools.

1.5   Methodology

This study defined *successful schools* as those showing superior gain or performance in NAPLAN during the time periods 2011–2013, and 2012–2014 from data provided by ACARA. Superior gain was defined as greater than one standard deviation (+1 *SD*) above the mean growth based on overall numeracy results, compared with like schools and with schools with similar starting scores. Superior performance was measured for schools in jurisdictions where no gain scores were possible for years 7–9. All other schools were defined as *other schools*.

To investigate the practices used in *successful school*s, this study used three data collection approaches: a desktop review of system level provisions; surveys of school leaders (for example principals, heads of mathematics), classroom teachers and students; and case study research in *successful schools*.

In addition to investigating the processes and practices of different education systems, the desktop review included a summary of factors that influence learning mathematics, as identified in academic literature.

Surveys were distributed across schools in Australia where permission had been given by relevant education systems. Responses were collected from 207 teachers (124 of whom were from 28 different *successful schools*), 111 school leaders (16 *successful schools*), 466 older students (years 7–10) and 601 younger students (years 3–6). Approximately half of the students were from *successful schools*.

Case studies were conducted in 52 different schools of the 619 that were identified as *successful schools* (28 primary, 17 secondary and 7 combined schools)*.* Researchers in *case study schools* interviewed students, teachers, leaders, and parents. They also observed classes, and reviewed relevant school documents. The schools were located in every state and territory, and covered primary, secondary, and combined schools in all three sectors: Government, Catholic and Independent. The ICSEA values ranged from 899 to 1212.

Teaching mathematics is a complex task. In addition to having a deep understanding of appropriate mathematics, teachers need to recognise the cognitive, emotional, and social development of the students they teach, to draw on a wide range of pedagogical practices, and, most importantly, have that specialised knowledge of mathematics for teaching that has become known as pedagogical content knowledge. Teachers, however, work within schools and the ethos and organisational arrangements, policies and practices of that school impact on teachers' effectiveness. Schools are part of wider societal provisions for education that provide processes for curriculum development and delivery, accountability and accreditation within a legal framework. These different levels of influence are interactive and dynamic, making the task of teaching mathematics a constantly changing process.

The Developing an Evidence Base for Best Practice in Mathematics Education Project aimed to identify key aspects that influence the learning and teaching of mathematics in Australian schools showing superior gain in NAPLAN numeracy. It provides a snapshot in time of schools successful in mathematics.

This study was commissioned by the Office of the Chief Scientist (OCS). The purpose of the project was to identify the practices of schools that achieved superior gains (or high performance in year 9 where gain scores were not available for growth from year 7 to year 9 in West Australia and Queensland) in NAPLAN numeracy during the time periods 2011–2013 and 2012–2014. NAPLAN is acknowledged as a narrow measure of success, but it is the only common tool used across the whole of Australia.

The goal of the project was to build a compelling evidence base for national best practice in mathematics education. To this end, the OCS identified a series of objectives:

1. To identify state and territory level, system level, school level, and teacher practices that achieve superior gain in NAPLAN numeracy test performance between 2011 and 2013 for years 3 and 5 and years 7 and 9.

2. To identify defined practices in primary and secondary schools that result in superior gain at the state and territory, educational system and school levels.

3. To identify schools with superior gain where students:

   a. are confident to use mathematics in routine and non-routine ways to solve real world and mathematical problems;

   b. feel positive about what they are doing in mathematics;

   c. have the cognitive skills to think deeply and meaningfully about application of mathematics to problems, and communicate these thoughts.

4. To identify the levels and types of mathematics teacher qualifications in these schools.

5 To identify the levels and types of professional development available to and undertaken by mathematics teachers in these schools.

6. To describe the teaching resources used by mathematics teachers in these schools.

7. To describe the practices, teaching philosophies and pedagogies used by mathematics teachers in these schools.

8. To understand the principal's and the school approach to mathematics teaching.

9. To determine the number of hours and lesson configurations for mathematics lessons.

Successful schools were defined in this study as those showing superior gain +1 *SD* above the mean gain based on overall NAPLAN numeracy results, compared with like schools and with schools with similar starting scores) in the time periods 2011–2013, and 2012–2014. ACARA provided a list of schools showing superior gain. In jurisdictions where limited gain scores were available for years 7 to 9 (Queensland, South Australia, and West Australia), year 9 performance at +1 *SD* above the score for all Australian schools or like schools was taken as the criterion. Schools showing superior performance in year 9 were identified from 2014 NAPLAN numeracy data, and school systems, and were confirmed by examination of the *My School* website.

There were three possibilities on which to base a judgement of superior gain defined as +1 *SD* above the mean gain for gains from year 3 to Year 5, and year 7 to year 9. Within each year band (year 3 to year 5, and year 7 to year 9), the first possibility was compared to all schools across Australia. The second was compared with 'like' schools as used by ACARA to provide *MySchool* website comparisons. The third possibility was compared to schools with similar start scores, as identified by ACARA. It should be noted that although these criteria were adopted, where these could be checked almost no schools met all three conditions (that is demonstrating superior gain compared with all Australian schools, like schools, and schools with similar starting scores). Wherever possible schools were selected that had met at least two of the three criteria, but there was also a requirement with the case studies to balance state, location, sector and Index of Community Socio-Educational Advantage (ICSEA, Australian Curriculum Assessment and Reporting Authority (ACARA), 2013). In addition, NAPLAN has some imprecision in the measurement (a margin of error) associated with it (Wu, 2010), that would also have had an impact. Hence, schools defined as having superior gain or performance were not as clearly defined a group as might have been expected. Nevertheless, all the schools that participated in the case studies had made superior gains during at least one of the defined time periods on two of the three criteria.

It is important to note that because the specified basis for school inclusion was gain, many of the schools considered were not necessarily high performing schools. It is possible to make significant gains from a low base, and still be performing below the national average. These schools are 'closing the gap', and hence are of interest in terms of practices and policies that help them to achieve this.

There are a number of reasons why schools may make gains, some of which are contextual rather than related to best practice. For example, schools that have a large intake of students who come from backgrounds where English is not the first language or are new to Australia may make large gains because the students become more proficient in English. Similarly, secondary schools that have a very diverse intake may have somewhat depressed scores in year 7, because the students are still settling in to the new context, but show good gains by year 9 because the students are now settled into the secondary school situation. Nevertheless, these schools have something to offer a study of this nature because they are able to mitigate the students' initial disadvantage.

Bronfenbrenner's (1989) Ecological Systems Theory was used as a broad structural framework. Ecological Systems Theory posits that there are different spheres of influence on an individual within a particular situation. These influences interact with each other, creating a complex web of effects that may be different for each person. In this study, the spheres of influence were the education system in the state or territory in which the school operated, the school, the classroom and teacher, and the individual student.

Several general framing questions guided the design of the study. These questions are not fine-grained research questions but provided guidance for the development of instruments and acknowledged the different levels of policy and practice influencing mathematics education. These questions were:

1. What system level influences are evident in schools with superior NAPLAN numeracy outcomes?

2. What school level influences are evident in schools with superior NAPLAN numeracy outcomes?

3. What classroom level influences are evident in schools with superior NAPLAN numeracy outcomes?

4. What individual student influences are evident in schools with superior NAPLAN numeracy outcomes?

2.1   Underpinning assumptions

The following assumptions underpinned this study:

1. There is no one method or approach that leads to the achievement of superior results in mathematics.

   It was expected that in different situations, diverse approaches would be identified in schools achieving success in mathematics. There are many ways of considering approaches to mathematics education, all of which have sound theoretical frameworks. For this research no value judgements were made about the approaches taken.

2. NAPLAN numeracy is the only common tool used across Australia; however, there may be other ways of defining success in mathematics.

   Systems, schools, and individuals (teachers, parents, and students) may perceive other outcomes to be as important as NAPLAN scores, such as participation, enjoyment, interest and so on. It was expected that this might be a consideration for many primary schools, for example, and because school contexts differ it was important to allow for this consideration in the study.

3. There are out-of-school factors that impact on outcomes.

   Out-of-school factors may be real or imagined but include, for example, additional tutoring and the school enrolment profile. Family factors can impact individual students but less so at the aggregated level of the school. Out-of-school factors are acknowledged but not explored in depth because they fell outside the scope of the study.

The focus of this study was the practices and processes used in schools of all types and backgrounds successful in NAPLAN numeracy testing in order to identify ways in which *other schools* (defined as schools that did not meet the *successful school* criteria) could adapt and emulate them. Against this background, a study was developed that used survey and case study approaches to collect data about factors influencing success in mathematics education. The full methodology is described in detail in Chapter 3.

2.2   Previous research

There is an extensive body of research that has considered successful outcomes in schools and more specifically in school mathematics. Only a brief review will be presented here, starting with some recent reports published during the period of this study, and then general (non-mathematics) findings, and finally, considering mathematics specific studies.

2.2.1   Recent reports

Since the project commenced in 2015, there have been several reports that have addressed matters of interest and relevance to this study. These are reviewed in this section.

A recent study in New South Wales aimed to identify school factors common to all schools that added value to students' learning based on NAPLAN data and qualitative data collected from 14 (seven primary and seven secondary schools) schools that achieved high growth over the period 2010 to 2014 (Centre for Education Statistics and Evaluation [CESE], 2015). Although not exclusively addressing mathematics, the findings suggested high value-add schools had six factors in place:

1. effective collaboration;

2. engaging and sharing in professional learning;

3. setting whole school goals and strategies for change;

4. using explicit and effective teaching strategies;

5. creating an environment that promotes learning and high levels of student engagement; and

6. setting high expectations for achievement.

The CESE study also identified lower level contributing factors, such as responsive use of data at the school, class and individual level to inform development of teaching programs. Other contributing factors identified in the literature include factors such as teachers' beliefs (see, for example, Leder, Pehkonen, & Törner, 2002) and student level factors such as being engaged and focussed on learning (see, for example, Jurdak, 2009). These syntheses provide valuable guidance, but limited detail about practices that lead to success.

The use of data to inform teaching was the focus of a report from the Grattan Institute (Goss, Hunter, Romanes, & Parsonage, 2015) that aimed to provide strategies for schools to follow. Their focus was less on system or school use of NAPLAN data (although they acknowledged that NAPLAN could be useful), and more on the ways in which individual teachers could target teaching effectively

to cater for every student. These researchers warned, however, that many schools '… say they already target teaching. Certainly, they are not short of data. But this does not mean they are collecting the right information at the right time and using it effectively. Most have a long way to go' (p. 1).

Using examples from the literature and from case studies conducted in six schools, Goss et al. provided a checklist of effective uses of data that included, among other factors, having a shared sense of responsibility for students' learning, developing a common language across the school, and in-house professional development.

Professional learning was the focus of a report from the National Center on Education and the Economy (NCEE) (Jensen, Sonnemann, Roberts-Hull, & Hunter, 2016) in which the authors used 'system' to refer to jurisdictions—specifically a Chinese city, a Canadian province, an autonomous region of China, and a city state. Using evidence from four high-performing systems, gathered from interviews with a range of stakeholders, the authors identified three potential policy reforms, namely: 'developing professional learning leaders, evaluation and accountability, and creating time for teachers to pursue effective professional learning' (p. 4). Jensen et al. illustrate these reforms with examples of effective professional learning programs targeting the development of learning communities, mentoring and the use of external expertise. The report provides specific tools and approaches that schools could adopt to develop effective teachers.

A recent report from the Organisation for Economic Cooperation and Development (OECD) considered teaching excellence (Schleicher, 2016). Of particular interest is what Schleicher terms 'cognitive activation' strategies, such as having students explain their thinking. Using students' responses to the Programme for International Student Assessment (PISA) background questionnaire (OECD, 2006), these approaches were widely used across OECD countries whereas student-centred strategies, such as small group work, were reported by students as being infrequently used. Results from PISA suggested that students exposed to cognitive-activation approaches scored higher on average, and particularly at the very highest levels of the PISA scale in mathematics. In addition, both memorisation and elaboration strategies, such as making connections with prior learning and real-life tasks, seem to be needed for effective mathematics learning, although elaboration strategies are associated with success on more difficult tasks. Of concern for Australia is that student reported use of memorisation strategies was well above the OECD average, but with respect to elaboration strategies, Australian students reported some of the lowest use.

Elaboration and cognitive activation would appear to be key teaching approaches in mathematics. In addition, the OECD examined teacher professionalism across three domains: knowledge, autonomy, and peer networks. Knowledge best practices included participation in long-term professional development and support for practitioner research. Autonomy best practices included decision making in terms of the curriculum, teaching materials and assessment. Peer networks involved formal induction into the profession and ongoing mentoring; peer feedback based on class observations; and development of a professional development plan. Overall, as presented in the OECD report, Australia performs in the middle of the OECD countries in terms of teacher professionalism but lies considerably below New Zealand, Singapore, and England. Schleicher also discusses ways of developing teacher professionalism and provides examples from diverse countries.

Finally, a recent report from the Australian Academy of Sciences (AAS) reviewed pedagogical approaches and learning resources for mathematics education (Stacey, Vincent, Stephens, & Holton, 2015). The key finding from this report was for 'a well-funded, well-evaluated long-term coherent

approach' (p. 7). Stacey et al. found that although there was a suitable range of pedagogical practices available to develop mathematics for the 21st century, the curriculum was often narrowed to a focus on a limited range of mathematical skills. In particular there was insufficient emphasis on the proficiency strands of the Australian Curriculum: Mathematics (AC-M), especially those of problem solving and reasoning.

With respect to resources, the AAS report identified three issues: first, teachers lack time and knowledge to find and evaluate resources adequately. This situation was especially applicable to beginning teachers and out-of-field teachers. Second, many available resources, especially from the internet are 'of poor quality' (p. 20). Third, planning a coherent program from the wide range of resources available, including textbooks and online resources, is a difficult and time-consuming process. The report highlighted a need for resources for high-level problem solving, including the use of technology as an integral component of the learning process rather than for skills practice.

There are many pointers in these reports to characteristics of effective systems, schools and teachers and practices that lead to improved student learning outcomes. The next section considers some aspects that influence students' learning in general (not just in mathematics).

2.2.2   General factors that influence learning

Hattie (2009) identified over 50 factors that provide large effect sizes in enhancing students' learning. He used meta-analysis across many different studies to provide overall measures of effect sizes and generalised information about elements influencing success. These elements address six areas of influence: the student, the home, the school, the curriculum, the teacher, and the approaches to teaching. In this project, no information was gathered about home influences, and limited data were collected about individual students as ACARA data were not available at the student level. Each of the other aspects identified by Hattie is considered in this brief review.

2.2.2.1 Students

Hattie reported that students' prior achievement, in the form of a self-report about their perceived success in the past, played a very large part in determining future success. Measured prior achievement also had a large effect. These findings imply that schools where students know that they are successful are likely to perform at higher levels. Of interest in this study is that some schools do not perform at high levels but create large gains, especially from year 3 to year 5. These schools may have been able to change students' perceptions of their mathematics learning. Additional student factors identified by Hattie include motivation, engagement and self-concept. These factors were also considered in this study.

2.2.2.2 School effects

Hattie identified many school level effects on learning. Classroom cohesion and management, school size, opportunities for small group learning, and the influences of peers all contributed to learning outcomes. School leadership had an impact, and in particular leadership that promoted, participated in, and supported teacher development. These findings were of particular relevance to this study because the school was the main level of reporting.

2.2.2.3 Curriculum effects

The nature of the curriculum has an impact on students' learning outcomes. The impact of the curriculum on teachers has been researched elsewhere, often in relation to high stakes testing (e.g., Dulfer, Polesal, & Rice, 2012). The implementation of the curriculum within a school has an impact on students' learning outcomes, but the school curriculum itself is subject to pressures from broader societal influences (see, for example, Reys, Reys, &. Rubenstein, 2010). Some of these were considered in this project, such as the nexus between numeracy and mathematics.

2.2.2.4 Teacher effects

Teachers have a large impact on their students' outcomes. Teachers' relationships with students, not labelling students, and teachers' expectations were among some of the important aspects. Professional development and the clarity of teacher explanations were also central to students' outcomes, and these factors may play a key role in mathematics, where many teachers are known to lack confidence (e.g., Bursal & Paznokas, 2010), and hence these ideas were of interest in this project.

2.2.2.5 Teaching approaches

Hattie found that teachers who provided feedback to students that gave students clear direction about ways in which they could move forward had a powerful effect. Black and Wiliam (1998) also identified feedback as a key classroom strategy. In mathematics, this finding implies not only that teachers can diagnose the problem but also that they can address it. Teaching approaches that develop meta-cognition, and opportunities for problem-solving that promote self-questioning, so that students reflect on their learning in a focussed way, also have an impact on outcomes. Teaching study skills themselves can help, as can direct instruction in the sense of having defined objectives and success criteria communicated to students, and a strong lesson structure including a formal 'wrap-up' of learning at the end. Clearly, what happens in the classroom is a key driver of students' outcomes.

2.2.2.6 Professional development (professional learning)

Teachers who engaged with professional development (professional learning) tended to have a greater impact on their students; however, effective professional development is more than a single session or presentation (Meiers & Buckley, 2009). To have an impact on students' learning outcomes it needs to be ongoing, and to focus on content and pedagogical knowledge. Schleicher (2016) echoes these principles.

2.2.3 Mathematics factors that influence learning

Although many of the studies used by Hattie involved mathematics, there is also a large body of research from the field of mathematics education. These studies are categorised in the same way as the more general studies.

2.2.3.1 Students

Studies focussing on students' mathematical development formed the backbone of mathematics education research for many years. Studies of this type originated with Piaget's research (for example, Piaget, 1941/1952). Although Piaget's ideas have been largely superseded, the notion of a developmental pathway in learning mathematics underpins many research studies. Developmentally Appropriate Practice (DAP) (Perry, 2000) for example, has been widely applied in the early years of

schooling, as exemplified in the work of Wright (1998). This approach underpinned many quality mathematics programs in the early years of schooling such as *Count Me In Too* (http://www.schools.nsw.edu.au/learning/k_6/maths/prosupport.php).

Programs based on developmental frameworks typically require individual student assessments, followed by appropriate teaching that addresses student needs. *First Steps, Mathematics* (http://det.wa.edu.au/stepsresources/detcms/navigation/first-steps-mathematics/) is one such approach. In the middle years of schooling the challenge is for students to move from additive to multiplicative thinking (Siemon, Breed & Virgona, 2010) and the use of the developmental Learning Assessment Framework (Siemon, Izard, Breed & Virgona, 2006) can aid this shift. Developmental hierarchies have also been identified in geometry (Crowley, 1987), statistics (Watson & Callingham, 2003), and mental computation (Callingham & Watson, 2004). Algebra also develops over a period of time as students move from concrete representations to using abstract thought (Susac, Bubic, Vrbanc, & Planinic, 2014). There is considerable evidence that students' stages of cognitive development are critical for mathematics learning. Meeting these diverse stages appropriately can be a challenge in classrooms where the difference in students' mathematical development can be as much as five or six years (Goss et al., 2015). One focus of this study was identifying practices used to meet this challenge (see Chapters 4, 5, and 6).

In addition to the intellectual aspects, students bring a wide range of beliefs and attitudes to the mathematics classroom. In both primary (for example, House, 2006; Thomson et al., 2012) and secondary schools (Mason, 2003; Southwell & Karmis, 1994) there is evidence that students do not like mathematics but recognise its importance, and that students who do like mathematics tend to do better in tests of mathematics competence. Gender effects are evident in Australia, with less than half of year 8 girls saying they like mathematics (House, 2006; Thomson et al., 2012). These effects impact later choices of mathematics-based enrolments and careers (Lazarides & Watt, 2015; Watt, Jansen, & Joukes, 2013).

Interest in mathematics is also related to achievement (Heinze, Reiss & Augsburg, 2005), but may also be mediated by other constructs such as self-efficacy (Hay, Callingham, & Carmichael, 2015). Motivation to learn mathematics is also associated with other constructs such as self-concept (Githua & Mwangi, 2003) and gender (Watt et al., 2012). Mathematics self-concept, interest, and importance are the primary motivations, which drive mathematics participation and aspirations (Watt et al., 2012). In summary, students' beliefs and attitudes are known to have an impact on students' mathematics learning outcomes.

2.2.3.2 School effects on mathematics

The socio-economic index of the school has a significant impact on students' mathematical outcomes, although this may differ across the different levels of student performance. In general, in international studies, Australia is identified by the OECD as high performing/high equity; that is, overall socio-economic disadvantage reduces students' mathematical performance somewhat less than it does in other countries. Principals perceived school climate, including factors such as bullying, truancy and lack of respect for teachers, as affecting students' performance in PISA (Thomson, De Bortoli, & Buckley, 2013). The claim of equity, however, has been challenged as being only relative to some other countries. There are considerable inequalities within Australian education (Jorgensen & Lowrie, 2014).

At the school level there are also organisational factors that impact on students' learning outcomes. Lamb and Fullarton (2001), using data from Trends in International Mathematics and Science Study (TIMSS) background surveys, identified that class grouping strategies (streaming), had a differential effect depending on the level of achievement: high performing students improved at the expense of low performing students. Teacher morale also appeared to play a part. These factors were of importance in considering aspects of schooling that affected students' outcomes.

2.2.3.3 Curriculum effects

Although Australia has a national curriculum, the ways in which the AC-M is implemented makes a difference to students' outcomes, through its impact on teachers' planning and programming, and choices of materials and approach. The 'packaging' of the curriculum also makes a difference. Separating content into 'silos' (like algebra and geometry taught as discrete courses or units) is less effective than a more integrated approach (Grouws et al., 2013). Although the Grouws et al. study was undertaken in the USA, (which has a very different mathematics curriculum structure to that of Australia), this finding is consistent with research that shows students are successful in mathematics when their teachers deliberately make connections, both within mathematics and with outside contexts (Askew, Brown, Rhodes, Wiliam, & Johnson, 1997).

The nature, emphases, and approaches advocated by the curriculum impact on the ways in which teachers approach their work (Callingham & Burgess, 2014). A report by Dulfer, Polesel, & Rice (2012) suggested the mathematics curriculum was being narrowed by the impact of NAPLAN.

2.2.3.4 Teacher effects on mathematics learning

There is a large body of research about teachers' beliefs about mathematics and its teaching. Teachers have lower expectations for students who appear to have difficulties learning mathematics (for example Beswick, 2007/2008). Teachers' beliefs about mathematics, such as whether they see the subject as a set of procedures or as a way of thinking and solving problems, have an effect on their teaching (Beswick, 2012). In addition, more confident teachers inspire more confidence in the students they teach (Stipek, Givvin, Salmon, & MacGyvers, 2001).

Teachers' knowledge of mathematics has been an important area of research for many years. There is evidence going back many decades that primary teachers may lack mathematics content knowledge (MCK) (Ma, 1999; Hurrell, 2013). In secondary schools there is a growing number of teachers who are teaching 'out-of-area' (that is, outside their area of expertise or qualification) and have limited training to teach mathematics (Weldon, 2015) and this limitation appears to be associated with lower mathematics performance (Hill & Dalton, 2013).

Despite this background, there is little evidence that mathematics qualifications alone lead to successful learning outcomes (Darling-Hammond & Young, 2002; Mewborn, 2001; Wilson, Floden, & Ferrini-Mundy, 2001). There is a growing body of evidence that teachers of mathematics need to have specialised knowledge of mathematics, variously called pedagogical content knowledge (PCK), or mathematics for teaching (MfT). Although defined in different ways, the specialised ways in which teachers know mathematics appear crucial. This specialised knowledge includes such aspects as understanding students' likely misconceptions, appropriate ways of representing mathematical ideas, giving clear and mathematically correct explanations in ways that students can understand, and recognising when students are ready to learn the next stage of mathematics (Ball, Thames, & Phelps, 2008). This type of teaching knowledge of mathematics makes an impact on students' learning outcomes, in primary schools (Hill, Rowan, & Ball, 2005), in middle years (Callingham,

Carmichael, & Watson, 2015), and secondary schools (Baumert et al., 2010). Teachers' knowledge as well as their attitudes and beliefs were of interest to this study (see Chapters 4 and 5).

2.2.3.5 Teaching approaches

The classroom activities and approaches to teaching mathematics used by teachers are related to issues of teachers' knowledge for teaching. There are many ways of achieving high performance in mathematics, and these can be placed on a continuum of teaching approaches from a didactic, teacher-centred model at one end to a social-constructivist, student-focussed model at the other. A detailed discussion of the theoretical underpinnings and merits of the approaches at the extremes is beyond the scope of this study. There has been, however, considerable debate about the efficacy of different approaches (Ewing, 2011; Klein, 2007; Schoenfeld, 2004. Anthony and Walshaw (2009) suggested mathematics pedagogy should be founded on a number of principles:

- all students have the right to access and experience 'mathematical culture';
- all students can become 'powerful mathematical learners';
- all cultures and heritages should be acknowledged;
- the pedagogy should lead to academic outcomes including 'conceptual understanding, procedural fluency, strategic competence, and adaptive reasoning'; and
- social outcomes should be developed within the mathematics classroom (p. 6).

In this study, no value judgements were made about different approaches to teaching mathematics, however, different approaches were canvassed and documented to provide an evidence base of what is happening in Australian mathematics classrooms.

2.2.3.6 Evidence-based teaching

Research indicates that using appropriate data to refine and target teaching approaches is an effective way to improve students' achievement (Goss, et al., 2015). NAPLAN provides useful information to systems, schools, and classes within larger schools. It is less useful for targeting individual student learning because of the nature of the data and associated measurement errors (Wu, 2010). Schools are provided with a variety of complex reports and ways in which they can consider the data from NAPLAN, but many teachers struggle with the statistical literacy needed to interpret the information (Chick & Pierce, 2013). At the same time, the practice of rigidly streaming students into particular groups based on a test is known to inhibit performance for some groups (Jorgensen & Sullivan, 2010). Using growth as a basis for determining success implies that all students will learn mathematics. There was, therefore, interest in identifying how schools and teachers used data to inform mathematics teaching for all students in this study.

It is worth remembering that all of these effects interact in the real world of a practising school, whereas in research studies they may be examined in isolation. In this study there was interest in the nature of the interactions among the diverse variables, and particularly how these interactions impacted on students' learning outcomes in mathematics (see Chapters 4 and 5).

2.2.4 Factors of interest to this study

Against the background of prior research outlined earlier, a range of factors was identified that play a part in students' learning outcomes, in mathematics and more generally, at each level of influence (system, school, classroom, student) following Bronfenbrenner's (1989) model.

Specific factors that provided the focus for the study at the school level included:

- ways in which the curriculum is implemented at system and school levels;
- organisation and grouping for learning, including the use of data to inform school level decisions;
- professional development, qualifications and backgrounds of teachers of mathematics;
- teachers' attitudes towards mathematics and its teaching;
- resources allocated to mathematics, including time and personnel, as well as material for classroom use; and
- attitudes and practices relating to NAPLAN, following reports that NAPLAN was causing undue stress to students and teachers.

At the classroom level, factors of interest included:

- teaching practices;
- classroom environment; and
- homework practices.

Individual level factors included:

- leadership;
- beliefs about mathematics and its teaching and learning;
- goal orientations (mastery or performance) perceived by teachers and students; and
- demographic information including teacher and student characteristics.

The study methodology which was used to investigate the different factors and their interactions is presented in the next chapter.

The project adopted a cross-sectional approach to provide a description of processes used by schools that demonstrated successful outcomes in NAPLAN numeracy. Successful outcomes were defined in terms of growth, and performance where growth data were not available (as in some secondary schools in Western Australia, South Australia and Queensland).

The study considered a continuum of practices based on goal orientation of mastery or performance (Kaplan & Maehr, 2007), and no judgements were made about the value or worth of these different orientations. A performance orientation has a greater focus on *demonstrating* competence, with a focus on skills (rather than understanding), achievement, and competition. A mastery orientation has a greater focus on *developing* competence, including making connections within mathematics, having an interest in mathematics, and cooperation (Kaplan & Maehr, 2007). The dual goal orientation framework also provided for the examination of a wide range of factors that impact on students' mathematics learning outcomes, as described in the previous chapter. Both performance and mastery goals, applied at different levels (system, school, classroom, individual) following Bronfenbrenner's (1989) model, were acknowledged as providing valid routes to high performance.

Regardless of the nature of the goal orientation framework, it was recognised that there are opportunity costs associated with choices made at every level of the system, in terms of resourcing and personal effort. Many of the factors outlined in Chapter 2 are cost variables, such as choices made in managing teaching, class groupings, programming and so on. These factors were also considered in this study.

3.1   Data collection approaches

Three data collection approaches were used:

1. a desktop review of system level provisions;

2. surveys of school leaders, teachers and students; and

3. case studies in schools in every state and territory.

Each of these approaches is described in the following sections.

3.1.1   Desktop review

Websites for all systems (state and territory, independent and Catholic sectors where these were available) were identified. These websites included those of specialist curriculum authorities as well as departmental agencies. In addition, informal interviews and conversations with curriculum specialists, professional development (professional learning) providers, and other researchers also helped to identify relevant activities, which addressed mathematics learning and teaching, occurring in different states across Australia. A summary of the websites examined is provided in Appendix A1.

A key consideration in this study was how the Australian Curriculum: Mathematics (AC-M) was being implemented across Australia. The system resources were examined for evidence of curriculum implementation, support for mathematics/numeracy, particular programs or approaches, and

strategic directions. Additional information was gathered by discussion with appropriate people within systems.

3.1.2   Surveys

Surveys were used to collect data from a wide range of schools. All schools that met the success criteria of growth or Year 9 performance (Growth: 2011–2013, *n* = 319; 2012-2014, *n* = 204; Performance *n* = 96; total = 619) were identified and a specific invitation to these schools was sent. In addition the survey was sent out to schools that did not meet the criteria (called *other schools*) across Australia, where systems agreed to participate. Survey invitations were sent by email directly to schools, and were supplemented by sending survey links through professional associations, including the Australian Association of Mathematics Teachers, some state systems and Catholic dioceses, and through the personal networks of the project team. Surveys were left open until the end of Term 4, and reminder emails send out twice during the period. In the last three weeks of term the superior gain/ high Year 9 performance schools that had not responded were contacted by phone.

Survey instruments were mostly taken from existing validated instruments and where these were used the original question structure was used to maintain the integrity of the instrument. The surveys were tailored to the target group of respondents, leaders, teachers, and students. In some instances questions were not presented depending on responses to prior questions. Some questions were presented only to secondary teachers at the request of the primary principals' organisations. Survey questions, target constructs, and response codes are provided in Appendix A2, together with links to the online surveys.

Details about sample responses are provided in section 3.1.3. Appendix B presents an analysis of the sample of schools identified by ACARA as *superior gain schools*, and the schools that responded to the surveys.

The next sections provide details of the survey instruments and structures.

3.1.2.1   Leader and teacher surveys

Demographic questions: these questions addressed a range of personal and school factors.

3.1.2.2   School level factors included in both leaders' and teachers' surveys

Collective efficacy: this construct provided a measure of the coherence of the school effectiveness in dealing with the students in the context of their community. Twelve questions from Goddard (2002).

NAPLAN: this construct addressed the impact and effects of NAPLAN in the school. Thirteen questions created for this study from themes identified in Thompson (2013).

Teacher practices leading to engagement: these questions addressed ways of teaching mathematics that may lead to increased engagement in mathematics. Nineteen questions, created from a variety of sources about mathematics teaching practices.

Teacher practices leading to achievement: these questions addressed ways of teaching mathematics that may lead to increased achievement in mathematics. Nineteen questions. Created from a variety of sources about mathematics teaching practices.

3.1.2.3 School level factors included in leaders' survey only

School climate: this construct provided a measure of the tone or 'feel' of the school and factors that impact on students' learning. Sixteen questions (secondary schools); 14 questions (primary schools) taken from background questionnaires from PISA 2012 (OECD, 2012).

Curriculum: this construct addressed the implementation of the AC-M and the school's use of external texts, as well as organisational factors such as timetable allocation for mathematics, and homework expectations. Four questions created for this study. Additional questions addressing the detail of the curriculum were included for teachers only.

3.1.2.4 Individual level factors included in leaders' and teachers' surveys

Hours worked: this construct determined the amount of time spent on teaching, and on 'school-related matters' on weekdays, and weekends. Three questions.

Stress and burnout: this construct addressed teacher and leader stress, positive and negative, including emotional exhaustion and depersonalisation. Nineteen questions. With some additions, taken from Maslach, Jackson, and Leiter (1996).

Mindset: this construct addressed perceptions of intelligence. Three questions from Dweck, Chiu, and Hong (1995).

3.1.2.5 Individual level factors included in leaders' surveys only

Leadership style: this construct addressed the way in which the school is managed and decisions are made. Twenty questions (Secondary School); 19 questions (some slightly adapted) (primary school) from the PISA 2012 School Questionnaire (OECD, 2012).

Perceptions of goal orientation: this construct addressed the way in which the school is oriented towards performance and/or mastery. Thirteen questions, adapted from Butler (2007).

Responsibility: this construct provided a measure of school autonomy. Eleven questions adapted for school leaders from Lauermann and Karabenick (2013).

Self-efficacy: this construct considered the individual sense of efficacy for school leaders. Twelve questions from Tschannen-Moran and Careis (2004).

Enthusiasm for Teaching: this construct considered the extent to which teachers and school leaders are enthusiastic about teaching. Eight questions adapted from Kunter et al. (2011) and Chan et al. (2008).

3.1.2.6 Individual level factors included in teachers' surveys only

Professional learning: addressed teachers' professional development specifically for mathematics. Five questions created for this study.

Goal orientation: this construct addressed teachers' perceptions of goal achievement. Twenty questions from Butler (2007).

Teachers' sense of efficacy: this construct addressed teachers' sense of efficacy for teaching mathematics. Twelve questions adapted for mathematics from Tschannen-Moran and Woolfolk-Hoy (2001).

Teacher responsibility: this construct addressed teachers' sense of how personally responsible teachers feel for educational outcomes. Thirteen questions from Lauermann and Karabenick (2013).

Teacher enthusiasm: this construct addressed how teachers feel about mathematics and its teaching. Five questions, adapted for mathematics from Kunter et al. (2011).

Teaching practices: this construct addressed teachers' approaches to teaching mathematics. Thirteen questions, adapted for mathematics from the German translation of Clausen (2002).

Teacher knowledge: this construct considered teachers' knowledge of mathematics and it's teaching, including pedagogical content knowledge. Ten questions appropriate to the school level selected from Beswick and Callingham (2011).

3.1.2.7   Student surveys

Student surveys were provided in two forms. One was designed for students from year 3 to year 6 and the other for students from year 7 to year 10. The younger students' survey asked similar questions to the older students' survey but the number of questions was reduced and questions relevant only to secondary schools were removed. Some questions were reworded to make them more understandable to young students.

Demographics: these questions asked only about basic information such as gender, age and year level, and a self-report of their last mathematics grade.

Mathematics classroom climate: these questions addressed the nature of the mathematics classroom. Sixteen questions from Watt (2012).

Friends perceptions of maths: this construct addressed the ways in which students' peers think about mathematics. Four questions from Watt (2012).

Perceptions of NAPLAN: this construct considered what students think about NAPLAN, Four questions based on themes in Wyn, Turnbull, and Grimshaw (2014).

Homework: these questions investigated students' perceptions of homework in mathematics. Three questions created for this study.

Mathematics motivations and perceptions: this construct addressed factors that impact on students' thinking about mathematics and their beliefs about themselves as mathematics learners. Twenty questions selected from Watt (2004), and the PISA (2006) Student Questionnaire (OECD, 2006).

Personal goals in mathematics: this construct identified students' goals in mathematics classes. Fourteen questions, selected from Fuchs et al. (1994).

Interest in mathematics: addressed students' interest and liking for mathematics. Nine questions, selected from Watt (2004).

Gender perceptions of mathematics: considered students' thinking about whether boys or girls do better in mathematics. Four questions from Watt (2012).

Mindset: this construct addressed perceptions of intelligence. Three questions from Dweck, Chiu, and Hong (1995).

Perceptions of school: the construct addressed students' perceptions of school. Four questions adapted from You et al. (2011).

Perceptions of mathematics teaching: this construct addressed students' views about mathematics teaching. Nine questions from Watt (2012).

Feelings about school: considered how students feel about school and their schoolwork. Nine questions from Samela-Aro, Kiuru, Leskinen, and Nurmi (2009).

Mathematics career: a series of mainly open questions about mathematically-related careers. Five questions from Watt (2012).

3.1.3   Survey responses

A brief outline of the samples that responded to the surveys is presented in this section. The term *successful school* is reserved for those schools defined in Chapter 1 as showing gain of +1 *SD*, or very high performance where gain scores were not available, during the defined time periods. The term *other school* is used for those schools that did not meet the success criteria for inclusion in the study.

Details of school level demographics of all surveys, broken down by *successful* and *other schools* are provided in Appendix B. *Successful schools* from which teacher and leader responses were received were compared with the ACARA dataset on five comparison categories: state, sector, school type, geolocation, and ICSEA. Schools in New South Wales and Queensland were somewhat under-represented in the surveys, as were schools in the Catholic education sector. Combined schools (foundation to Year 10 or Year 12) were slightly over-represented in the survey schools. The geolocation distribution was very similar. The ICSEA measure between the survey *successful schools* and the ACARA dataset showed no statistically significant difference, although there was a statistically significant difference between the *successful* and *other schools* that participated in the survey. ICSEA, as a measure of socio-economic status, is a key determinant of educational advantage (e.g., Sirin, 2005). The results presented in this chapter are of individual responses, and are not aggregated by school.

3.1.3.1. Leaders' survey responses

Of 107 school leaders who had started the survey, responses were received from 97 individuals. A summary of responses by school type is shown in Table 3.1:1.

Table 3.1:1   Leaders' responses

School type	School sector			Total
	Government	Independent	Catholic	
Primary school	40	2	12	54
Secondary school	14	2	1	17
Combined school	6	20	0	26
Total	60	24	13	97

These leaders were located in 16 *successful schools* (31 responses in total) and 61 *other schools* (66 responses in total). Of these 16 *successful schools*, six had shown sustained high growth across both time periods (2011–2013 and 2012–2014). Eleven of these schools participated in case studies.

3.1.3.2 Teacher survey responses

Of 207 teachers who had started the survey, responses were received from 202 individuals, not all of whom responded to every question. A summary of responses by primary or secondary teachers is shown in Table 3.1:2.

Table 3.1:2   Teachers' responses by school type

School type	School sector			Total
	Government	Independent	Catholic	
Primary school	79	14	23	116
Secondary school	29	2	35	66
Total	108	16	58	182*

*Note: 182 teachers responded to this question.

These teachers were located in 28 *successful school*s (124 responses overall) and 31 *other schools* (58 responses overall). Of the 28 *successful schools*, 17 were also involved in case studies. Every year of schooling was covered, from foundation to year 12, although it should be noted that respondents could indicate more than one year level. Seven teachers were not teaching a class—these were most likely senior teachers, curriculum leaders, or coaches.

3.1.3.3 Students' survey responses

The data reported in this report are taken from a total of 1095 responses, of which 28 (2.6%) were invalid—that is, they chose not to complete any part of the survey after logging on. It is possible some of these invalid responses were from teachers or school leaders who wanted to know what the survey contained before presenting it to their students. Of the valid responses, 56.3% came from

young students (years 3 to 6) and 43.6% from students in years 7 to 10. A summary is provided in Table 3.1:3.

Table 3.1:3   Students' responses

Year level	Number	% of total valid responses
3	103	9.65
4	149	13.96
5	194	18.18
6	155	14.53
7	232	21.74
8	84	7.87
9	129	12.09
10	21	1.97
Total valid responses	1067	
Missing	28	

Of these students, 63.2% were in Government schools, 20.9% in Catholic schools and 15.9% in Independent schools. Overall, 33 different schools were represented, of which 14 were *successful schools* and 19 *other schools*. Of the individual responses, 54.1% of students were in *successful schools* and 45.9% were in *other schools*. In every sector, students were distributed across all year levels. All states were represented. Table 3.1:4 provides a summary of students' responses by school type and sector.

Table 3.1:4   Students' responses by school type

School type	School sector			Total
	Government	Independent	Catholic	
Primary school	346	56	188	590
Secondary school	316	110	32	457
Total	662	166	219	1047*

* Only 1047 responses to this question were valid.

As the socio-economic status of a school has an impact on students' outcomes, the distribution of students by ICSEA value, used as a measure of social and economic advantage, was considered. The frequency of students against the school's ICSEA value is shown in Figure 3.1:1. It should be noted that in some schools a large number of students participated; whereas in others only a small number answered the survey. The distribution of students, although somewhat skewed, is not restricted to schools with high ICSEA values, with about 25% of respondents being in schools with an ICSEA value below 1000, the median value for Australian schools (ACARA, 2013).
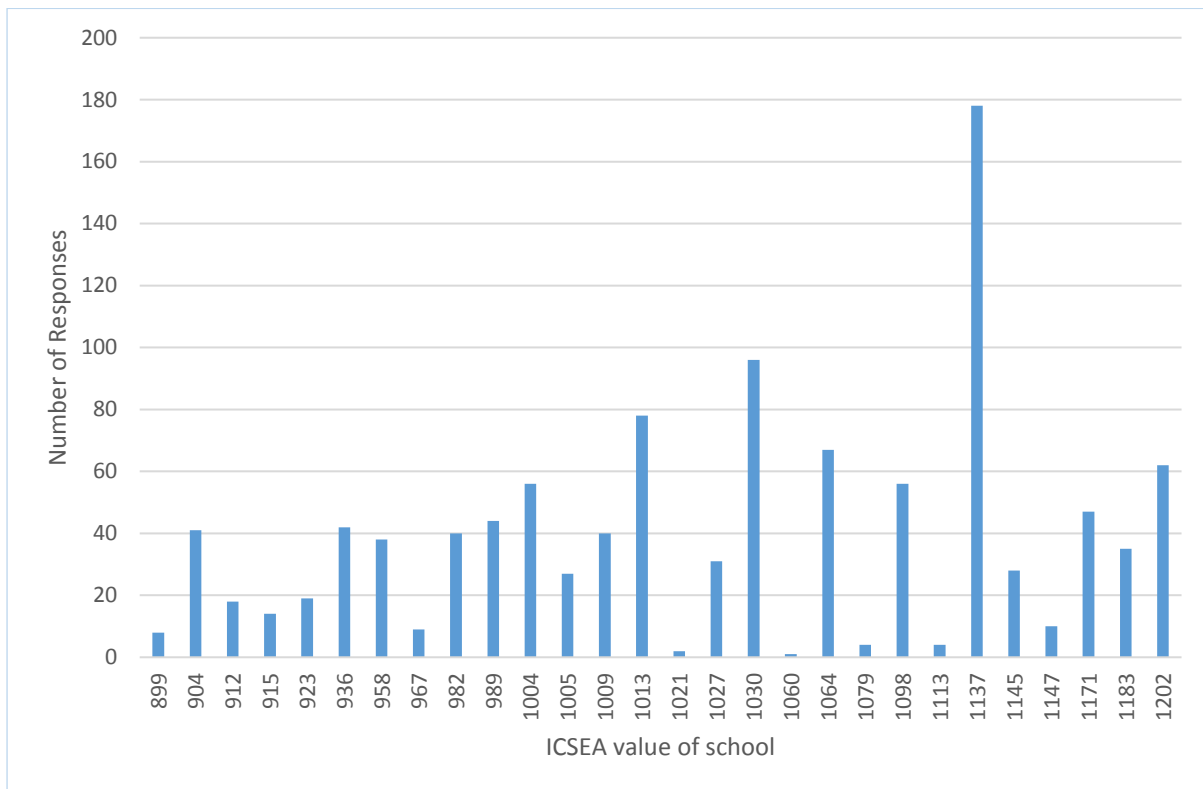
Figure 3.1:1   Distribution of student responses by the ICSEA value of their school

3.1.4   Case studies

The aim for the case studies was to identify 60 *successful schools* across Australia.

Schools were selected from the superior gain/high performance schools identified in ACARA data sets to cover a variety of school types (primary, secondary, combined), all sectors, diverse locations, school size, socio-economic status as measured by ICSEA, and other features of interest such as selective secondary schools, and single sex schools. A number of schools declined the initial invitation because of other commitments or delays in obtaining clearance from the relevant authority. When this happened, attempts were made to replace these schools with a similar school.

To ensure national coverage, a minimum of five schools was the target for each state or territory. In small states and territories, this requirement meant there was a restricted pool of potential case study sites. Schools were grouped into target schools and reserve schools that were matched as far as possible in terms of sector, school type, and location. In particular, efforts were made to identify schools outside capital cities. Schools were not approached until system permissions were granted; in practice this meant that access to schools was not possible until Term 4. Perhaps because of the time of year many schools declined to participate, and most *case study schools* agreed to the case study but not the student survey because of the disruption. Of the initial 60 schools approached, 41 refused to participate. These schools were replaced with reserve list schools wherever possible, leading to a final sample of 52 schools. In three of the combined schools, both primary and secondary sites provided case studies. Altogether 55 case studies were conducted. Details about the sample are provided in the next section.

To ensure consistency across such a large number of case studies, a detailed protocol was developed. Semi-structured interviews were conducted with the principal and/or a school

mathematics leader, at least two teachers, and a focus group of students where appropriate permissions were obtained (40 schools). In addition, two ordinary mathematics lessons were observed, and in some schools a focus group was conducted with parents. Because of timing three schools were contacted by phone only. In these instances, the appropriate school leader or teacher interview protocol was used.

To minimise school disruption, the case studies were undertaken on a single day. The choice of teachers and classes available was hence restricted. In general, visits were arranged on the ground by either the principal or another school leader, as appropriate to that school. This practice is consistent with case study research which '…is not sampling research' (Stake, 1995, p. 5).

Every case study was undertaken by an experienced researcher with recent experience of visiting schools, and familiarity with undertaking observations. These researchers reported to three members of the project team who led 'hubs' responsible for about 20 case studies. The hub leaders organised training, managed the case study process and the data collected.

A reporting template was developed for those undertaking the individual case studies to provide a consistent reporting focus. These reports were descriptive in nature, and were submitted to the hub leader. Each hub leader then synthesised the reports for which they were responsible to provide an overall view of factors within these schools that impacted on mathematics learning and teaching. These initial reports were circulated among the project team, and discussed during three teleconferences. The hub leaders also provided the school stories that were the basis for a series of vignettes. Finally, the three hub reports were synthesised to identify the key ideas and themes emerging from the study. This process ensured considerable crosschecking of the qualitative data by researchers.

Copies of the data collection and case study report protocols are provided in Appendix A3.

3.1.4.1 Case study sample

Case studies were undertaken in every state and territory of Australia.

The location of the *case study schools* is shown in Figure 3.1:2. Although all schools were classified as metropolitan or provincial, several were in relatively remote locations.

Figure 3.1:2   Locations of case study schools

Case studies were undertaken in every sector. Table 3.1:5 shows the distribution of schools by state and sector. Catholic schools were slightly under-represented in the case studies. The target total for each state is shown. A number of schools invited to participate chose to decline, most likely because of timing and the lateness of getting permissions from state authorities. Wherever possible attempts were made to find a replacement but this was not always possible. As a result, the target was not met in every state.

Table 3.1:5   Case study schools by state and sector

	Government	Independent	Catholic	Total	Target
ACT	5	1	1	7	6
NSW	6		2	8	12
NT	2	1		3	4
QLD	2	2	1	5	7
SA	3	2	2	7	7
TAS	3	3		6	5
VIC	5	4	1	10	12
WA	2	3	1	6	7
Total	28	16	8	52	60

Case studies were undertaken in primary and secondary settings. In some instances in combined schools both primary and secondary conditions were examined as a single entity. In three combined schools, which ran as separate schools on different campuses, two case studies were conducted. Table 3.1:6 shows the breakdown by school type.

Table 3.1:6   Case study schools by school type

	Combined	Primary	Secondary
ACT		5	2
NSW		4	4
NT		2	1
QLD	1	3	1
SA		5	2
TAS	4	2	
VIC	1	5	4
WA	1	3	2
Total	7	28	17

School socio-economic status is a predictor of achievement so there was interest in visiting a range of *successful schools* including those that were below average ICSEA values. The average ICSEA value of the *case study schools* was 1068, which is slightly above the mean ICSEA value, which is set at 1000. The ICSEA values ranged from 899 to 1212. The distribution of ICSEA values for the *case study schools* is shown in Figure 3.1:3.
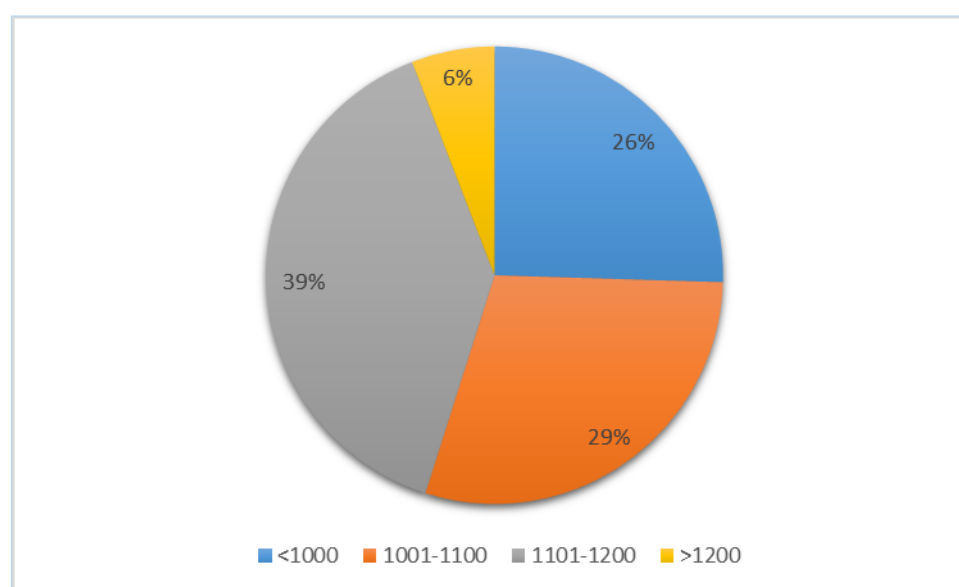
Figure 3.1:3   ICSEA value distribution of case study schools

Table 3.1:7 shows the *case study schools* sampled from the ACARA superior gain in numeracy lists from 2011–2013 and 2012–2014. The highlighted cells indicate the gain scores deemed by ACARA to meet criteria for high gain against either similar schools or schools with the same start scores. Where additional NAPLAN data were available estimated values have been included (including gains from year 5 to year 7 in combined schools). Two schools were included because of performance in year 9 in states where there were limited examples of *superior gain schools* from year 7 to year 9 because of organisational arrangements in these states.

These schools were all flagged by ACARA as having superior gain in at least one of the relevant time periods. The highlighted cells indicate the time period in which the superior gain was identified by ACARA. No gain indicates that the school was included on the basis of year 9 performance.

Table 3.1:7   Case study sample schools

School ID*	ICSEA	Time period	State	Location	Sector	School type	Gain Year 3–Year 5		Gain Year 5–Year 7		Gain Year 7–Year 9	
							2011–2013	2012–2014	2011–2013	2012–2014	2011–2013	2012–2014
101	1155	11-13	ACT	Metro	G	Primary	123	86				
102	1128	12-14	ACT	Metro	G	Secondary						52
111	1203	12-14	ACT	Metro	I	Secondary		82		48		56
118	1128	12-14	ACT	Metro	C	Primary		101				
126	1156	12-14	ACT	Metro	G	Primary		102				
149	973	12-14	ACT	Metro	G	Primary		86				
108	911	Both	NSW	Metro	G	Secondary					61	69
125	1022	Both	NSW	Metro	G	Secondary					63	67
127	1095	12-14	NSW	Metro	C	Secondary					59	65
128	921	11-13	NSW	Provincial	G	Primary	116	80				
130	1149	12-14	NSW	Metro	G	Primary		106				
131	1212	11-13	NSW	Metro	G	Secondary					78	41
140	1202	11-13	NSW	Metro	C	Primary	129					
141	939	11-13	NSW	Metro	G	Primary	111					
150	1129	11-13	NSW	Metro	G	Secondary					59	
117	1028	12-14	NT	Provincial	I	Combined		79		69		54
119	924	12-14	NT	Provincial	G	Primary		119				
120	899	11-13	NT	Provincial	G	Primary	123	87				
100	1020	Both	QLD	Metro	I	Combined	132	92	62	58		44
124	998	12-14	QLD	Metro	G	Primary	118	122		73		
139	1052	11-13	QLD	Provincial	C	Primary	117	130		78		
144	1113	11-13	QLD	Metro	I	Combined	116	111		64		44
148	1103	2014	QLD	Metro	G	Secondary						
109	1055	12-14	SA	Metro	C	Combined						64
129	1021	12-14	SA	Provincial	I	Combined		127		69		45
135	1185	11-13	SA	Metro	I	Primary	115	95			60	

ID		Time period	State	Location	Sector	Type					
137	1071	12-14	SA	Provincial	C	Primary		111	43		
138	1048	12-14	SA	Metro	G	Primary		148	63		
145	1004	12-14	SA	Provincial	G	Combined		129	87		67
147	987	2014	SA	Provincial	G	Secondary					
122	1147	12-14	TAS	Metro	G	Primary		106			
123	1120	12-14	TAS	Metro	I	Secondary		56	45		54
132	994	11-13	TAS	Metro	I	Combined	118	92			
133	1014	12-14	TAS	Metro	G	Primary		94			
143	1171	12-14	TAS	Metro	I	Combined		77	61		57
146	923	12-14	TAS	Provincial	G	Combined		117	71		73
103	1111	11-13	VIC	Metro	I	Combined		109	74	99	27
105	1155	Both	VIC	Provincial	I	Combined		98	91	70	79
106	978	11-13	VIC	Provincial	G	Combined	128	99	79		52
110	1183	11-13	VIC	Metro	I	Secondary		87	77	63	51
112	1016	12-14	VIC	Metro	G	Primary		114			
113	936	12-14	VIC	Provincial	G	Secondary					66
114	958	Both	VIC	Provincial	G	Primary	136	140			
115	1106	12-14	VIC	Provincial	I	Combined		116	59		39
116	1098	11-13	VIC	Metro	G	Secondary				60	58
134	1193	12-14	VIC	Metro	C	Primary		122			
104	946	11-13	WA	Metro	G	Primary	130	113	90		
107	1130	12-14	WA	Provincial	I	Combined		107	57		73
120	1079	Both	WA	Metro	I	Combined	126	109		63	89
121	985	Both	WA	Provincial	G	Combined	120	123		96	68
136	1016	12-14	WA	Provincial	C	Primary	117	135			
142	1075	12-14	WA	Metro	I	Combined		108	26		65

Notes: The 'Time period' columns refer to the period over which the school achieved superior gain. The abbreviations in the 'Sector' column are C = Catholic, G = government, I = independent. *In order to preserve school anonymity, the School IDs in Table 3.1:7 in are unrelated to the IDs in Table 6.2:2.

This chapter outlines the evidence of system-level current practice in mathematics education at the time of the study identified from the desktop review. For the purpose of this study, 'system' is used to mean Government, Catholic, and Independent sectors working within a state or territory jurisdiction, The sectors and jurisdictions interact in that schools within different sectors within a state or territory generally follow the curriculum as it is implemented within the home state or territory. The evidence from the desktop review pertains particularly to systems, but these influence what happens in schools. The findings are organised around four key themes:

1.   curriculum implementation;

2.   support for mathematics and numeracy;

3.   particular programs; and

4.   strategic direction.

Findings at the system level are largely based on the review of websites as well as comments made by members of the reference group during meetings and in other conversations, and from other sources, including professional development providers and system employees. Unless otherwise stated, all information in this chapter was obtained from the websites listed in Appendix A1.

4.1   Key findings

Across the states and territories:
- there is diversity in the way in which the AC-M is delivered and supported.
- there is duplication in the nature and types of materials developed and provided to teachers;
- different research-based programs are suggested, depending on the location of the underpinning research;
- the use of data is a key strategic focus, but more examples are needed in mathematics, especially addressing the mathematics proficiencies; and
- numeracy is a dominant theme, and the Number and Algebra strand of the curriculum is emphasised.

4.1.1 Curriculum implementation

All states and territories implemented the AC-M although the two largest states, Victoria and New South Wales, used curriculum structures with which their schools were familiar (*AusVELS* levels in Victoria and *Stages* in New South Wales) and fitted the AC-M into this framework. Other states, particularly small ones, referred to the ACARA website.

Mathematics and numeracy were both represented in systems' documentation. Numeracy is recognised in the Australian Curriculum as a cross-curriculum capability, which is the responsibility of all teachers to develop and foster. Mathematics is the defined subject area. On websites, there

was a strong emphasis on numeracy, to the point where, in some places, the numeracy continuum within the general capabilities (ACARA, 2014) appears to have become a de facto mathematics curriculum, especially in the primary years. In part, this situation has come about because of the requirement for the formal Australian Curriculum to be presented in a consistent way across the country. The statutory curriculum authorities in each state are responsible for the mathematics curriculum. Curriculum support arrangements fall within the remit of education departments. In larger states both organisations provide good quality research-based support materials, whereas in smaller states the mathematics curriculum is provided through a link to the ACARA website with little additional material. That said, there is evidence of systems using publically available material from other systems as support for the implementation of the curriculum.

Catholic systems tend to follow the state's direction but independent schools may implement alternative curricula, such as the International Baccalaureate (IB) programs. Teachers in some *case study schools* where the IB was used pointed to the difficulty of implementing the IB and, at the same time, having to report on the AC-M. The integrated nature of IB programs seemed to be at odds with the Australian Curriculum, particularly through the reporting requirements. In secondary schools offering the IB in years 11 and 12, students had to opt into either the state-based year 11/12 program or the IB because the expectations were so different.

This fragmented situation is unlikely to change in the foreseeable future because of the constitutional arrangements for education. Nevertheless, there is room for a more focussed and strategic approach nationally to the development of approaches for the delivery of the mathematics curriculum.

4.1.2   Support for mathematics/numeracy across states and territories

There is considerable support provided to schools, teachers, and parents in the form of resources and advice for numeracy in particular, with literacy and numeracy strategies available in all states and territories. Support includes additional personnel such as coaches and curriculum leaders. There is a strong emphasis on developing leadership.

Despite the support, there was an impression overall that literacy takes the major share of resources. Examples provided on websites of the work of literacy and numeracy coaches, for example, although labelled literacy *and* numeracy, focus on literacy, specifically reading. There is also a focus on early- and primary years numeracy, with less support available for secondary years in either numeracy or mathematics. The exception to the secondary years support is in the large states with well-resourced curriculum authorities. Many of the states have excellent numeracy resources available but these are not always accessible to all teachers and schools. Sometimes specialist materials can only be accessed by teachers in a particular state. Although this situation is understandable it leads to duplication of effort.

For example, in 2015 New South Wales published a *Numeracy Skills Framework,* and Queensland is in the process of developing something similar, drawing on the same research background to a large extent. Although recognising the need for contextual sensitivity, this example of duplication might be avoidable, and points to a need for closer inter-state collaboration.

A number of systems use coaches, whose responsibility is to improve the teaching of literacy and numeracy. These individuals are often experienced teachers with skills in pedagogical approaches,

but may not have specific expertise in mathematics or numeracy. They work with a group of allocated schools. The approach that they take varies but is often based on the work of Boyd (see Boyd, 2008). Coaches may be an effective approach to professional learning, but they may need additional knowledge of effective mathematics pedagogy. Although in some systems numeracy and mathematics pedagogical content knowledge was included in coaches' training programs, the time allocated was, of necessity, limited. In secondary schools, coaches with subject specialisation may be more effective.

In general, systems used additional support funding through a range of federal and state initiatives. National partnerships funding was mentioned often in the school examples available. The relatively short-term nature of program funding raises issues about sustainability, and this was sometimes mentioned in the school-based reports available on the web when this study was conducted.

From phone and personal discussions by researchers undertaking the system level review with professional development providers and systems experts, the approach to curriculum implementation appeared often to be focussed on deficit, that is bringing low achieving students closer to the average performance, rather than on developing the mathematical capacity of all students. Comments included many generalisations about the quality of teachers and their pedagogy, notably in secondary schools. There seemed to be a particular philosophy of what constituted effective mathematics or numeracy pedagogy, with a focus on student centred approaches using small group work and concrete materials, and scaffolding students' development through activities that build understanding. Rather than identifying or building on effective practices, professional learning provided a single approach to address perceived problems.

4.1.3   Particular programs or approaches

Because the AC-M does not address approaches to teaching, there was interest in examining whether systems appeared to favour particular approaches. Depending on the state, specific programs are presented on websites, such as *Count Me In Too*, *QuickSmart*, *First Steps*, and *Scaffolding Numeracy in the Middle Years (SNMY).* These programs take different routes to developing mathematics, and are intended for diverse student groups. By and large, these programs have tended to influence their home state—the state in which the original research was undertaken—rather than have a national influence, although individual schools across Australia did use some aspects of programs from other states.

An example of a quality research-based resource is the *Fractions and Decimals Online Interview* available to Victorian Government schools. This resource is based on empirically tested tasks mapped to the number strand of the Victorian AusVELS and focusses on middle-years students. It is underpinned by a sophisticated Learning Management System that provides tracking information about individual students. The tasks are open-ended and require an active response rather than multiple choice questions typically used in commercial products. The resource is supported by recommended readings, classroom activities and suggestions for making use of the tool. Packages of this type are needed in the less well-addressed areas of the curriculum.

Among the other support materials available through systems there is a strong emphasis on investigation, together with the use of concrete materials. Queensland has developed a *Curriculum into the Classroom (C2C)* resource and some of these materials are available through *Scootle*. Broadly, the approaches seem to take a socio-constructivist line, underpinned by the work of

researchers such as Vygotsky (1986) that suggests that students need to interact with a more knowledgeable other (teacher or peer) to develop understanding. In classrooms taking this approach dialogue and discussion are important. Students experience different activities and discuss these to develop mathematical understanding. The extent to which the activities suggested on systems websites (see Appendix A1) build to a coherent mathematics program varies. There is always a considerable emphasis on number and very little on geometry, and statistics is fairly undeveloped compared with other countries such as New Zealand. There is, however, little emphasis on the curriculum proficiencies of fluency, problem solving, reasoning and understanding other than some articles and presentations. For the teacher who wants to understand what fluency, for example, looks like in geometry there is not a lot of help. *Scootle* has a wide variety of resources and was mentioned by some schools. When searching using the AC-M as a basis, the general capabilities and cross-curriculum priorities are explicitly available but the underpinning proficiencies do not appear to be addressed explicitly. Investigative approaches can be used to develop these aspects of mathematical thinking, and there is a broad research base that supports an emphasis on the proficiencies on both cognitive and equity grounds (Boaler, 2016; Kilpatrick, Swafford, & Findell, 2001).

In some states a Direct Instruction model of teaching is used, especially for low achieving and Indigenous students. This is highly scripted and focussed on behavioural psychology (e.g., the work of Gagné (1970)). The approach is contentious with considerable discussion about its effectiveness, especially in numeracy (for example, ACER, 2013). There is room, however, to consider alternative approaches as well, together with the evidence base for all pedagogical interventions, without reverting to a transmission model of teaching (Lobato, Clarke, & Burns Ellis, 2005; Masters, 2009).

4.1.4   Strategic directions

The key strategic direction for states involves the use of data. There is considerable information about the NAPLAN data, and schools are now provided with many ways of considering their own data. Much of this information is of very high quality but many examples on the various websites focus on reading rather than numeracy. The materials available to schools could usefully be supplemented with examples of using other sources of data, including classroom assessment data and moderation tasks. Schools and teachers need to develop skills in the interpretation of complex assessment data, appreciating the limitations and affordances of data like NAPLAN. In addition, information is wanted about ways of supplementing this information with classroom based data. Schools then have to go beyond the data and use the information effectively to plan interventions at the school, class or individual level. Specific numeracy examples are needed to realise the potential of data use.

Targeted teaching based on effective use of data to group students for learning does impact on students learning outcomes (Goss et al*.,* 2015). In mathematics, however, testing can lead to high levels of anxiety. For example, testing arithmetic computation rather than explicitly focussing on strategies has led to depressed performance and increased worry for students (McIntosh, 2005). Hence collecting data for the purpose of grouping students in mathematics has to be undertaken sensitively with the purpose clearly explained to students, and the resulting teaching focussed on the development of cognitive thinking skills in mathematics. In addition, the assessment tools available tend to emphasise the number strand of the curriculum. Such assessment may be less useful for effective grouping for the development of other strands of the mathematics curriculum, or for grouping to develop the mathematics proficiencies of problem solving, reasoning, understanding,

and fluency. At present there is little support for teachers to develop skills in collecting and analysing mathematics data from the classroom, drawing inferences from these data, and developing effective teaching programs to develop students' mathematical proficiencies.

In this chapter, evidence of best practice is taken from the survey results and includes a comparison of responses from *successful schools* and *other schools*. The surveys had a focus on school climate and goal orientation using teachers' and students' perceptions. Evidence is organised at school, classroom, and individual level, and includes inferential analysis of the impact of variables identified as potentially important on students' engagement and interest in mathematics.

The analyses between groups of survey respondents, including those comparisons between *successful schools* and *other schools,* used data provided by survey participants (principals, leaders, teachers and students). Where a statistically significant difference was identified between any two groups then that difference refers to the sample of respondents who completed the survey. See Appendix B and section 3.1.3 for an indication of the surveys' sample sizes, and a comparison of how the survey sample of *successful schools* compares with all of the *successful schools* identified by ACARA. Participation was voluntary; hence the leaders, teachers, and students who participated may not have been representative of their respective schools. This caveat is relevant for survey participants from both *successful and other schools,* and is in line with other education research practice.

It should be noted that not every question was answered by the same number of respondents. Not only were different versions of the surveys used for primary and secondary schools, but also respondents participated voluntarily and hence could choose not to answer a particular question. For this reason, response numbers differ from question to question.

5.1   Key findings

- Teachers and leaders who responded to the surveys were better qualified in general than teachers in the general population. There were no differences, however, in the level or type of qualifications held by teachers and leaders of *successful schools* compared with *other schools*.
- Leaders in *successful schools* were more likely to acknowledge the role of community factors in students' learning than were leaders in *other schools*.
- *Successful schools* were less likely to group mathematics classes by ability. Whereas 67% of all teachers and school leaders in *successful schools* indicated that they grouped students for at least some of their mathematics classes, in *other schools* this proportion was 78%. The difference between *successful and other school* respondents was statistically significant for this sample of respondents.
- Allocating more time to mathematics did not ensure success.
- There was no standout program or resource used in schools. *Successful schools* used a wide range of resources.
- Regardless of whether they went to a *successful* or *other school*, most students reported that they had received an A or B rating in their most recent report; very few students received a D or E.
- All schools acknowledged positive aspects of NAPLAN but *other schools* were more likely to focus on the negative effects.

- Compared with secondary schools, teachers and leaders in primary schools were more likely to acknowledge NAPLAN's positive effects; but they were also more likely to agree that NAPLAN can have a negative impact.
- Student focussed approaches, such as students explaining their own thinking, were seen as important by teachers for both engagement and achievement in mathematics.
- Teachers' enthusiasm for *teaching* mathematics had a greater impact on students' interest and engagement than did teachers' enthusiasm for mathematics itself.
- Teachers' enthusiasm for teaching mathematics was highly associated with mastery goal oriented classrooms.
- Younger students were significantly more likely to value mathematics and to be interested in mathematics overall.
- For primary students in *successful schools* (the only group where there was sufficient data to match students with teachers), girls and older students had less emotional and cognitive interest in mathematics.
- Within *successful schools* (the only group where there was sufficient data), three groups of students were identified that showed different profiles of engagement: engaged, compliant, and disengaged. Boys were overrepresented in the disengaged group, and girls in the compliant group.

5.1.1   School characteristics

In this section aspects of schools and teachers identified from the surveys are presented. These include background information about teachers, organisational arrangements in schools, resources used in teaching, and perceptions of NAPLAN.

5.1.1.1 Year groups taught by respondents

Teachers were asked to indicate the year groups in which they were currently teaching, as well as whether they thought of themselves as a primary or secondary mathematics teacher. Of the 120 teachers that identified as primary teachers who responded to this question, 96 were working in multiple year groups, either on mixed year classes such as a year 2/3 class, or across multiple year groups as a numeracy coach. In contrast all of the 67 secondary teachers who responded to this question were teaching across more than one year group, as is usual in secondary school settings. When the year groups were considered by the primary/secondary identifier the responses revealed that a small number of secondary teachers taught in the primary years but a larger proportion of primary teachers taught in the early secondary years of schooling. The findings are summarised in Figure 5.1:1.
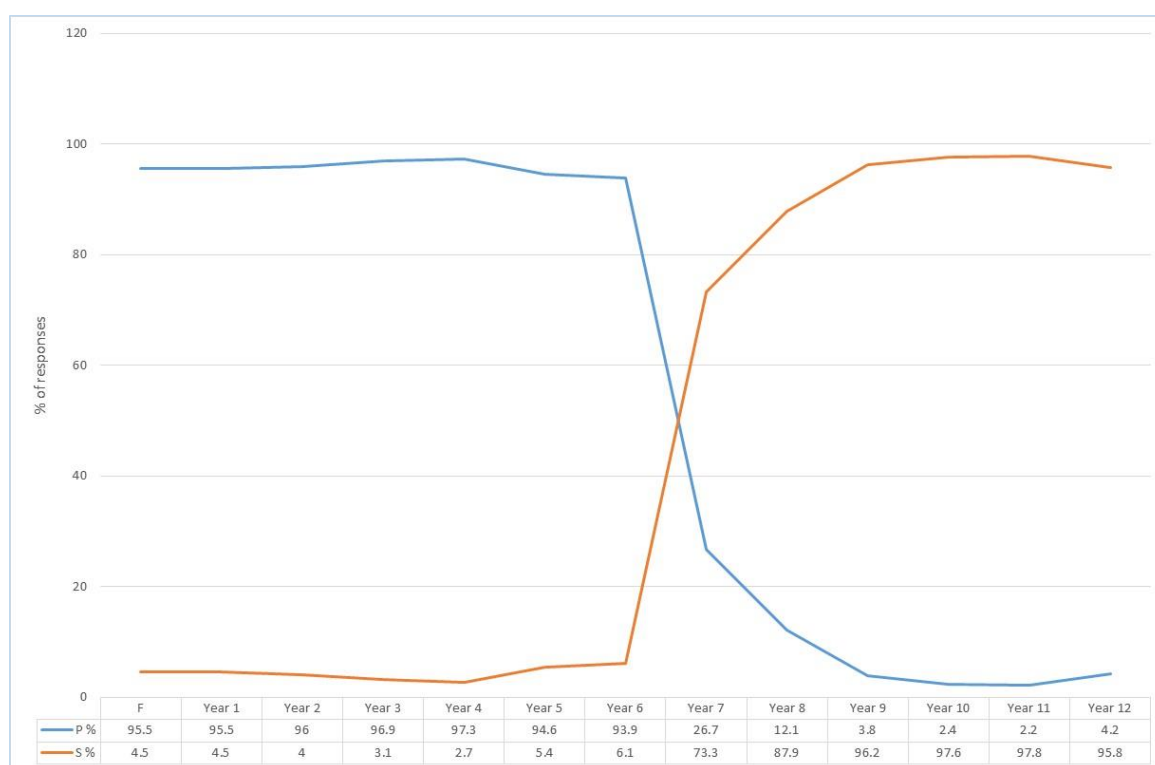
Figure 5.1:1   Year levels taught by respondents as a percentage of teachers who identified as either primary (p %, blue line) or secondary (s %, orange line) teachers

The crossover from teachers identifying as primary or secondary teachers was clear at the transition from year 6 to year 7. When the data were collected, only South Australia still located year 7 in primary school. It is possible that some primary teachers had moved into secondary school settings when the changes were made in West Australia and Queensland to include year 7 in secondary school. There was, however, a sizeable minority of primary teachers teaching in Year 8 (12.2%). The teaching backgrounds in the middle years of schooling appear to be more mixed than in the early or later years. This finding has implications for professional development (professional learning) programs (see section 5.1.1.5).

The actual number of teachers teaching in each year group was very similar as shown in Table 5.1:1. Note that there was a total of 187 teachers who responded to the question about which year levels they taught. The total number (431) of year level 'mentions' in Table 5.1:1 is larger than 187 because of the 163 teachers who taught across multiple year levels.

Table 5.1:1   Number of respondents who taught in different year levels

Year level	F	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12
N	22	22	25	33	36	37	33	30	33	26	41	46	47

5.1.1.2 Teacher and leader qualifications

Teachers and school leaders were asked a series of questions about their educational and mathematics qualifications, and their teaching experience. Most teachers held a bachelor degree (103/182, 56.6%), with nearly 20% having a postgraduate qualification in education. Among those who had responded to the school leaders' survey, over half had a bachelor degree (49/96, 51.0%) and one third (32/96, 33.3%) held a postgraduate degree. The number of postgraduate degrees may reflect the move to a Master of Teaching (MTeach) as the postgraduate entry qualification; however, for those who achieved their highest educational level before about 2005 this is less likely. Data from the National Teaching Workforce Dataset (NTWD), Data Analysis Report 2014 (Willett, Segal, & Walford, 2014) indicates that in Australia overall, less than 10% of all teachers hold postgraduate degrees, and about 7% hold educational postgraduate degree qualifications. The teachers who responded to the survey appear to be atypical of Australian teachers overall in terms of postgraduate study. This finding may indicate that teachers who responded to the survey had a particular interest in further professional qualifications, and this may influence how they think about teaching.

A majority of teachers had studied mathematics as part of a bachelor degree (101/182, 55.5%) and a similar proportion of leader respondents also indicated this level of mathematics (55/96, 57.3%). It is likely that some of these teachers had taken mathematics courses as part of a Bachelor of Education (BEd) or similar degree. Some respondents indicated that they held a postgraduate degree in mathematics or statistics (teachers: 7/182, 3.8%; leaders: 3/96, 3.1%). Such degrees are likely to include both mathematics and mathematics education. Nevertheless, these data suggest that around 3.5% of all respondents had some further qualification in mathematics. No data exist at the national level about the focus of postgraduate qualifications, that is whether they are education focussed or from some other discipline, nor whether they have a mathematics component, but given the overall proportion of teachers holding postgraduate degrees it may be a reasonable assumption that teachers in *successful schools* are well qualified in mathematics or mathematics education although there was no apparent difference in qualifications between teachers in *Successful schools* and *other schools*. This finding is in line with other research (Darling-Hammond & Young, 2002; Mewborn, 2001; Wilson, Floden, & Ferrini-Mundy, 2001).

There were predictable differences between primary and secondary teachers. Table 5.1:2 shows a comparison between the highest educational levels of teachers regarding themselves as primary or secondary teachers. The differences in the postgraduate qualifications and the bachelor degree most likely reflect the predominant initial teacher education pathways, with secondary teachers more likely to undertake a specialist degree followed by teacher education, either a graduate diploma or Master of Teaching.

Table 5.1:2   Teachers' reported educational levels

Highest educational level	Primary teachers		Secondary teachers		Total	
	N	*%*	*N*	*%*	*N*	*%*
Postgraduate degree	15	12.9	18	27.3	33	18.1
Graduate Diploma or Graduate Certificate	14	12.1	23	34.8	37	20.3
Bachelor Degree	81	69.8	22	33.3	103	56.6
Advanced Diploma	6	5.2	2	3.0	8	4.4
Certificate	0		1	1.5	1	0.5
Total	116	100	66	100	182	100

The Leaders' survey produced similar results. Leaders were not asked to nominate whether they considered themselves a primary or a secondary teacher, but were asked about the type of school: primary, secondary or combined primary/secondary. The results are summarised in Table 5.1:3.

Table 5.1:3   Leaders' reported educational levels

Highest educational level	Primary school		Secondary school		Combined school		Total	
	N	*%*	*N*	*%*	*N*	*%*	*N*	*%*
Postgraduate Degree	16	29.6	3	18.8	13	50.0	32	33.3
Graduate Diploma or Graduate Certificate	3	5.6	3	18.8	5	19.2	11	11.5
Bachelor Degree	32	59.3	10	62.5	7	26.9	49	51.0
Advanced Diploma	3	5.0	0	0.0	1	3.8	4	4.2
Total	54	100	16	100	26	99.9	96	100

When considered by the success criterion, the overall qualification patterns were similar for *successful schools* and *other schools*. Table 5.1:4 shows the comparison between teachers and leaders in both *successful schools* and *other schools*. Leaders appeared to be more likely to hold a postgraduate qualification, but there were no major differences between *successful* and *other* schools overall.

Table 5.1:4   Teachers' and leaders' reported educational levels by success

	Successful schools				Other schools			
	Teachers *N*	Teachers %	Leaders *N*	Leaders %	Teachers *N*	Teachers %	Leaders *N*	Leaders %
Postgraduate Degree	20	16.1	12	29.3	13	22.4	20	37.0
Graduate Diploma or Graduate Certificate	31	25.0	9	22.0	6	10.3	2	3.7
Bachelor Degree	70	56.5	19	46.3	33	56.9	30	55.6
Advanced Diploma	2	1.6	1	2.4	6	10.3	2	3.7
Certificate	1	0.8				0		
Total	123	100	41	100	58	100	54	100

Very similar patterns were also seen for the reported level of Mathematics studied, except teachers were more likely than leaders to hold a postgraduate qualification in mathematics or statistics. This finding is not surprising given that, in secondary schools, teachers are the specialists who are focussed on mathematics. Again, however, there appeared to be little difference between *successful* and *other schools*. Findings are summarised Table 5.1:5.

Table 5.1:5   Teachers' and leaders' highest reported level of mathematics studied by success

	Successful schools				Other schools			
	Teachers *N*	Teachers %	Leaders *N*	Leaders %	Teachers *N*	Teachers %	Leaders *N*	Leaders %
Postgraduate mathematics/ statistics	4	3.3	1	2.4	3	5.2	2	3.7
Bachelor mathematics/ statistics	69	56.1	24	58.5	32	55.2	31	57.4
Year 11/12 specialist tertiary	4	3.3	2	4.9	0	0	5	9.3
Year 11/12 general tertiary	28	22.8	6	14.5	8	13.8	8	14.8
Year 11/12 non tertiary	9	7.3	4	9.8	6	10.3	3	5.6
Year 10 mathematics	8	6.5	3	7.3	2	3.4	5	9.3
Can't remember	1	0.8	1	2.4	7	12.1	0	0

There was no association between level of qualification of a leader and whether or not a school had displayed high growth or sustained growth, irrespective of whether it was in secondary or primary school contexts. Similarly, the highest mathematical qualification was not associated with high growth or sustained growth, irrespective of secondary or primary school contexts. A similar finding was reported in Chiang, McCulloch, Lipscomb, and Gill (2016).

5.1.1.3 Teachers' and leaders' experience

In addition to qualifications, teachers were asked about both their overall teaching experience and their mathematics teaching experience, and leaders were asked about their overall teaching experience and their leadership experience. The respondents were highly experienced overall, with about one-third of the teachers and over half of the leaders having taught for over 20 years. Table 5.1:6 shows the overall teaching experience of respondents in the teachers' and leaders' surveys.

Table 5.1:6   Teaching experience of survey respondents

Years of teaching experience	Teachers *N*	Teachers %	Leaders *N*	Leaders %
0–5 years	38	20.9	9	9.2
6–10 years	36	19.8	9	9.2
11–15 years	32	17.6	16	16.3
16–20 years	16	8.9	8	8.2
> 20 years	60	33.0	55	56.1

When overall teaching experience was considered by school type there was again very little difference across primary and secondary schools. There was, however, some suggestion in the data that *successful schools* tended to have more experienced teachers, although differences were small.

The distribution of mathematics teaching experience for teacher respondents is shown in Figure 5.1:2.
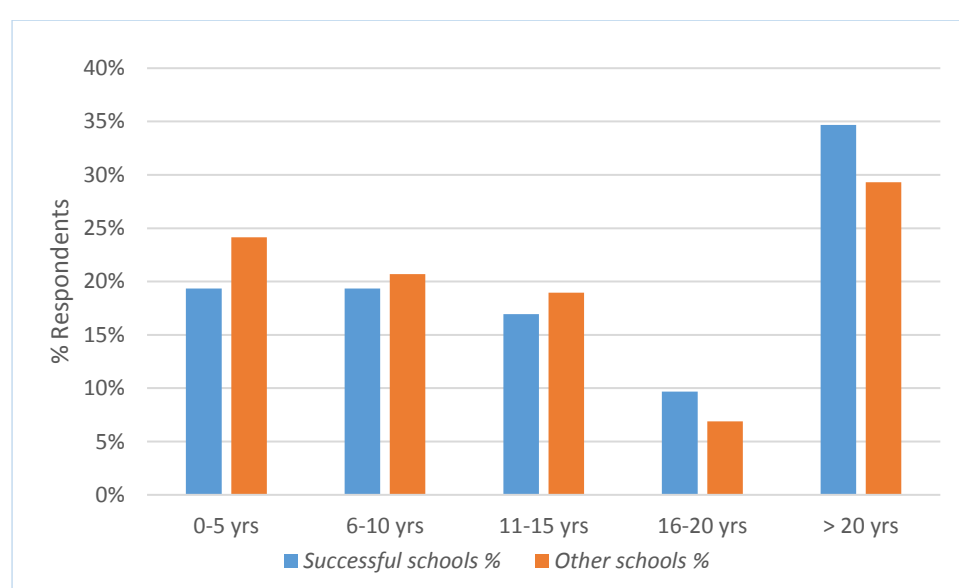
Figure 5.1:2   Mathematics teaching experience in years for teacher respondents by success

A somewhat different picture emerged from the leadership experience. When asked how long they had been working in schools as a leader, over one quarter had been in leadership roles for less than five years. A summary of the responses is shown in Table 5.1:7.

Table 5.1:7   Leadership experience

Years of leadership experience	*Success N*	*Success %*	*Other*	*Other %*	Overall	Overall %
0–5 years	0	0	9	13.6	9	9.3
6–10 years	4	12.9	5	7.6	9	9.3
11–15 years	5	16.1	11	16.7	16	16.5
16–20 years	3	9.7	5	7.9	8	8.2
> 20 years	19	61.3	36	54.5	55	56.7
Total	31	32.0	66	68.0	97	100

When considered by school type and by success, the distribution of leadership experience appeared similar. These findings are shown graphically in Figure 5.1:3.
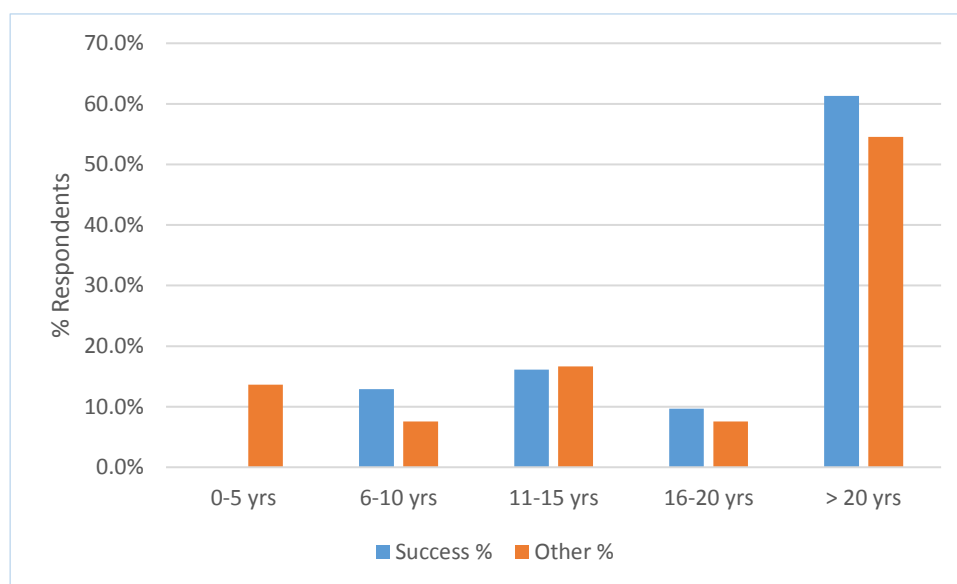
Figure 5.1:3   Leadership experience by success

It is possible that at least some of the leaders were in roles such as numeracy coaches or numeracy coordinators because a number of states have established these positions relatively recently. This notion is supported by the case studies, in which a number of mathematics/numeracy leaders had been in their role for relatively short time periods.

5.1.1.4 Aspects of leadership

Leaders were asked a number of questions relating to perceptions of their schools and their leadership. One series of six questions related to school communities, such as, 'The students come to this school ready to learn'. Leaders in *successful schools* were statistically significantly more likely to acknowledge the role of the community factors in students' learning (t (92) = 2.135, p = .035). It should be noted that the *successful schools* had a slightly higher ICSEA score (Mean=1057, *SD* =94) than *other schools* (Mean=1008; *SD* =75) (See Appendix B). Community factors have been associated with socioeconomic status in earlier research studies (Jorgenson & Lowrie, 2014) but productive links with the community have been shown to be advantageous to all students (Sanders, 2015).

5.1.1.5 Professional learning (professional development)

In this report the term professional learning is used because that is the terminology understood in schools and education systems. It can be considered interchangeable with professional development.

About one quarter of the teacher respondents to the survey (48/200, 24.0%) had undertaken no professional learning for mathematics teaching within the past year. About the same proportion (49/200, 24.5%) had attended only a session or two. In contrast, about one fifth (39/200, 19.5%) had attended professional learning events for more than three days. Of interest was that teachers in secondary school settings were statistically significantly more likely to attend for longer periods whereas more teachers in primary schools had undertaken no professional learning addressing mathematics ($X2$ = 12.78, df = 199, p = .012). It may be that secondary teachers, who are usually mathematics subject specialists, are more inclined to take up professional learning opportunities in mathematics, or engage in programs that require several sessions. The findings are summarised in Table 5.1:8.

Table 5.1:8   Professional learning by school type

	Primary school		Secondary school		Overall	
	Teachers *N*	Teachers %	Teachers *N*	Teachers %	Teachers *N*	Teachers %
None	38	29.7	10	13.9	48	24.0
A session or two	36	28.1	13	18.1	49	24.5
About a day	12	9.4	12	16.7	24	12.0
2–3 days	21	16.4	19	26.4	40	20.0
> 3 days	21	16.4	18	25.0	39	19.5

When considered by whether the school was successful in NAPLAN using the success criteria (*successful* school), or was from a comparison school that did not meet all criteria for success (*other schools*), there was no statistically significant difference, although there was a slight indication that *successful schools* were undertaking longer professional development opportunities. This comparison is summarised in Figure 5.1:4.

	None	A session or two	About a day	2-3 days	> 3 days
Successful Schools %	24.2	24.2	10.5	19.4	21.8
Other Schools %	24.1	25.9	13.8	22.4	13.8
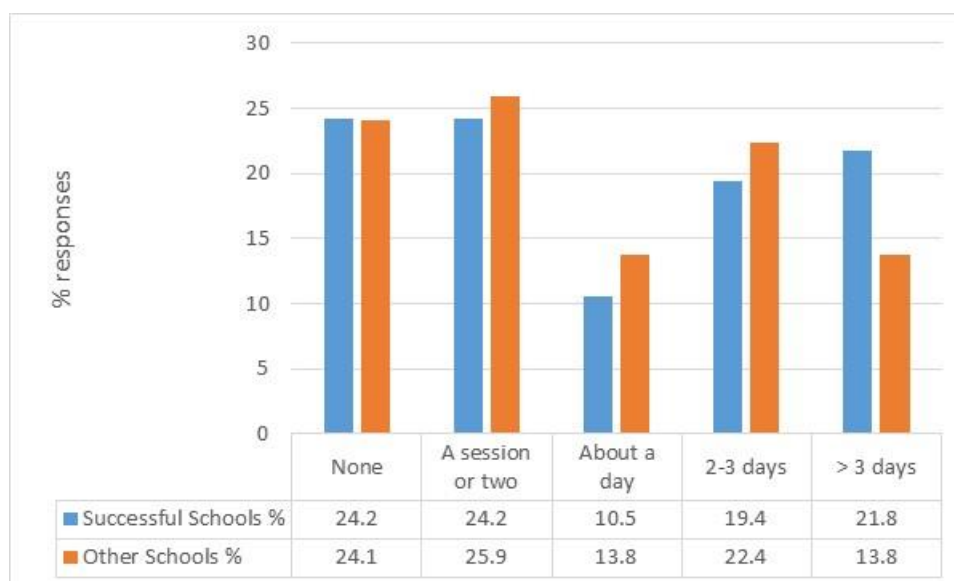
Figure 5.1:4   Duration of professional learning by success

In addition to how much structured professional learning they undertook, teachers were asked about the year levels that the professional learning targeted. Each teacher could respond with more than one year level to account for multiple experiences of professional learning, and for learning programs that may have targeted several year levels. Of particular interest is that a there were a number of primary teachers who undertook professional learning that targeted year 7 and year 8. There are several possible reasons for this finding. During the period immediately prior to the study, Queensland and West Australia were preparing for the transition of year 7 from primary to secondary school settings. This transition entailed considerable discussion across primary and secondary schools, and it may be that teachers were thinking about these discussions. In South Australia year 7 is located in primary school. Table 5.1:9 summarises the survey responses. The proportions are based on responses from teachers in both primary and secondary schools.

Table 5.1:9   Target year groups for professional learning by primary or secondary teacher

Professional development target year groups	Number of primary teachers	% primary school responses*	Number of secondary teachers	% secondary school responses*
F–year 3	47	56.6	0	
Year 4–year 6	52	62.7	2	3.4
Year 7–year 8	10	12.0	16	27.6
Year 9–year 10	2	2.4	18	31.0
Year 11–year 12			40	69.0
No particular year level	13	15.7	15	25.9

* The percentages shown relate to the number of responses to that question, by teachers' indication of primary or secondary teacher. Teachers could respond to multiple target year group categories and hence the percentages do not add to 100.

These results point to a limited amount of professional learning targeting the lower secondary years of schooling, years 7–8, and years 9–10. When compared with the large 69.0% of Secondary teachers who had undertaken professional learning targeting years 11–12 and the large proportion of primary teachers who had undertaken professional learning targeting years F to 3 and years 4 to 6, the upper primary and lower years (years 7–10) of secondary schooling may be somewhat neglected in professional learning provision. It should also be noted that in the period immediately prior to this study, considerable work had been undertaken in Western Australia and Queensland involving both primary and secondary schools in preparation for the transition of year 7 to secondary settings which may also have influenced the results.

In response to a question about the content of the professional learning, 12 responses stated unspecified curriculum or mathematics as a focus; eight responses indicated the new curriculum in years 11–12. There was some mention of problem solving (two instances) and two of mathematical investigations and applications. Data analysis was mentioned in three responses. Other responses were spread across a range of categories, including general pedagogy, peer observation, and dyscalculia (one mention each) or specific programs adopted by a school (one mention each). A full list of professional learning content focus is provided in Appendix C2.

5.1.1.6 Grouping for mathematics teaching

Teachers were asked in the survey whether mathematics classes in their school were grouped by student ability. A majority of teachers (110/181, 61%) reported that ability grouping occurred in some classes, with only 53/181 (29%) reporting no grouping, and a small number (18/181, 10%) reporting that ability grouping occurred in every class.

Perhaps surprisingly, the distribution of ability grouped classes in mathematics was similar for primary and secondary schools as shown in Table 5.1:10, although a slightly higher percentage of secondary teachers reported that all classes were grouped for mathematics.

Table 5.1:10   Ability grouping for mathematics by school type

Ability grouped mathematics classes	Primary teachers *N*	Primary teachers %	Secondary teachers *N*	Secondary teachers %
None	34	30%	19	29%
Some	72	63%	38	58%
All	9	8%	9	14%

When the results were considered by whether the school was successful or otherwise, respondents in *successful schools* were statistically significantly less likely to report that their school grouped mathematics classes by ability (X^2 (2, *N* = 181) = 8.42*, p* = .01) as shown by the proportions in Table 5.1:11. Despite there being a statistically significant difference, only one third of teachers from *successful schools* reported that no classes in their school were grouped by ability, compared with one fifth of classes in *other schools*. At the other end of the scale only 6% reported that they grouped students in every class compared with 19% in *other schools*. The predominant pattern appeared to be grouping by ability in some classes.

Table 5.1:11   Reported incidence of ability grouped mathematics classes by success

Ability grouped mathematics classes	*Success N*	*Success %*	*Other N*	*Other %*
None	40	33%	13	22%
Some	76	62%	34	59%
All	7	6%	11	19%

5.1.1.7 Time allocation for mathematics learning

The number of hours each week allocated to mathematics in each year from Year 3 to Year 10 is shown in Table 5.1:12. The median values of five hours in the primary year levels and four hours in the secondary year levels appeared to be fairly typical, although there was considerable variation as shown by the maximum and minimum values.

Table 5.1:12   Time allocation in hours per week for mathematics learning

	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Mean	5.30	5.36	5.29	5.23	4.14	4.03	3.94	3.96
Median	5.00	5.00	5.00	5.00	4.00	4.00	3.75	4.00
Mode	5.00	5.00	5.00	5.00	4.00	4.00	4.00	4.00
Minimum	3.50	3.50	3.50	3.50	2.70	3.00	3.00	3.00
Maximum	10.00	10.00	10.00	10.00	8.00	8.00	8.00	8.00

When the values were considered by whether the school was successful or not in mathematics as defined for this study, there was no difference in the median values. The mean values for time allocated to mathematics in schools is shown in Table 5.1:13 for *successful* and *other schools.*

Table 5.1:13   Mean time allocation in hours per week for mathematics learning by success

	Success			*Other*			Mean difference	*t*	*p*
	N	Mean	SD	N	Mean	SD	(*Other – Success*)		
Year 3	28	4.93	1.14	39	5.60	1.52	0.67	1.99	.05*
Year 4	29	5.02	1.17	39	5.69	1.56	0.67	1.93	.05*
Year 5	28	5.09	1.28	39	5.48	1.48	0.39	1.11	0.27
Year 6	28	5.01	1.30	38	5.43	1.50	0.32	1.18	.24
Year 7	14	3.77	.64	24	4.37	1.27	0.60	1.63	.11
Year 8	14	3.85	.41	23	4.13	1.11	0.28	0.89	.39
Year 9	14	4.09	.49	23	4.04	1.10	-0.05	-0.16	.88
Year 10	14	4.09	.49	23	4.08	1.09	-0.01	-0.34	.97

The mean values showed that *other schools* reported on average more time as allocated to mathematics in every year except Year 9 and Year 10, and the mean values were significantly different in year 3 and year 4. The findings suggest that simply allocating more time to mathematics does not ensure success.

5.1.1.8 Teaching resources

School leaders were asked about their school's curriculum, and commercial programs or resources used for teaching mathematics. Most schools used the AC-M as a basis for their curriculum. Of those that responded 'no', two mentioned the IB program. The basis for the curriculum in remaining responses is unknown because no response was given to the question that asked for details. Table 5.1:14 provides a summary. Statistical significance could not be determined because of low cell counts.

Table 5.1:14   Responses from school leaders about the use of AC-M

	Success N	*Success %*	*Other N*	*Other %*	Overall	Overall %
Yes	36	94.7	44	83.0	80	87.9
No	2	5.3	9	17.0	11	12.1
Total	38		53		91	

The majority of school leaders indicated that they did not use a commercial program for mathematics in their school. Results are summarised in Table 5.1:15, broken down by success. There was no statistically significant difference between responses from *successful schools* and *other schools*.

Table 5.1:15   Responses from school leaders about the use of commercial programs

Commercial Program Use	*Success N*	*Success %*	*Other N*	*Other %*	Overall	Overall %
Yes	11	28.9	16	30.2	27	29.7
No	27	42.2	37	69.8	64	70.3
Total	38	41.8	53	58.2	91	100

Where leaders indicated in the survey that they used a particular program or resources in their school, a variety of packages was noted. These programs and resources included online and text based resources. A list of programs or resources mentioned within individual schools is provided in Table C2 in Appendix C. Where there was mention in a school, by more than one respondent, this program or resource has been counted only once to avoid over-counting. No percentages are given because some leaders mentioned several programs or resources whereas others only mentioned one program or resource. Further information about resources used in *successful schools* is provided in Chapter 6, section 6.2.6.

Table 5.1:16   Responses from school leaders about programs and resources used in individual schools.

Program or Resource	Number of Schools
International Baccalaureate	2
Origo	3
iMaths	2
Oxford	3
Mathletics	4
Pearson	2
Targeting Maths	1
Maths 300	1
Jacaranda	2
Maths Online	1
First Steps	1
Nelson	1
Macmillan MathsWorld	1

5.1.1.9   Assessment and reporting

There was interest in examining assessment practices in schools because of the emphasis on data and evidence driven teaching. In the survey, teachers were asked about the extent to which they could use a range of assessment strategies. On a scale of 1 (nothing) to 9 (a great deal) the overall mean score was 7.05 (*SD* = 1.46) indicating that teachers felt able to use a range of assessment approaches. There was no statistically significant difference between *successful* and *other schools*.

Students were asked to report the rating that they received for mathematics on their last school report. All schools in Australia are required to report on an A to E scale twice a year as part of their funding agreements. Despite the intention of this being a common scale, it has subtly different interpretations from state to state. For example a C rating was described as:

- evidence in a student's work typically demonstrates a sound level of knowledge and understanding of the content (facts, concepts and procedures) and application of skills;
- the student has a sound knowledge and understanding of the main areas of content and has achieved an adequate level of competence in the processes and skills;
- evidence of learning demonstrates sound achievement at this year level;
- C indicates that a student is performing at the standard expected;
- C At the standard expected at this time of year;
- your child is demonstrating satisfactory achievement of what is expected at this year level;
- satisfactory. The student demonstrates satisfactory achievement of what is expected for this year level; and
- demonstrating satisfactory achievement of what is expected.

Of the students who responded to this question, it was notable that 63% reported receiving an A or B grade, and only 6% reported a D or E grade. The distribution of responses by year level is shown in Table 5.1:17. A graphical comparison is provided in Figure 5.1:5.

Table 5.1:17   Students' self-reported grades for mathematics by percentage of respondents in each year level

	A	B	C	D	E
Year 3	20	43	22	4	1
Year 4	11	64	53	5	2
Year 5	30	69	62	6	4
Year 6	43	65	37	5	1
Year 7	58	61	65	18	0
Year 8	29	27	18	6	0
Year 9	48	40	25	9	3
Year 10	1	3	13	3	1
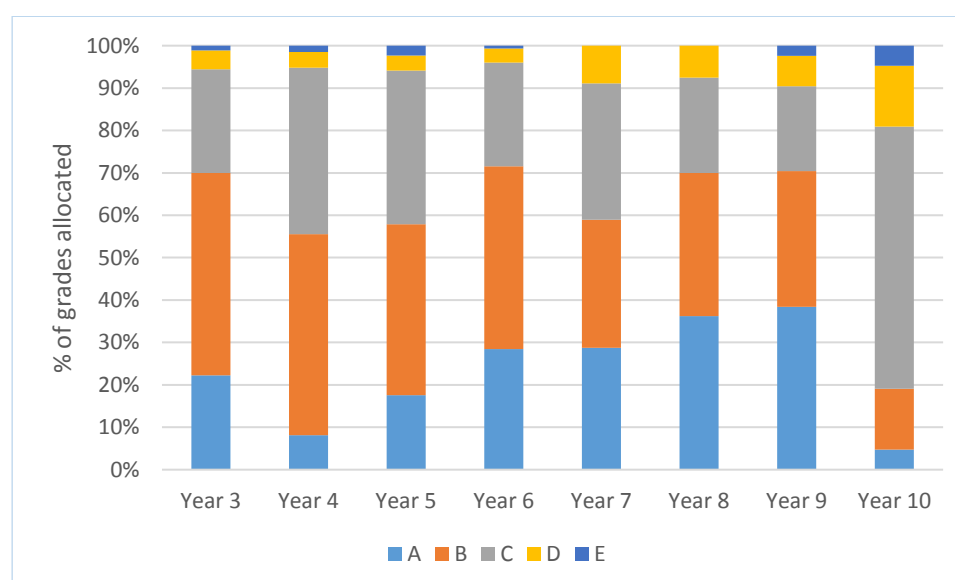
Figure 5.1:5   Proportion of A to E grades by year level

This skewed distribution is rather surprising. If C is the satisfactory grade for a year group, the distribution of grades across a sample of over 1000 students would be expected to be roughly symmetrical around the C grade, or to peak in that level. When considered as to whether the school was a *successful* or *other school*, the distribution was almost exactly the same as shown in Table 5.1:18.

Table 5.1:18   Students' self-reported grades for mathematics by school success

	A	B	C	D	E
Successful	124 (25%)	198 (40%)	160 (32%)	14 (3%)	3 (1%)
Other	120 (25%)	187 (37%)	143 (28%)	44 (9%)	9 (2%)

If the distribution of A to E grades had been markedly different for *successful schools* compared with *other schools*, it might have been argued that the students in *successful schools* were performing at a higher level. The different interpretations of A to E ratings, however, make these figures unreliable and the very similar distributions for *successful* and *other schools* suggest that teachers are making judgements within their own frame of reference, rather than against an absolute standard.

5.1.1.10   Attitudes to NAPLAN

The 13 item scale of items addressing aspects of NAPLAN from the teacher and leader surveys was analysed using an exploratory factor analysis. Teachers and leaders asked to rate on a scale of 1 (strongly disagree) to 7 (strongly agree) their agreement with the 13 items. Details are provided in Appendix D. The items loaded onto two factors which accounted for 66.0% of the variance. One factor was positive including items such as, 'In this school implementation of NAPLAN has led to increased opportunities for collaboration and sharing of resources'; the second factor was negative, including items such as, 'In this school implementation of NAPLAN has increased the stress and pressure on teachers'. These two factors were, however, not significantly correlated, suggesting that both factors coexist independently; that is, people who strongly endorse the negative effects of NAPLAN may also strongly endorse the positive effects.

When factor mean scores were compared across primary and secondary school respondents, Primary teachers were statistically significantly more likely to endorse the positive effects of NAPLAN (t = 5.15, df = 170, $p<.001$) and also endorse the negative effects ($t=5.51$, $df=170$, $p<.001$). NAPLAN testing appears to have a greater impact on primary schools, leading to stronger endorsement of both factors. It may be that secondary schools have a longer history of external, high stakes assessment through Year 12 examinations, and are therefore less concerned about NAPLAN processes.

When the same analysis was undertaken to compare *successful schools* with *other schools*, there was no significant difference in terms of the positive factor (t (170) =1.36, $p=.175$); that is both groups appeared to endorse the positive aspects equally. The *other schools*, however, were statistically significantly more likely to be negative about the effects of NAPLAN (t (170) =2.088, $p=.038$), that is teachers in *other schools* were more likely to endorse the negative aspects of NAPLAN. This finding suggests that although teachers in all schools acknowledged positive aspects of NAPLAN, teachers in *other schools* were more likely to focus on the negative effects.

Leaders were asked the same questions. When analysed by success, leaders in *successful schools* were significantly more likely to be positive about the effects of NAPLAN (t (87) =1.993, p=.049) but leaders in the *other schools* were significantly more likely to be negative about the effects of NAPLAN (t (87) = 2.031, $p=.045$). It is interesting that school leaders and teachers in schools that did not meet the success criteria tended to focus on the negative value of NAPLAN.

Schools successful at numeracy as measured by NAPLAN appear to be able to reduce the negative effects of the testing program. This finding implies that *successful schools* have identified ways to mitigate potentially negative effects of high stakes testing without losing a focus on excellence.

5.1.2   Classroom characteristics

In this section aspects of classrooms identified from the surveys are considered. These included approaches to teaching, homework practices, and teachers and students' perceptions of the classroom and school environment.

5.1.2.1   Approaches to teaching

Teachers were asked to rate the extent to which different approaches to mathematics teaching had a positive impact on students. These questions were asked twice; once with a focus on mathematics achievement, and once in relation to student engagement with mathematics.

An exploratory factor analysis was conducted on each set of questions (see Appendix D for details). This analysis identified four engagement factors, together explaining 60.3% of the variance. Factor 1 explained 34.3% of the variance, with the remaining three factors explaining 11.0%, 8.5% and 6.5%, respectively.

The four underlying engagement factors were:

- Student discussion;
  for example, 'students listening to and questioning other students' thinking', and 'students explaining their own thinking'.
- Using materials;
  for example, 'using concrete materials and manipulatives', and 'playing maths games (including computer games)'.
- Rewards;
  for example, 'extrinsic rewards (lollies, less homework)', and positive reinforcement (smiles, encouraging words)'.
- Independent practice;
  for example, 'students learning rules and procedures', and 'opportunity for students to work by themselves'.

When considered by success, there were no differences on any factor of engagement between teachers in *successful* and *other schools*. There were statistically significant differences between primary and secondary teachers on *student discussion* (t (143) = 4.31, $p < .001$); *using materials* (t (143) = 6.02, $p < .001$); and *independent practice* (t (144) = 2.006, $p = .047$). In each instance primary teachers had higher endorsement of the engagement factor than secondary teachers.

The factor analysis also identified four achievement factors, together explaining 61.5% of the variance. Factor 1 explained 37.7% of the variance, with the remaining three factors explaining 11.0%, 7.2% and 5.5% respectively. The four achievement factors were:

- Student language and challenge;

  for example, 'students explaining their own thinking', and 'working on tasks students see as challenging'.
- Practice and recognising success

  for example, 'practising skills they have already been taught', and 'students knowing the purpose and intent of the lesson'.
- Materials and relevance;

  for example, 'using concrete materials and manipulatives', and 'having tasks set in contexts relevant to students' lives'.
- Rewards and technology use;

  for example, 'extrinsic rewards (lollies, less homework)' and 'students working with digital technologies'.

When it came to achievement in mathematics, again there were no statistically significant differences between teachers in *successful* and *other schools* on any factor. There were statistically significant differences between primary and secondary teachers on *student language and challenge* (t (159) = 3.891, p < .001); *practice and recognising success* (t (160) = 3.865, p < .001); and *materials and relevance* (t (161*) = 4.834, p < .001). There was no difference shown on the rewards factor. Primary teachers were again more likely to endorse all factors.

These survey results indicate that student focussed approaches, with a focus on student talk such as students explaining their own thinking, are seen as important by teachers in both *successful* and *other schools* for both engagement in mathematics and achievement in mathematics.

Teachers were also asked about their own enthusiasm for mathematics itself (TSE) (for example I engage in mathematics because I enjoy it). There was a statistically significant difference in favour of secondary teachers between primary and secondary teachers (t = 2.89, df = 163, p = .004), but not between teachers in *successful* and *other schools* (t = 0.581, df = 163, p = .163).

5.1.2.2 Classroom environment

On the surveys, all students were asked about several dimensions of the classroom environment:

- mastery environment (SCM) (for example, 'our maths teacher really wants us to enjoy learning new things');
- performance environment (SCP) (for example, 'our maths teacher tells us how we compare with others'); and
- teacher enthusiasm for teaching mathematics (STE) (for example, 'our maths teacher teaches maths with great enthusiasm').

When responses were compared by success, students at *successful schools* reported statistically significantly lower scores on *performance environment* (SCP) (t = 2.9, p <.001); that is, in *successful schools* students were less likely to perceive their mathematics classrooms as having a focus on doing better in comparison to other students. There was no difference, however, between *successful schools* and *other schools* in terms of students perceiving that their teachers wanted them to understand the mathematics that they were learning, that is had a mastery approach (SCM). These findings suggest that, although teachers at *other schools* want their students to understand

mathematics, students at *successful schools* benefit from a reduced focus on performance which allows them to focus on mastery goals.

There were also differences between older and younger students. Older students were more likely to perceive their mathematics classrooms as both *per*formance (*t* = 8.37, *df* = 1065, *p* = <.001) and *mastery* (*t* = 6.36, *df* = 1059, *p* = <.001) oriented. These findings seem somewhat counterintuitive but they indicate that older students may feel more pressure to learn mathematics, both in terms of performing well and in developing understanding of the material.

All students were asked about their teachers' enthusiasm for teaching mathematics. Although there was no difference between *successful* and *other schools*, teachers' enthusiasm for teaching mathematics was highly correlated with a classroom *mastery environment* (ρ = .747), but showed a very low correlation with a classroom *performance environment* (ρ = .132).

Older students were also asked about their teachers' enthusiasm for mathematics itself. For these older students the correlations among teachers' subject and teaching enthusiasm and the mastery and performance classroom environments are summarised in Table 5.1:19.

Table 5.1:19   Correlations between teacher enthusiasm and classroom environment variables

Older student perceptions	Classroom mastery environment	Classroom performance environment
Mathematics subject enthusiasm	0.54**	0.16**
Mathematics teaching enthusiasm	0.68**	0.08

** Significant at 0.01 level

Although correlation cannot be considered as any more than an association, that is, it does not imply causation, the strong association between teachers' enthusiasm, both for their subject and for teaching mathematics, with mastery environments is important. The relationship indicates that teachers who know and enjoy teaching mathematics were more likely to teach with a focus on understanding rather than achievement.

5.1.2.3 'Costs' associated with learning mathematics

Older students (year 7 upwards) were asked a series of questions about the 'costs' associated with learning mathematics in three domains:

- effort (for example, 'When I think about the hard work needed to get through in maths, I am not sure that it is going to be worth it in the end');
- psychological costs (for example, 'I'm concerned that I won't be able to handle the stress that goes along with studying maths'); and
- social costs (for example 'I worry about losing some valuable friendships if I'm studying maths and my friends are not').

Older students were also asked about the extent to which they found mathematics difficult (for example, 'To what extent do you consider maths to be a tough subject?'). These questions were not asked of primary school students because of their complexity.

Older students were also asked to rate their own teachers' enthusiasm for mathematics – subject enthusiasm (for example, 'Our maths teacher finds mathematics exciting'), and their own teachers' enthusiasm for teaching mathematics – maths teaching enthusiasm (for example, 'our maths teacher really enjoys teaching maths').

The associations among the cost variables, and the students' reports of their teachers' enthusiasm, for subject mathematics and for teaching mathematics were correlated to identify potential factors that could support mathematics learning. The perceptions of their classrooms as Mastery or Performance oriented were also considered. Results are summarised in Table 5.1:20.

Table 5.1:20   Correlations among teacher and classroom variables and students' costs

Student perception variables (older students only)	Effort cost	Psychological cost	Social cost	Mathematics difficulty
Teachers' enthusiasm for mathematics (SSE)	-0.186**	-0.071	-0.050	-0.048
Teachers' enthusiasm for teaching mathematics (STE)	-0.242**	-0.136*	-0.119*	-0.093*
Mastery classroom (SCM)	-0.269**	-0.170**	-0.180**	-0.042
Performance classroom (SCP)	0.192**	0.120*	0.183**	0.137*

Statistically significant: * $p < .05$ ** $p < .01$

Older students' perceptions of their teachers' enthusiasm for mathematics (SSE) and its teaching (STE) were generally associated with reduced costs, as shown by the negative correlation in **Error! eference source not found.**. Enthusiasm for the subject (SSE) was only statistically significant in relationship to Effort costs. Teachers' subject enthusiasm (SSE) statistically significantly reduced effort cost, but had almost no association with psychological or social costs or with perceptions of difficulty. Teachers' enthusiasm for teaching mathematics (STE) had a statistically significant association with reduction of all costs associated with learning mathematics, especially the effort involved. Enthusiasm for teaching mathematics (STE) also impacted on students' perceptions of mathematics difficulty. A mastery oriented classroom (SCM) was also significantly associated with cost reduction in the three cost domains, but not with perceptions of the difficulty of mathematics. A performance oriented classroom, however, was significantly positively associated with costs, that is, the more performance oriented that students reported their classroom to be, the greater the costs associated with learning mathematics in all domains for students.

These findings are potentially important because they suggest that teachers who are only enthusiastic about mathematics itself are not necessarily going to be associated with productive mathematics classrooms. Teachers have to possess a genuine passion for teaching mathematics and create mastery oriented classrooms to be associated with reductions in student's reported psychological and social costs and perceptions of difficulty. In particular the performance orientation of classrooms appears to be detrimental to learning mathematics. The common practice of comparing students' success on '10 quick questions' at the start of a lesson, for example, is a performance oriented activity that might be associated with students' increased effort and perceptions of mathematics as difficult.

In the Teacher survey, questions were asked about homework practices, including how often homework was set, how long students were expected to spend on homework, and why teachers set homework. Unsurprisingly, more primary than secondary teachers indicated that they never set homework, but a larger proportion of primary teachers also set homework every weeknight. These findings are summarised in Table 5.1:21.

Table 5.1:21   Frequency of homework by school type

	Primary schools		Secondary schools		Total	
	Teachers *N*	Teachers %	Teachers *N*	Teachers %	Teachers *N*	Teachers %
Never	22	20.2	1	1.6	23	13.5
Rarely	13	11.9	6	9.7	19	11.1
Only when necessary	23	21.1	30	48.4	53	31.0
Every weeknight	51	46.8	25	40.3	76	44.4
Total	109		62		171	

When the expectations for students' homework were examined, there were clear differences between primary and secondary school practices. Nearly 70% of primary teachers only expected a few minutes of homework, and this short duration may be related to the high frequency with which homework was set by primary teachers. It is also worth noting that over half of the secondary teachers also expected a few minutes, although homework expectations of longer duration were also more common in secondary schools. Results are summarised in Table 5.1:22. It is interesting that seven primary teachers who apparently set homework as shown in Table 5.1:21 did not expect any homework to be done in Table 5.1:22 (29 responses that set homework, as opposed to 22 respondents who responded None to the frequency of homework set).

Table 5.1:22   Duration of homework by school type

	Primary schools		Secondary schools		Total	
	Teachers *N*	Teachers %	Teachers *N*	Teachers %	Teachers *N*	Teachers %
None	29	26.6	1	1.6	30	17.5
A few minutes	76	69.7	33	54.1	109	64.1
About half an hour	4	3.7	20	32.8	24	14.1
About 1 hour	0	0	5	8.2	5	2.9
More than 1 hour	0	0	1	1.6	1	0.6
Total	109		60		169	

School policy was given as the reason for homework practices by nearly one quarter of primary teachers, but by less than 10% of secondary teachers (primary: 22/97; 22.7%; secondary: 6/62; 9.7%). The largest proportion of teachers indicated that homework helped students learn (primary: 36/97; 37.1%; secondary: 41/62; 66.1%). Being useful for consolidation was the most commonly

cited reason in the other category. In other words, teachers saw homework as related to students' learning.

When the responses were analysed using the success criteria, using a combined primary and secondary school dataset because of small numbers of responses in some categories, very similar results were observed. There appeared to be little difference in expectations for homework among teacher respondents whether they were located in *successful schools* or *other schools*. The results for frequency of homework assignment are shown in Table 5.1:23.

Table 5.1:23   Frequency of homework set by teachers by success

	Successful schools		*Other schools*		Total	
	Teachers *N*	Teachers *%*	Teachers *N*	Teachers %	Teachers *N*	Teachers %
Never	14	11.8	9	17.3	23	13.5
Rarely	13	10.9	6	11.5	19	11.1
Only when necessary	40	33.6	13	25.0	53	31.0
Every weeknight	52	43.7	24	46.2	76	44.4
Total	119		52		171	

Students were asked to rate on a scale of 1 (never) to 7 (every class) their responses to the question 'How often does your maths teacher assign maths homework?' The results are shown in Table 5.1:24. The distribution of responses indicates that students perceived that teachers in *successful schools* were more likely to assign some homework, but not every lesson; whereas teachers in *other schools* were more likely to be at the extreme ends of the scale. Student perceptions were that teachers in *other schools* were more likely to never assign homework (11.4%) compared to teachers in *successful schools* (2.4%). These findings reinforce the teachers' responses to the similar question.

Table 5.1:24   Students' responses to 'how often does your maths teacher assign maths homework?' by success

	Success	*Success %*	*Other*	*Other %*	Total	%
1 (never)	13	2.4	61	11.4	74	6.9
2	58	10.8	52	9.7	110	10.3
3	93	17.4	54	10.1	147	13.7
4	151	28.2	108	20.2	259	24.2
5	94	17.5	88	16.5	182	17.0
6	63	11.8	51	9.6	114	10.7
7 (every class)	64	11.9	120	22.5	184	17.2
Total	536		534		1070	

Teachers were asked about the duration of time they expected their students to spend on homework. Most teachers in both *successful* and *other schools* expected only a few minutes of homework. A greater proportion of teachers in *other schools* expected no homework to be completed, and a greater proportion of teachers in *successful schools* expected about half an hour of homework. Findings are shown in Table 5.1:25.

Table 5.1:25 Duration of homework expected by teachers by success

	Successful schools		*Other schools*		Total	
	Teachers *N*	Teachers %	Teachers *N*	Teachers %	Teachers *N*	Teachers %
None	18	15.3	12	23.1	30	17.5
A few minutes	74	62.7	35	67.3	109	64.1
About half an hour	20	16.9	4	7.7	24	14.1
About 1 hour	4	3.4	1	1.9	5	2.9
More than 1 hour	1	0.8	0	0	1	0.6
Total	117		52		169	

Students were asked about how much homework they actually did on weekdays. Findings are summarised in Table 5.1:26. Students in *successful schools* were more likely to do some homework. The largest proportion of students from both *successful* and *other schools* reported that they spent about half an hour on homework on weekdays. This finding indicates that in both *successful* and *other* schools most teachers expected students to spend only a few minutes on homework; however the most commonly reported amount of time by students was about half an hour.

Table 5.1:26 Students' responses to the amount of time spent on mathematics homework on weekdays by success

	Successful schools		*Other schools*		Total	
	Students *N*	Students %	Students *N*	Students %	Students *N*	Students %
I don't do maths homework	26	5.2	59	11.5	85	8.4
A few minutes	184	36.5	186	36.3	370	36.4
About half an hour	215	42.7	192	37.5	407	40.1
About 1 hour	52	10.3	61	11.9	113	11.1
More than 1 hour	27	5.4	14	2.7	41	4.0
Total	504		512		1016	

Students were also asked how much time they spent on mathematics homework at weekends. Over half of the students, whether in *successful* or *other schools*, responded that they did no mathematics homework or only a few minutes at weekends. There was very little difference overall in the amount of homework done at weekends, as shown in Table 5.1:27.

Table 5.1:27   Students' responses to the amount of time spent on mathematics homework on weekends by success

	Successful schools		Other schools		Total	
	Students N	Students %	Students N	Students %	Students N	Students %
I don't do maths homework	199	38.6	192	38.2	391	38.4
A few minutes	114	22.1	101	20.1	215	21.1
About half an hour	114	22.1	131	26.1	245	24.1
About 1 hour	65	12.6	61	12.2	125	12.4
More than 1 hour	24	4.7	17	3.4	41	4.0
Total	504		512		1016	

The findings about homework indicate teachers in *successful schools* take a sensible, balanced approach to homework. They set homework for a purpose, and did not expect students to spend more than a reasonable amount of time (a few minutes to about 30 minutes) on it. Students' responses were very consistent with those of teachers.

In *other schools* more students reported that their teachers assigned homework every class but a large minority (11.5%) also indicated that they did not do homework. Teachers in *other schools* either indicated that they set little or no homework, or set homework every weeknight. Nearly one quarter of teachers in *other schools*, however, indicated that they did not expect students to do any mathematics homework, despite setting homework, suggesting a potential mismatch between the amount of homework set for students and their expectations of students. The sections earlier related only to teachers' or students' responses compared between categories of *success* and *other* showing there were no differences. When students' comments from the two groups of schools about what they actually did, however, were combined with the teachers' expectations there were differences in the mismatch of teachers/students within *successful* and *other schools*. The expectations of teachers and students within *successful schools* were more consistent between frequency and duration of homework that a reasonable amount of homework would be set and that students would do this.

When considered by ICSEA, there was no difference on either teachers' or students' responses to any of the homework questions; however, differences were observed between older and younger students. Older students were significantly more likely to spend more time on homework during the week and at weekends, as might have been expected, but there was no difference in the frequency of assigned homework.

These findings about ICSEA are noteworthy. Recent studies have identified that there are often disparities in the relationship between time spent on homework and students' achievement between schools and students with high or low socioeconomic status (Dettmers, Trautwein, & Lüdtke, 2009). Australia is one country where there is no difference in mathematics achievement in relation to time spent on homework based on PISA data, when differences in socio-economic status are controlled (OECD, 2014). The *successful schools* in this study that achieved high growth in their student performance appear to have reduced the impact of low ICSEA in terms of homework

expectations. It should be noted, however, that growth and absolute performance are different, and this positive finding may not necessarily translate into high absolute performance.

5.1.3   Students' characteristics

Students in the survey were asked a range of questions that addressed underlying factors that might impact on their mathematical outcomes. Students could answer the questions on a scale from one ('not at all', or 'strongly disagree') to seven ('extremely', or 'strongly agree'). Findings are summarised in Table 5.1:28. The student factors included:

- interest in mathematics (for example 'I want to know all about maths');
- intrinsic value of mathematics (for example, 'I like maths more than my other subjects');
- how they valued mathematics from an instrumental use perspective (for example 'I study maths because I know it is useful for me');
- an attainment value (for example 'Being good at maths is an important part of who I am');
- their personal goal orientation as:
    - mastery (for example 'One of my goals in maths is to learn as much as I can');
    - performance approach (for example, 'One of my goals is to look smart in comparison to others'); or
    - performance avoidance (for example 'One of my goals is to keep others from thinking I'm not smart in maths classes').

Students in *successful schools* were statistically significantly more likely to value mathematics for its instrumental use and attainment value. They were also significantly less likely to have a performance approach goal orientation. The students' attainment value finding is interesting as it suggests students in *successful schools* value mathematics because of what it can do for them personally, which resonates with the instrumental use value. Students in *successful schools* valued mathematics, and hence these students were more likely to engage with mathematics, even though there was no difference in the interest of their students for mathematics compared with *other schools*.

Table 5.1:28   Key constructs from students' survey responses by success

Construct	N	Mean *success* (*SD*)	Mean *other* (*SD*)	t	p
Interest in mathematics	1049	4.20 (1.58)	4.35 (1.74)	1.43	.155
Intrinsic value of mathematics	1042	4.38 (1.94)	4.26 (1.91)	1.01	.271
Instrumental value of mathematics	1036	5.86 (1.26)	5.61 (1.42)	2.99	.003**
Attainment value of mathematics	1045	5.09 (1.64)	4.87 (1.79)	2.08	.038*
Mastery goal orientation	1027	4.31 (0.890)	4.27 (1.061)	0.59	.558
Performance approach goal orientation	1036	2.72 (1.245)	2.91 (1.387)	2.33	.020*
Performance avoidance goal orientation	1033	3.21 (1.287)	3.210 (1.405)	0.04	.967

** significant at .005 level * significant at .05 level

The influence of age and ICSEA on these variables was examined. ICSEA made a difference only to the performance approach goal orientation, with students in higher ICSEA schools less likely to endorse questions such as, 'I aim to look smart in comparison to the other students in maths'.

There were, however, a number of differences between *older* (*n* = 366) and *younger* (*n* = 675) students. In every instance, younger students were significantly more likely to endorse the statements. They showed more interest in mathematics, valued it more highly in all domains, and had stronger goal orientations towards mathematics. Findings for the comparisons between older and younger students are shown in Table 5.1:29.

Table 5.1:29   Differences between younger and older students on personal mathematics constructs

Construct	Mean younger (*SD*)	Mean older (*SD*)	*t*	*p*
Interest in mathematics	4.61 (1.62)	3.64 (1.78)	9.38	<.001
Intrinsic value of mathematics	4.66 (1.85)	3.72 (1.78)	7.92	<.001
Instrumental value of mathematics	6.10 (1.10)	5.06 (1.51)	12.75	<.001
Attainment value of mathematics	5.43 (1.50)	4.13 (1.78)	12.46	<.001
Mastery goal orientation	4.57 (0.90)	3.77 (0.90)	13.60	<.001
Performance approach goal orientation	3.03 (1.41)	2.42 (1.02)	7.24	<.001
Performance avoidance goal orientation	3.56 (1.30)	2.55 (1.17)	12.22	<.001

These findings for older students are potentially of concern, as they indicate that as students get closer to making decisions about their futures, they are losing interest in mathematics and valuing it less. The findings are in line with other research that has reported declines in interest in mathematics as students get older (for example, Frenzel, Dicke, Pekrun, & Goetz, 2012).

To examine whether *successful schools* were making a difference to older students, the same analysis was carried out using only the older students' responses compared by whether they attended a *successful school* or not. The findings for this analysis are shown in Table 5.1:30. Older students in *successful schools* were significantly more likely to value mathematics for its utility (Instrumental Value) and the importance of doing well in mathematics (attainment value), and to have a personal mastery goal orientation. They were no more interested in mathematics, however, than students in *other schools*.

Table 5.1:30   Older students' responses to personal mathematics constructs by success

Construct	Mean *success* (*SD)*	Mean *other* (*SD)*	*t*	*p*
Interest in mathematics	3.67 (1.33)	3.61 (1.75)	0.37	.712
Intrinsic value of mathematics	3.72 (1.59)	3.71 (1.95)	0.098	.922
Instrumental value of mathematics	5.25 (1.46)	4.86 (1.54)	2.45	.015*
Attainment value of mathematics	4.39 (1.68)	3.87 (1.85)	2.82	.005**
Mastery goal orientation	3.93 (0.84)	3.61 (0.94)	3.51	.001**

Performance approach goal orientation	2.39 (1.01)	2.44 (1.03)	-0.53	.594
Performance avoidance goal orientation	2.51 (1.12)	2.60 (1.21)	-0.757	.450

** significant at .005 level * significant at .05 level

5.1.4   Teachers' and students' responses in *successful schools*

Section 5.1.4.1 further examines how teachers influence their students' outcomes. It does this by using student survey responses that have been matched with their classroom teachers' responses. There was only sufficient matched data to consider a subset of students and teachers from *successful schools*. By considering students within classes, models could be built that indicate the weighting and pathways of influence using sophisticated multi-level modelling techniques. Two different models are reported here.

5.1.4.1   Influences on primary students' interest in mathematics

For 303 primary students, including some in year 7, matched data were available from 28 teachers in 11 *successful schools*. Of these students, 44% were male. Their ages ranged from eight to 13 years (M = 10.1 years, SD = 1.2). Table 5.1:31 shows the number of students and teachers by year level.

Table 5.1:31   Distribution of students and teachers across year levels

Year Level	Year 3	Year 4	Year 5	Year 6	Year 7
Students (n)	9	53	158	48	35
Teachers (n)	1	5	11	7	4

Student interest in mathematics was assessed using the students' self-report on a 7-point scale from 1 (not at all) to 7 (extremely). Two different constructs were involved: students' emotional interest (SEI) with items such as, 'I like maths more than my other subjects at school' and Students' Cognitive Interest (SCI) using items such as, 'after a math class, I am often curious about what we are going to do in the next lesson'. Measures of students' learning environment were taken from the students' and their teachers' mastery (SCM, TCM) and performance orientation (SCP, TCP) scales, and students' perceptions of teachers' enthusiasm for teaching mathematics (STE) and teachers' perceptions of their enthusiasm for mathematics (TSE) scales (details of these scales are provided in the survey instruments in Appendix A2). ICSEA and gender were also included as independent variables.

Figure 5.1:6 shows the results of the student comparisons. The model shows that student perceptions of teachers' enthusiasm for teaching mathematics (STE) was mediated through the kind of teaching environment created, with a strong positive association with a mastery environment, and a smaller association with a performance environment. Boys were slightly less likely to perceive a mastery goal orientation in the classroom, but were more likely to show both cognitive and emotional interest in mathematics. Of concern, and somewhat unexpected, given that the primary students in this study were generally very positive about mathematics, is the negative association between age and interest. This has long been reported for secondary age students, but these results indicate that students are losing interest in mathematics much earlier than might have been expected. A mastery environment was positively associated with both cognitive and emotional interest, but a performance environment had a small negative association with emotional interest

only, and no significant influence on cognitive interest. Overall these findings mirror those from previous studies in secondary schools, but have not before been shown in a primary setting (for example, Kunter et al., 2008; Zhang, 2014).
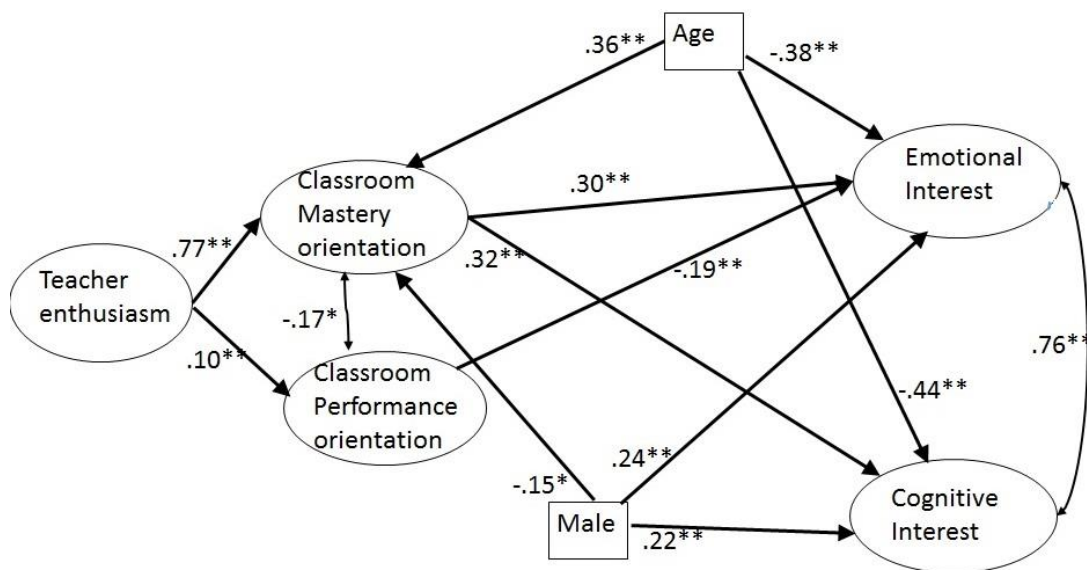
*Figure 5.1:6   Structural equation model showing factors that impact on primary students' interest in mathematics * p < 0.05 ** p < .01*

> Note: The model included student perceptions of their teachers' enthusiasm for teaching mathematics (STE) mediated through students' perceptions of classroom environment (SCM and SCP). The model includes age and gender (male) as independent variables. Outcome measures are students' cognitive interest (SCI), and students' emotional interest (SEI). Single-headed arrows show the direction of the influence, and double headed arrows between indicate a relationship but with no direction specified.

Teaching enthusiasm (STE) impacted positively on students' perceptions of both mastery (SCM) and performance (SCP) orientations, but particularly in relation to the mastery orientation, which in turn impacted students' interest. It has been suggested that this relationship could come from two possible causal links. Enthusiastic teachers are more likely to 'infect' their students with their enthusiasm and hence generate higher levels of emotional interest. Second, enthusiastic teachers may be more likely to seek interesting and appropriate activities for their students, hence generating cognitive interest (Kunter et al., 2008, 2011).

There is evidence from other studies that teachers in mastery oriented classrooms are more enthusiastic and encouraging than those in performance oriented classrooms (Patrick et al., 2000). Teachers in mastery oriented classrooms, who are likely to be enthusiastic about teaching, motivate their students intrinsically through encouragement, whereas teachers in performance oriented classrooms may be more likely to use extrinsic motivation, such as challenging students to perform well in tests. Teacher enthusiasm for teaching seems to be a critical component for creating and maintaining a mastery oriented environment, and this environment in turn has an effect on students' interest in mathematics.

When a comparison was made between different classes, some surprising relationships were identified. ICSEA was a predictor of teachers' perceptions of a performance orientation, suggesting that teachers in higher ICSEA schools were more likely to create environments that fostered competition and performance against external benchmarks. Surprisingly, teachers' perceptions of a

performance environment also impacted positively on their students' emotional interest. Because of the confounding impact of ICSEA, it may be that students in high ICSEA schools are more likely to come from social environments where school is perceived positively, leading to more support from parents for students and for the school. This in turn impacts on students' general emotional interest in school, which flows into their mathematics classrooms.

There are several implications for schools and teachers from these findings. Even among young students in primary schools, age and gender are beginning to play a part in students' interest in mathematics. Programs designed to maintain girls' interest in mathematics, for example, may need to begin earlier than secondary school.

The strong relationship between primary students' perceptions of teachers' enthusiasm for teaching and of a mastery classroom, that in turn affects students' emotional and cognitive interest, has an implication for professional learning programs. Professional learning programs for teachers need to focus not only on content and pedagogical knowledge, but also on changing teachers' attitudes and thinking about mathematics. The challenge to change these attitudes is considerable given primary teachers' negative feelings and attitudes towards mathematics (Beswick et al., 2006) This could be addressed in part by having specialist teachers of mathematics in primary schools to teach mathematics and to lead teacher development. These finding have implications for numeracy coaches, for example, or for in school professional learning groups.

5.1.4.2 Students' engagement profiles in mathematics

A second analysis undertaken in *successful schools* considered students' engagement with mathematics from the perspective of different dimensions of engagement. This analysis was undertaken with 550 students taught by 37 teachers in 15 schools, both primary and secondary schools. Of the students, 46% were boys, the age range was from 8 to 15 years (M = 10.2, SD = 1.5), and the students were in Years 3 to 9. Students were asked to rate their agreement with nine statements on a seven point scale from strongly disagree to strongly agree. The word 'engagement' has little meaning for students, so the statements were constructed and combined to represent student engagement for each of three dimensions:

- behavioural engagement (for example 'I work hard in maths');
- emotional engagement (for example 'I like maths better than other subjects'); and
- cognitive engagement (for example 'I want to know all about maths').

Scores for each student were compiled for each of these dimensions. A latent class analysis (LCA) was applied to the data. LCA assumes that rather than being selected from one population, students have in fact been drawn from a number of hidden (latent) classes. Details of the analysis are provided in Appendix D. The analysis identified three subgroups of students, termed *engaged* (n = 305), *compliant* (n = 206), and *disengaged* (n = 40). These underlying subgroups had distinctly different engagement profiles as shown in Figure 5.1:7.
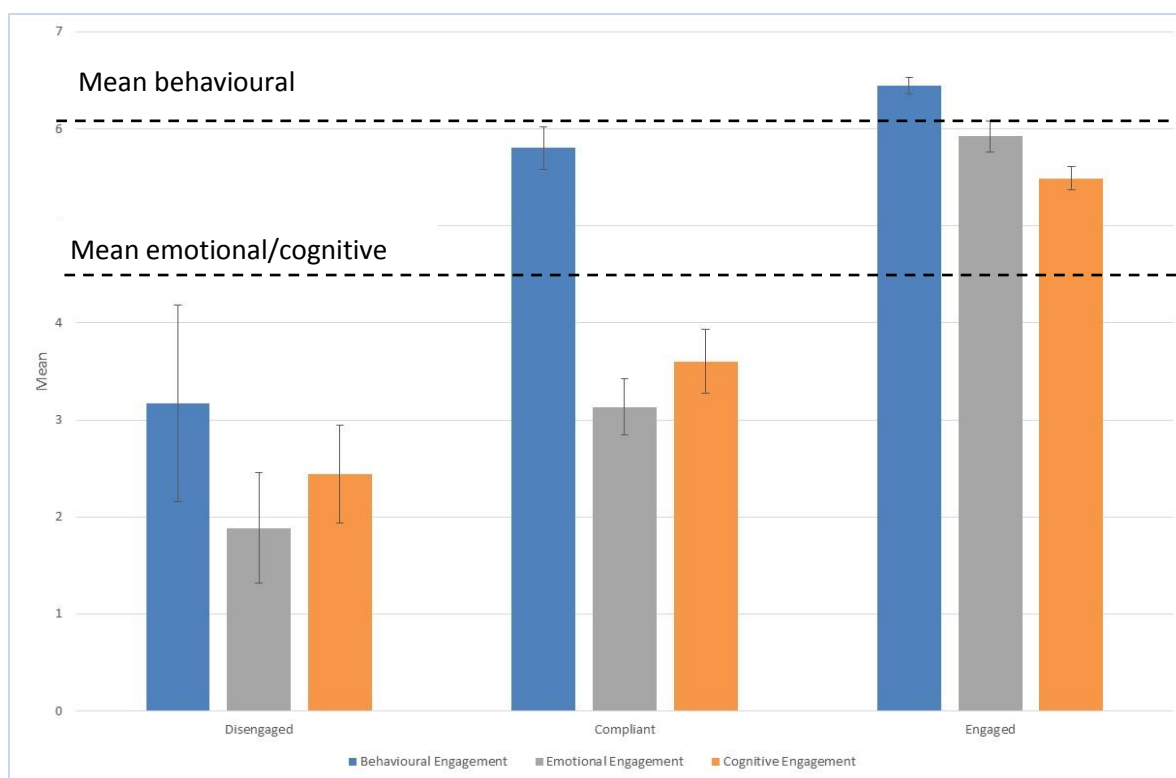
Figure 5.1:7   Students' engagement profiles showing the relative components of engagement

In terms of gender distribution, there was an almost equal proportion of boys and girls in the *engaged* group (boys 51%, girls 49%), but statistically significant differences between the *compliant* (Boys 34%, Girls 66%) and *disengaged* (boys 68%, girls 32%) groups. There was an association with students' self-reported most recent grade for mathematics using the A to E scale. Students in the *engaged* group were statistically significantly more likely to report an A or B rating, whereas students in the *disengaged* group were more likely to report a D or E grade. There was no significant difference, however, between the *engaged* and *compliant* groups.

When these groups were compared with respect to the teacher enthusiasm and classroom goal orientations, the results were not surprising. *Disengaged* students perceived less Teacher Enthusiasm and had lower perceptions of a Mastery classroom environment than either the *compliant* or *engaged* groups. Similarly, *compliant* students were lower than *engaged* students on these two variables, with all differences being statistically significant. Similar results were seen with respect to a global measure of school caring (using items from You et al. (2011). For example, the teachers here respect me'). There was no difference among any groups for a performance orientation. Younger students were more likely to be in the *engaged* group than older students.

There are implications for schools and teachers from these findings. The identification of the *compliant* profile is useful: students in this group were conscientious, as shown by their high behavioural engagement, but did not particularly like nor were they interested in mathematics. Girls dominated this group, and it might be that to move these students to an *engaged* profile distinctly different classroom activities might be needed. The disengaged group was fairly small, and dominated by boys. The sample came only from *successful schools* and the small number in the *disengaged* group may imply that a focus on school and classroom environment factors may be a precursor to moving students into at least a behavioural level of engagement. Without appropriate

comparison data, however, this notion can only be a conjecture. These findings indicate that, in line with current research, programs targeted at disengaged students warrant some rethinking (Taylor & Parsons, 2011) because they may neglect the largely hidden group of *compliant* students. Given the decline in mathematics enrolments in the upper years of schooling and in tertiary education, this finding indicates that further research is needed about ways in which students can be emotionally and cognitively engaged with mathematics.

In this chapter, findings from the analysis of the *successful school* case studies are presented and discussed, with examples. The focus is on successful practice at school, classroom and individual levels, and on providing exemplars of good practice that could inform *other schools* that want to improve their mathematics' learning and teaching. In the examples, care has been taken not to provide any information that might identify a particular school, which is an issue for schools in small states or systems. For that reason only brief background information is provided. The chapter is structured around school and classroom characteristics.

Evidence is provided in the form of direct quotes from school leaders, teachers, and students; examples of classroom or school practice taken from field notes during the visits; and vignettes in which a particular school's practices are provided in an elaborated form to provide an exemplar for schools. All material presented has been anonymised to protect confidentiality.

Table 6.2:1 summarises the key characteristics of case study schools. Table 6.2:2 summarises the information from each school visited.

6.1 Key findings

- *Case study schools* had a clear and purposeful focus on mathematics/ numeracy.
- *Case study schools* built on what was going well. There was a culture of continuous improvement and they did not take a negative view of teachers or students.
- Mathematics in *case study schools* was led by a member of staff, who had input at the decision making or policy level at the school.
- *Case study schools* used data effectively to identify strengths and weaknesses in programs, classes, and students, and planned accordingly to meet the identified needs.
- Resources were directed specifically at mathematics/numeracy. These resources included provision of time and materials. Schools were creative in providing these resources.
- In *case study schools* there was a strong emphasis on collaborative professional learning through learning groups. In these groups, teachers discussed mathematics and its teaching and learning.
- The broad approach to mathematics across the school was consistent, in that school level plans underpinned the collection of data upon which student groupings were based, the language used to describe mathematical concepts, and sometimes the lesson structure.
- Within the broad school frameworks established, teachers were autonomous and could usually use resources and pedagogies that suited their particular year level or class group.
- In *case study schools*, NAPLAN was not a primary focus; i.e. it was considered as 'one test on one day'.
- There was no standout approach to teaching mathematics.
- Teachers in *case study schools* were able to change their teaching approaches to cater for different types of student learning styles.
- Teachers were enthusiastic about teaching mathematics. Students recognised this enthusiasm.

- In classrooms, there was a focus on students developing understanding through dialogue with the teacher and each other. This focus provided opportunities for elaboration.
- Teachers deliberately rarely told students what to do, but fostered a range of strategies for students to draw on when they became stuck.
- The curriculum delivered is unbalanced. Most lessons observed addressed number and algebra, and teachers overwhelmingly talked about the Number and Algebra strands.

6.2   Characteristics of *case study schools*

This section presents key characteristics of *case study schools*. These characteristics include aspects of school organisation and staffing, professional learning, and attitudes to NAPLAN. In some schools it was not possible to collect relevant data; for example researchers were only able to interview students in 40 of the 52 *case study schools*. Summary data are presented in Table 6.2:1, and Table 6.2:2 presents data from each one of the *case study school*s.

Table 6.2:1   Summary of key findings of characteristics of case study schools

Key finding	*N* schools	% schools
Numeracy leader with policy input (section 6.2.1)	52/52	100.%
Extra-curricular activities (section 6.2.1)	51/52	98%
Pastoral care (section 6.2.1)	51/52	98%
Professional learning groups/specialised meetings (section 6.2.3)	49/52	94%
Teacher enthusiasm reported (section 6.4)	36/40	90%
Grouping for learning	Flexible grouping 19/46 Mixed ability grouping 17/46 Combination of flexible grouping and mixed ability 10/46	Flexible grouping 41% Mixed ability grouping 37% Combination of flexible grouping and mixed ability 22%
In-school professional learning (section 6.2.3)	38/52	73%
Use of data to inform planning and teaching (section 6.2.4)	45/52	87%
NAPLAN downplayed as 'one test on one day' (section 6.2.5)	45/52	87%
Mathematics inquiry and investigations (section 6.3)	21/52	40%
Emphasis on student understanding (student talk for understanding) (section 6.3.2)	45/52	87%
Set lesson structure (section 6.3.2)	6/52	12%
Students reported liking mathematics (section 6.4)	33/40	83%

Table 6.2:2   Summary of analysis of data from case study schools

School ID	ICSEA level	Time	Location	School type	Numeracy leader	Extra-curricular activity	Pastoral care	Grouping for learning	Professional learning group	Teacher enthusiasm reported	In school professional learning	Use of data to inform planning and teaching	NAPLAN downplayed	Mathematics inquiry and investigations	Student talk for understanding	Set lesson structure	Students like mathematics
1	M	Both	Metro	Combined	Y	Y	Y	FG	Y		Y	Y	Y		Y	Y	Y
2	H	11-13	Metro	Primary	Y	Y	Y	FG	Y	Y	Y	Y	Y	Y	Y		Y
3*^	H	12-14	Metro	Secondary	Y	Y	Y	FG	Y		Y	Y	Y				
4	H	12-14	Metro	Secondary	Y	Y	Y	FG	Y	Y		Y	Y		Y		Y
5	L	11-13	Metro	Primary	Y	Y	Y	MA	Y		Y	Y	Y	Y	Y		
6	H	12-14	Metro	Primary	Y		Y	FG	Y		Y	Y	Y	Y	Y		Y
7	H	12-14	Metro	Primary	Y	Y	Y	FG	Y	Y	Y	Y	Y		Y	Y	Y
8	L	Both	Metro	Secondary	Y	Y	Y	FG	Y	Y	Y	Y	Y		Y		Y
9	M	12-14	Metro	Primary	Y	Y	Y	FG	Y	Y		Y			Y		Y
10	M	Both	Metro	Secondary	Y	Y	Y	MA/FG	Y	Y	Y		Y		Y		
11^	M	12-14	Metro	Secondary	Y	Y	Y	FG	Y	Y	Y	Y	Y		Y		
12^	H	2014	Metro	Secondary	Y	Y	Y		Y	Y		Y	Y		Y		
13^	L	11-13	Provincial	Primary	Y	Y	Y	MA/FG			Y	Y	Y		Y		
14^	H	12-14	Metro	Primary	Y	Y	Y	MA	Y	Y	Y	Y	Y	Y	Y		
15	H	11-13	Metro	Secondary	Y	Y	Y		Y	Y	Y		Y		Y		

School ID	ICSEA level	Time	Location	School type	Numeracy leader	Extra-curricular activity	Pastoral care	Grouping for learning	Professional learning group	Teacher enthusiasm reported	In school professional learning	Use of data to inform planning and teaching	NAPLAN downplayed	Mathematics inquiry and investigations	Student talk for understanding	Set lesson structure	Students like mathematics
16^	M	11-13	Provincial	Primary	Y	Y	Y	MA	Y		Y	Y	Y		Y		
17	H	11-13	Metro	Combined	Y	Y	Y	MA	Y	Y	Y	Y	Y				Y
18	H	Both	Provincial	Combined	Y	Y	Y	FG	Y	Y	Y	Y	Y		Y	Y	Y
19	M	11-13	Provincial	Combined	Y	Y	Y	FG	Y	Y	Y	Y	Y	Y	Y		Y
20	H	11-13	Metro	Secondary	Y	Y	Y	MA		Y			Y		Y		
21	M	12-14	Metro	Combined	Y	Y	Y	MA	Y	Y	Y	Y	Y	Y	Y		Y
22	H	11-13	Metro	Primary	Y	Y	Y	MA/FG	Y			Y	Y				
23^	L	11-13	Metro	Primary	Y	Y	Y	MA/FG	Y			Y			Y		
24^	H	11-13	Metro	Secondary	Y	Y	Y					Y	Y		Y		
25	L	12-14	Provincial	Primary	Y	Y	Y	FG	Y	Y	Y	Y	Y	Y	Y		Y
26^	H	11-13	Metro	Combined	Y	Y	Y		Y	Y	Y	Y	Y		Y		
27	M	12-14	Provincial	Combined	Y	Y	Y	MA	Y	Y	Y	Y	Y	Y			Y
28	M	12-14	Provincial	Combined	Y	Y	Y	MA/FG	Y	Y	Y	Y	Y	Y	Y		Y
29	H	11-13	Metro	Primary	Y	Y	Y	MA/FG	Y	Y	Y	Y	Y	Y	Y		Y
30	L	11-13	Provincial	Primary	Y	Y	Y	FG	Y	Y	Y	Y	Y	Y	Y		Y
31	M	12-14	Provincial	Primary	Y	Y	Y	MA	Y		Y	Y	Y	Y	Y		Y

School ID	ICSEA level	Time	Location	School type	Numeracy leader	Extra-curricular activity	Pastoral care	Grouping for learning	Professional learning group	Teacher enthusiasm reported	In school professional learning	Use of data to inform planning and teaching	NAPLAN downplayed	Mathematics inquiry and investigations	Student talk for understanding	Set lesson structure	Students like mathematics
32	M	12-14	Metro	Primary	Y	Y	Y	MA	Y	Y	Y	Y	Y	Y	Y		Y
33	M	12-14	Provincial	Combined	Y	Y	Y	MA	Y		Y	Y	Y		Y		Y
34	M	2014	Provincial	Secondary	Y	Y	Y	MA	Y	Y		Y	Y		Y		Y
35	H	12-14	Metro	Primary	Y	Y	Y	FG	Y	Y	Y	Y	Y	Y	Y		Y
36	H	12-14	Metro	Secondary	Y	Y	Y	FG	Y	Y		Y	Y		Y		Y
*37^*	M	11-13	Metro	Combined	Y	Y	Y	MA	Y	Y	Y		Y				
38	M	12-14	Metro	Primary	Y	Y	Y	FG	Y		Y	Y		Y	Y	Y	Y
39	H	12-14	Metro	Combined	Y	Y	Y	MA/FG	Y	Y			Y	Y	Y		Y
40	L	12-14	Provincial	Combined	Y	Y	Y	MA	Y			Y	Y				Y
41	H	12-14	Metro	Primary	Y	Y	Y	FG	Y	Y		Y	Y		Y		Y
*42^*	M	12-14	Metro	Primary	Y	Y	Y	MA/FG	Y		Y	Y	Y	Y	Y		
43	L	Both	Provincial	Primary	Y	Y	Y	MA/FG	Y	Y	Y	Y		Y	Y	Y	Y
44	H	12-14	Provincial	Secondary	Y	Y	Y	MA	Y	Y	Y	Y	Y		Y		Y
45	H	12-14	Provincial	Combined	Y	Y	Y	FG	Y	Y		Y	Y	Y	Y		Y
46	L	12-14	Provincial	Secondary	Y	Y	Y	MA	Y	Y	Y	Y		Y	Y	Y	Y
47	M	11-13	Metro	Secondary	Y	Y	Y	MA	Y		Y		Y		Y		

School ID	ICSEA level	Time	Location	School type	Numeracy leader	Extra-curricular activity	Pastoral care	Grouping for learning	Professional learning group	Teacher enthusiasm reported	In school professional learning	Use of data to inform planning and teaching	NAPLAN downplayed	Mathematics inquiry and investigations	Student talk for understanding	Set lesson structure	Students like mathematics
48	M	Both	Metro	Combined	Y	Y	Y	MA	Y	Y	Y	Y	Y		Y		Y
49^	M	Both	Provincial	Combined	Y	Y	Y	FG	Y	Y	Y	Y			Y		
50	M	12-14	Provincial	Primary	Y	Y	Y	MA	Y	Y	Y	Y	Y	Y			Y
51	M	12-14	Metro	Combined	Y	Y	Y	MA/FG	Y	Y		Y	Y		Y		Y
52*^	M	12-14	Metro	Primary	Y	Y			Y		Y				Y		

Note: Y: yes, FG: flexible groups, MA: mixed ability groups. Blank: no data available. ICSEA values: H = ≥ 1100, M = between 950 and 1099; L = < 950.

* Telephone interviews only.

^ No student data available.

Time refers to the time period over which the school achieved superior gain.

School ID numbers are unrelated to the IDs in Table 3.1:7 in order to preserve anonymity.

This chapter is organised around the following major themes:

- Characteristics of *case study schools*:
    - school organisation and staffing;
    - teachers' knowledge for teaching mathematics;
    - professional learning;
    - use of data and collaborative planning;
    - attitudes to NAPLAN; and
    - assessment and reporting.

- Approaches to teaching:
    - explicit teaching;
    - supporting students' mathematical thinking;
    - differentiating teaching for learning; and
    - supporting teachers.

- Students and mathematics.

Each of these themes is described and quotes, examples and vignettes are presented as evidence. Vignettes, because of their elaborated format often address more than one aspect of the themes. Table 6.2:3 summarises the key themes addressed in each vignette.

Table 6.2:3   Summary of themes reported in the vignettes

Vignette	Theme 1	Theme 2	Theme 3	Theme 4	Theme 5
Vignette 1	School organisation	Cross school and cross-campus consistency	Leadership of mathematics/ numeracy	Grouping for mathematics learning	Use of data
Vignette 2	School organisation	Catering for difference	Teacher autonomy		
Vignette 3	Grouping for learning	Implementing the AC-M	Using data to set goals		
Vignette 4	Planning for mathematics	'Guaranteed and viable' curriculum	Grouping for learning		
Vignette 5	Teachers' knowledge	Catering for high ability	Student engagement	Classroom performance orientation	Grouping for learning
Vignette 6	Professional learning communities	Feedback	Use of data	Use of community resources	
Vignette 7	Real-life problems	Teachers sharing ideas	Classroom discussion	Student talk	
Vignette 8	Backwards mapping	Using data to diagnose program weaknesses	Collaborative programming to develop strengths K-3		
Vignette 9	Collaborative planning	Whole school program	Resource use	Use of NAPLAN data	
Vignette 10	Choosing a good problem	Involving students in solutions			

Vignette 11	Teaching for understanding	Mathematical connections			
Vignette 12	Classroom risk-taking	Using different teaching approaches	Cross-curriculum integration		
Vignette 13	Lesson structure	Learning intentions			
Vignette 14	Lesson structure	Classroom talk	Focus on strategies	Small-group work	
Vignette 15	Differentiated teaching	Grouping for learning	Teacher enthusiasm		
Vignette 16	Independent learning contracts	Problem solving	Inquiry teaching		
Vignette 17	Whole-school focus	Changing teaching approaches	Community involvement		

6.2.1   School organisation and staffing

In every *case study school* (52/52, 100%) there was a dedicated mathematics/numeracy leader who had input into school policy decisions. This curriculum leader or mathematics coordinator had a passion for mathematics and led the development process in the school, often through extensive mentoring of other staff. This person was able to articulate a clear vision for the school in terms of mathematics. The schools had a clear sense of cohesion that was freely acknowledged by administrators and teachers alike; the latter acknowledging the extent to which they felt 'part of a strong team'. School vignette 1 demonstrates these ideas.

6.2.1.1   School vignette 1: Independent co-educational F to year 12 school in Tasmania

Key themes: school organisation; cross school and cross-campus consistency; leadership of mathematics/numeracy; grouping for mathematics; and use of data.

The school operates on three campuses covering primary (years F to 6), high (years 7 to 10) and senior secondary (years 11 and 12) programs. These campuses are geographically close and are linked by faculty structures, shared facilities and underpinning values. To maintain a whole of school approach to teaching there are eight faculties matching the eight learning areas of Arts, English, Health and Personal Development, Humanities, Languages, Mathematics, Science, and Technology. Each Head of Faculty is responsible for the delivery of their subject area from K–12, supported by senior staff in each part of the school, and the Deputy Principal – Curriculum. This approach ensures continuity in each subject area across the school.

The school has just appointed a mathematics coordinator at each campus who, along with the Deputy Principal – Curriculum, is responsible for how mathematics is organised in the school. Colleagues mentor and support each other. In the primary years the school follows the International Baccalaureate Primary Years Programme (IBPYP). This program takes an investigative approach, rather than the content focus of the AC-M. The AC-M is used to inform planning alongside the IBPYP and reporting is against the A to E standards, although teachers did say that this was difficult in an IBPYP environment.

Secondary mathematics classes are divided into two types: classroom groups for general mathematics classes and grouped for speciality topics, such as proportions, where year groups are pre-tested and re-grouped. Internal data are used more than NAPLAN. Re-grouping is not necessarily about ability, although this does play

an important part. For example, groups often include students who may assist with the learning of the group, and there are different groups for different topics. Each teacher has a diverse group made up from all students in a particular year level. Parents find the organisation fluid and positive and are kept informed through the school's intranet system.

Mathematics was afforded a position of importance in schools, but not to the detriment of other learning areas. Notably, in nearly every *case study school* analysed (51/52, 98%) there were broad curriculum offerings and a range of extra-curricular opportunities such as school camps, excursions, sport and music. Principals and leaders were emphatic they aimed to develop their students in holistic ways, with a rounded education. Pastoral care programs were strong in every school where this could be determined (51/51, 100%) and supported both individual teachers and students. In no schools were there any comments about teachers or students not being capable of teaching or learning mathematics; that is, *case study schools* did not take a view that either students or teachers were lacking in some way. They aimed to move students onwards from where they were, whatever their level of achievement or understanding, and teachers were supported to do this task, through methods such as flexible grouping, provision of internal professional learning, and opportunities to observe other teachers. The approach taken was universally to start from what students and teachers knew and could do, and to build on these strengths. School vignette 2 illustrates some of these ideas.

6.2.1.2 School vignette 2: co-educational government secondary school in Victoria

Key themes: school organisation; catering for difference; and teacher autonomy.

The school has an emphasis on personalised learning, lifelong learning, and integration of information communication technologies (ICT) into the teaching practices, for example using Smartboards. A high proportion of the students speak languages other than English.

The middle school mathematics leader plans the overview of the year, using the Australian Curriculum in Victoria (AusVELS), the Victorian version of the Australian Curriculum. Teachers are given this overview, which consists of topics and associated concepts rather than a detailed program. Some variation from AusVELS is included. Once the overall scope and sequence is decided, after some discussion with teachers, individual teachers have a high level of autonomy to prepare lessons suited to their classes. The mathematics leader stated '[you might be working] on the same topic at the same time [but] maybe only within the same staffroom because it's easier. I think probably all the different teachers are doing different things. I wouldn't say they're all doing the same topic at the same time.' There was considerable flexibility for teachers to follow approaches that best suited their classes.

There is no ability grouping (the allocation of students to classes based on ability) in the school before year 10 when some students take units 1 & 2 Foundation Mathematics; some do units 1 & 2 of Mathematical Methods; and most do core year 10 leading onto units 1 & 2 of Mathematical Methods in year 11. NAPLAN is seen as an opportunity to gain more information about students in order to identify those needing extra support or enrichment.

Support is provided in the form of a before-school maths club twice a week where students are invited to attend. The attendance, however, is 'not that great' and consists mostly of girls. Enrichment takes the form of withdrawal from class for invited students to engage in 'breadth not depth' activities looking at mathematical topics not usually part of the curriculum. It is taken by a mathematics teacher as part of the allocated load. Opportunities are limited, however, because of timetable pressures on both students and staff. There is no accelerated program, with many staff not in favour of acceleration.

Different *case study schools* used alternative approaches to address the same issue of catering for a wide range of abilities and students. Grouping for learning was used in 90% (47/52) of schools and this grouping was either mixed ability (a class in which students are placed using criteria other than measured ability) or flexible grouping, or some combination of these approaches rather than differentiating by ability. Grouping students was often on the basis of some form of assessment or test, but schools did not maintain these groupings rigidly ('streaming') but rather formed and reformed groups as needed. Sometime these groupings took place within the classroom, sometime across year levels. The schools where no flexible grouping was mentioned (5/52, 11%) were either small schools where provision for individual learning was made within the classroom using individual programs (see School Vignette 16), or schools that espoused streaming.

School vignette 3 demonstrates another approach to managing a diverse intake. Described as streaming but lacking the rigidity of fully streamed classes, this flexible grouping of identifying top, middle, and bottom students was seen in secondary schools. The flexibility to move between classes in the school in vignette 3 was genuine, with interviewed students reporting they had moved from group to group.

6.2.1.3 School vignette 3: Catholic all boys secondary school in New South Wales

Key themes: grouping for learning; implementing the AC-M; and using data to set goals.

No academic standards are set for school entry—the purpose of the school is to provide a Catholic education for boys. Students entering the school in year 7 come from up to 40 different primary schools. The school has a large population of Asian students.

The school uses the AC-M syllabus and program as handed down by the New South Wales Board of Studies The school does not adapt it, apart from putting it online and adding their own resources and material to it. The school is grappling with implementing AC-M and the time needed to teach it. What used to be senior work (year 11/12) is now in the junior syllabus (year 9/10). There are regular teacher meetings to work out how to roll it out.

Mathematics is the only subject to stream students most of the way through secondary school. Year 7 students are often at very different levels of mathematics understanding. They are graded on their previous NAPLAN results and an entrance exam when they first enter the school. This forms the basis for mathematics streaming. Following the school's strategic plan, mathematics students are streamed into high ability, middle and support groupings. The high ability students are extended through a quicker teaching pace and more complex tasks, the middle group focus on consolidating their mathematics knowledge so they reach a 'standard' while the support group works to bring them up to a 'standard'. There is 'relegation' and 'promotion' between streams.

NAPLAN data are used to create a document for staff with an analysis of results that helps set the goals for the following years. Students and teachers discussed the data during a program being run by the school's CEO in which the group's strengths and weaknesses around NAPLAN were identified.

In large secondary schools one or two classes were sometimes created for students needing extension in mathematics, with a similar grouping for those students requiring additional support. All other classes were heterogeneous, comprising students grouped randomly or according to home groups rather than by some ability measure.

All *case study schools* (52/52, 100%) had a dedicated time for mathematics/numeracy, that is students were required to spend a certain number of hours learning mathematics/numeracy each

week. This is significant because, in some Australian schools, mathematics is hardly taught, or is left to the individual teacher despite a mandated requirement for mathematics to be taught. A minority of *case study schools* (6/52, 12%), mainly in primary schools, used a specific structure for lessons and planning that had been collaboratively developed over time. In some schools mathematics time was deliberately uninterrupted, that is students were not withdrawn from mathematics (or literacy) for any purpose. Although not a universal practice, there was a sense that interruptions were kept to a minimum. School vignette 4 is an example of the level of planning that *case study schools* undertook.

6.2.1.4 School vignette 4: government primary school in Queensland

Key themes: planning for mathematics; 'guaranteed and viable' curriculum; and grouping for learning.

Teachers are using AC-M as the basis for planning and drawing upon and incorporating, where appropriate, the curriculum into the classroom (C2C) resources available from Education Queensland. The Administration team allocates time for staff to plan for mathematics learning in Professional Learning Communities (PLCs). These planning sessions have occurred as part of professional learning days and as part of staff meetings. Teachers are required to use their own time to plan on a weekly basis. Teachers have taken ownership of planning and are developing a Guaranteed and Viable Curriculum (Marzano, 2012), based on the AC-M to suit their needs. The guaranteed and viable curriculum is a process where teachers unpack the AC-M and classify the content descriptions as either essential or supportive. This classification allows teachers to focus on learning specific to their year level. A scope and sequence for mathematics from Prep to year 6 has been developed with the essential and supportive content descriptions identified. Teachers have contributed to the development of this program and can see where the students have come from, where they are expected to be now for the students in a particular cohort, and where the students are going. The analysis of the curriculum in this way has assisted teachers to see the development of mathematics as a continuum.

At a cohort level, teachers also develop a weekly 'Maths Push in' test. This test, usually comprising 10 questions based on the content focus for that particular week, is administered every Friday. The primary purpose of the weekly test is to monitor student progress. Based on the individual's test result, students are allocated to a particular group (such as, like results/like successes/like difficulties) the following week to attend three half-hour lessons for targeted mathematics learning to receive extension, or to address individual needs.

The school is focusing resources in this area of using small groups to develop targeted and differentiated learning. In Terms 1 and 2 of 2015, the year 3 cohort of 81 students (a NAPLAN cohort) was divided into eight groups based on learning needs. The three year 3 teachers, members of the administration team (three teachers), and two other available teachers were rostered to take their allocated group of students for three half-hour lessons the following week. It was the allocated teachers' responsibility to prepare the learning activities for these targeted lessons for their group of students, thus not impacting on the year level teachers' preparation time. In Terms 3 and 4, the same process was undertaken with the year 2 and year 4 cohorts of students. The school has allocated finances to enable this small group teaching with extra teachers to occur.

In *case study schools* there were regular meetings and discussions about mathematics between administrators, curriculum leaders, mentors and teachers, to ensure that the best available learning opportunities were provided for every student. Time was allocated during staff meetings or within professional learning groups (49/52, 94%). Informal discussions focussing on mathematics were also observed. For example, a researcher in one school reported that as the Principal was coming along the corridor to meet her, a teacher stopped the Principal to discuss some aspect of mathematics. The researcher observed that the Principal followed up this brief conversation during recess, when a time was set aside to discuss the idea more formally. In secondary schools, teachers of mathematics

usually shared a staff room or had a common area where mathematics was taught. These spaces created opportunities for Informal conversations, about students and mathematics.

6.2.2   Teachers' knowledge

Information from the *case study schools* suggested that mathematics teaching qualifications were highly valued. School principals, where they had control of their staffing and particularly in secondary schools, tended to stress that they sought qualified mathematics teachers who knew the mathematics content. It was evident in the lessons observed that teachers in these *case study schools* had a deep knowledge and understanding of the mathematics they were teaching. They recognised potentially productive problems and provided good explanations. Where students were observed in classes and interviewed in focus groups (40 schools) 90% (36/40) commented that their mathematics teachers liked mathematics, and were able to explain it clearly. As one student commented, 'he re-languaged' it for us'. Students appreciated this understanding of the mathematics by their teachers.

Those teachers who undertook further study, appreciated formal opportunities for accredited study. For example, this quote came from a secondary mathematics teacher:

> *I'm doing a final [Masters] unit in mathematics education … it's certainly made me question how I teach mathematics. It's certainly changed my approach to the classes and it's also given me some ideas … its broadened my horizons a little bit because sometimes you can fall into 'this is what we do this is how we do it this is the way we'll keep doing it' … you can find yourself trapped in it.*

A similar comment was made by a non-mathematics trained teacher who had undertaken a graduate certificate as part of a retraining program. This teacher would not, however, have taken on this retraining program if it had not been fully funded. Teachers confident with mathematics were able to cater for students in a variety of ways. School vignette 5 describes a school where all teachers were qualified and enjoyed mathematics.

6.2.2.1   School vignette 5: Independent secondary school in the Australia Capital Territory

Key themes: teachers' knowledge; catering for high ability; student engagement; performance orientation; and grouping for learning.

Although students are not heavily streamed, they are grouped for learning mathematics when they enter the school, based on an internal test. High ability students, and those needing additional support, are grouped together for learning, but all other classes are heterogeneous. There is movement in and out of these groups, although one teacher commented that some students preferred to stay in lower groups as there was less pressure. One student interviewed said that when he came into the school he was in a lower group but quickly became bored and was moved into another group, which he described as 'a pretty good group'. Additional support was offered to students at lunchtimes, as well as before and after school for any student who requested it.

All teachers were qualified to teach mathematics. There was no 'out of area' teaching. Classrooms were conventional with students sitting at desks usually placed in rows. Some classrooms had mathematics posters on the walls, and all had Smartboards. There was a sense of teachers caring for the students. One student with diagnosed Asperger's Syndrome, for example, was able to come late into the class and complete the work without having to interact with other students, although the rest of the class was working in pairs and small

groups. Although the teaching was explicit and teacher-led, and had a focus on high performance, the feeling within the classrooms was of the whole class aiming to perform well, rather than the individualistic performance orientation often described in the literature.

One teacher extended her Year 8 class by giving them opportunities to explore different aspects of mathematics. Each student chose a topic and taught this to the rest of the class. The topics were varied including a way of squaring 2-digit numbers mentally, Japanese multiplication, lucky numbers, multi-dimensional space, and Keeler's Theorem (as part of a Futurama episode). Activities such as these kept these mathematically capable students engaged with mathematics.

There was a strong emphasis on performance in exams in the school. This focus did not come at the expense of developing understanding. In two revision lessons observed, teachers were questioning, providing opportunities for students to suggest approaches to problems, and using a wide variety of materials, including from the nrich website (nrich.maths.org) and Geogebra (geogebra.org). Teachers identified and used different resources for teaching, and did not simply rely on the textbook. Textbooks were used as a resource for examples.

Students were engaged and appeared to enjoy their classes. There were strong positive relationships among the teachers and the students, including the students' use of nicknames for the teachers, and an obvious feeling of students being able to ask any questions that they wished without fear of being seen as foolish.

6.2.3   Professional learning

From the case studies, it appeared professional learning was valued, but that much of it took place 'in-house'. Formal professional learning within the school was mentioned by nearly three-quarters of the *case study school* personnel (38/52, 73%). Schools promoted models of collegiality, such as a 'community of learners', or a 'professional learning community' with formal meetings where resources were available to support this approach. These sessions were sometimes led by numeracy coaches in primary schools, or by the mathematics leader in secondary schools. Wealthier schools had made strategic decisions about the use of funds, whereas others used additional funding provided through a range of state and federal programs, such as national partnerships, or student free days to provide time for meetings.

The impression of predominantly school based professional learning was confirmed by discussion with 10 professional learning providers from different parts of Australia, including Tasmania, West Australia, South Australia, Queensland, and New South Wales. The expense associated with finding relief teachers, and in many areas the difficulty of finding relief teachers, made releasing a large number of teachers to attend professional learning sessions impractical for many schools. Typically one or two teachers might attend a professional learning session and these teachers then relayed the information to their colleagues. At its best, this approach works well when there is sufficient time allocated for the new ideas to be shared and developed. In many situations, however, this approach can become like 'Chinese whispers' and important core concepts can be diluted or lost. Where this approach was taken, in *case study schools* the time was made available through learning groups.

Professional learning communities or similar teacher groups were common *in case study schools* (49/52, 94%). Although these groups may have had a general focus on all subjects, mathematics was addressed explicitly, and sometimes exclusively when these groups were located in secondary school subject groups. There was a strong theoretical focus, with readings and case studies often being

allocated to groups. Teachers regularly observed each other's mathematics lessons in a structured and purposeful way, using a framework agreed by the school. They discussed their teaching of mathematics, tried new approaches and set goals. Often an action research framework, that is a model of professional learning in which teachers undertake some focussed change in their classrooms, reflect on the outcomes, usually with colleagues, and then refine the new approach in a cycle of continuous improvement, supported these new ideas. In some schools numeracy coaches or coordinators were used to promote professional conversations, in others the impetus came from the Principal or from a senior staff member.

All teachers were expected to engage in activities of this kind, and to participate in regular, genuine appraisal activities. There was no sense that these undertakings were tokenistic—the teachers worked hard at improvement in mathematics but did this willingly and with enjoyment. These *case study schools* created working environments that were challenging, exciting and non-judgemental for both teachers and students.

These learning groups within schools provided most of the professional learning in mathematics for teachers. This learning may be supplemented by sessions with outside providers, including from education departments. Typical arrangements were for a single teacher, or at most two teachers, to attend external sessions and then share their new experience with all staff.

Teachers of mathematics in *case study schools* were knowledgeable about mathematics. They explained and represented mathematical ideas in a variety of ways. They were able to challenge their students in a variety of ways, and were not afraid to admit to not knowing some aspect of mathematics.

Internal professional learning sessions are exemplified in school vignette 6. This school had received some additional funding to support change but had also worked with its community to organise additional time for teacher discussion. There was a whole school commitment to action and local resources, including the school farm, were used to make mathematics meaningful and relevant.

6.2.3.1 School vignette 6: government F to 10 school in Western Australia

Key themes: professional learning communities; feedback; use of data and community resources; and use of data.

Responsibility for mathematics is in the hands of an experienced mathematics coordinator who has the full confidence of the Principal. This person was identified as having considerable knowledge and passion about mathematics that was gained from working with influential others at previous schools. A change in approach to planning for mathematics was based on the development of professional learning communities (PLCs) across the school. The PLCs have fortnightly meetings, for which time has been found through a 2.30pm 'early finish' every Monday. PLC activities usually consist of a reading done by all members, which has a focus on a particular strategy, this strategy is then put into practice in classrooms, and teachers bring back the feedback for discussion. Strategies are all based on the work of Dylan Wiliam (for example, Wiliam, 2011) in formative assessment, which is considered to be one of the biggest factors in the improvement of mathematics teaching. The strategies include, for example, 'traffic lights' where students show a card indicating 'I've got this' (green), 'getting there but need a bit more help' (yellow), and 'I'm stuck' (red) and the use of small individual whiteboards on which students record their answers and show to the teacher. These practices give immediate feedback to the teacher about the progress of the lesson and changes can be made as needed on the run. For each strategy trialled, teachers provide comments to their PLC group. Following this PLC meeting, observations are set up so teachers can watch teachers in other year levels and provide each other observational feedback

about how the formative strategies are working. A number of teachers also went to a Dylan Wiliam conference and found that 'incredible'.

In addition to the immediate feedback at classroom level, the school makes extensive use of NAPLAN data. The focus is on grouping children of like ability, because of a time factor. Once teachers have identified children who don't understand specific concepts, such as place value or money, they form 'guided numeracy groups'. In the secondary school, where there are small numbers of students, the school has begun to use case management strategies, identifying strengths and weaknesses at an individual level, using NAPLAN and other school based data.

Teachers analyse NAPLAN data forensically to see which questions the students had got wrong, and identify the cognitive demands in the questions and the common misconceptions. Teachers consider whether or not the same issues are happening across the school. This analysis then becomes the focus of term planning documents and lesson planning. For case management groups, there is a column in planning documents asking 'what was the specific identified target that these children didn't understand?' Teachers use this data every day to make sure that they are teaching those students what they didn't know, from the higher order thinking questions in NAPLAN.

The school also makes extensive use of the school farm with many teaching episodes based on resources available through the farm. For example, students in the secondary school worked out the fencing requirements of the farm, and calculations relating to fertiliser, seeding, and the wool cheque are part of the mathematics program. This work is undertaken in classrooms and the students then go onto the farm to implement their findings.

Case study schools put considerable resources into providing opportunities for professional conversations to occur. For example, one primary school had organised the timetable such that groups of teachers had a long block of time from 10:30 am onwards, providing nearly a full day to work together once a week. There was a requirement during this time to focus on learning and teaching through, for example, structured discussion and working through case studies. One secondary school required all teachers to commit to a process of continuous appraisal and improvement using collegial lesson observations.

Another successful approach that supported teachers' professional learning is described in school vignette 7. This school was one of three using the International Baccalaureate (IB) curriculum.

6.2.3.2 School vignette 7: independent F to 12 school in the Northern Territory

Key themes: real-life problems; teachers sharing ideas; classroom discussion; and student talk.

The school has a strong Christian ethos and aims to develop the whole person. The Principal stated, 'it is about equipping kids not only to be great academically but also to take their part in society, understand the nature of service, compassion and respect.' The school introduced the IB curriculum in 2009 and the general feeling among teachers and senior staff was that this curriculum had made a huge difference in the school.

The focus on inquiry in the IB has forced teachers to pose problems and look at deep questions such as, 'what does equal mean?' real-life problems where children have to use mathematics to solve problems of relevance to them are important. Through the IB, everything is brought back to a real world context, which can be quite difficult especially for young mathematics teachers who may not have the background and breadth of understanding because they perceive mathematics as being about having the answers.

The school is textbook free from years 6 to 9. There are some small sets of textbooks, not full class sets, available for short-term use and teacher reference. The AC-M provides the content for mathematics, but the IB

frameworks in primary and middle years are used to develop understanding through an inquiry approach. Inquiry is being developed into the middle school and up into senior classes. The head of mathematics said, 'It's about getting the children to discover what's happening and why it's happening … it's so powerful for them and they remember it into the following year.' Taking this IB approach has made demands on staff. A program of sharing ideas was instituted to develop the content knowledge of the teachers and to get them used to teaching understanding through inquiry, rather than procedures.

Good mathematics lessons are those where there is a lot of discussion and dialogue, 'lots of conversations to unpack the maths'. A certain amount of noise was expected, with students talking to each other as they worked on problems, students engaged with the material and were not on phones or iPads (unless they were part of the lesson), and the teacher circulating through the class talking with students. Teachers ask leading questions, students pose questions and work out the answers for themselves. At times students drive the class agenda. Discussion has a focus as to why an approach worked and what didn't work, and the lesson ends with a reflection on the lesson objectives.

These principles were observed in classrooms. For example, a year 8 lesson was following up on the previous lesson, which had taken place outside the classroom measuring steps and slopes. The teacher re-introduced the concept of slope, and emphasised that it took time to fully understand a new idea. A series of problems was presented with different approaches to slope, including positive and negative slopes. All of these examples were accompanied by dialogue between students, and with the teacher. Questions were posed by students and by the teacher that not only addressed the idea of slope, but also picked up on incidental opportunities (for example, 'why can't we simplify 2/5?'). In a year 9 classroom, data about the students were used to develop a stem and leaf plot, from which the mean, median and mode were calculated. The lesson concluded with an interactive discussion and explanation of the comparison between different data representations histogram, box and whisker plot, frequency table, stem and leaf plot—using aggregated data from the whole year 9 cohort (heights, and so on) on a laptop linked to a display screen. Individual students are tracked using a Learning Management System. The Learning Support Team monitors progress and develops individual plans as needed. There is a clear and unambiguous focus on catering for the needs of each individual student and providing opportunities for each person to 'be the best that they can be'.

Faculty meetings are seen as very important, as they provide a forum for professional learning, collaborative planning across cohorts, and moderation and cross marking of student work. Considerable effort has been put into building staff expertise through a 'show and tell' process. Teachers will 'bring maybe a game that they play so we'll play it as a staff and then everyone can take that game away or they can say, 'no it's not for me or my class'. It works really well'. Within the inquiry approach, explicit teaching is used when content is newly introduced or as needed during the course of an inquiry.

Overall, professional learning was seen as important but tended to focus on opportunities within the school, rather than external provision. Some teachers did attend sessions with different providers and generally shared what they had learned with their colleagues at school. Teachers also mentioned attending local mathematics conferences, but it was not clear whether they considered these as structured professional learning.

When asked about specific opportunities for professional learning, the major theme was that of in-house groups, with a focus on internal mentoring and ongoing professional conversations (49/25, 94%). Sometimes a school (38/52, 73%) would have sessions with an external provider, usually an individual consultant. These sessions were tailored to individual schools' identified needs. These sessions were not always related to mathematics and tended to have a local focus, depending on the provider available. In some instances, professional learning had a focus on a particular program. Visible Learning (http://visiblelearningplus.com/) based on Hattie's (2009) work was a

priority in three *case study schools*. Programs for the younger years of schooling, such as *Count Me In* and *First Steps*, were also mentioned.

Some schools appeared to use several external providers, whereas others relied on internal staff leading professional development, or encouraged staff to attend professional development opportunities (Professional learning) such as local mathematics association conferences or professional development (professional learning) sessions run by local associations. Sometimes a school identified a particular need, such as using graphing calculators, and arranged for sessions addressing this. Teachers also drew on their previous experiences to contribute to school-based professional learning. Teachers who had come from New Zealand, for example, mentioned numeracy projects from that country. Others talked about IB programs and approaches.

When teachers were asked about their professional learning, no individual standout program, provider or theme emerged, apart from the school based focus. Nor was there any particular mathematical topic or approach, although aspects of using data to understand the school's and individual students' progress were mentioned fairly frequently (45/52, 87%). *Case study schools* appeared to make use of available professional development sessions, as needed or as identified by the school. The standout feature was the focus on teaching and learning of mathematics by small groups of teachers, supported by decisions made by school leaders about resource use.

In some schools however, there were comments that where a system provided support personnel, such as coaches or curriculum support officers, these were not available for a sufficiently long period to make a lasting change in teachers' practice. Principals and teachers in the *case study schools* all recognised the value of ongoing professional learning, although they also acknowledged the limited resources that systems had available, and the difficult decisions that had to be made about access to support. This unavoidable tension was addressed in *case study schools* by in house provision.

Data from the National Teaching Workforce Dataset (NTWD), data analysis report 2014 (Willett, Segal, & Walford, 2014) suggest that the focus of the professional development undertaken by teachers in *case study schools* was similar to that undertaken nationally. For example, there was a strong focus in the NTWD of, 'learning how to evaluate and improve my own teaching' with around 60% of all teachers indicating some professional development in this area. Professional development communities in the *case study schools* also directly addressed these issues. *Case study schools* in this study may be more deliberately focussing on numeracy than was observed in the NTWD, where about half of all primary teachers, and one-third of secondary teachers were reported as engaging in 'developing strategies for teaching numeracy'. In contrast, a majority of *case study primary schools* (19/22, 86%) reported a professional learning focus on numeracy. In secondary and combined schools the school level focus was more general, although teachers within mathematics faculties in large schools did engage in mathematical professional development activities, including in one school solving mathematics problems collegially in the mathematics staffroom during recess or lunch.

These finding were confirmed by discussion with members of the Towards Educating Mathematics Professionals Encompassing Science and Technology (TEMPEST) project team. As part of the project they surveyed teachers about professional learning. As in this project, there was a wide range of professional development undertaken but no clear themes emerged. TEMPEST respondents indicated that schools made use of state-based programs delivered by systems by sending one or two teachers to these when the school deemed this was an appropriate use of resources, but this approach was not universal.

6.2.4 Use of data and collaborative planning

One standout feature identified in the case studies was the ongoing and purposeful use of data (45/52, 87%). A range of data sources were used extensively to diagnose issues with programs, classes and individuals. Action was then taken to address the identified challenges, and this action was broader than simply fixing up the program in a NAPLAN year group (year 3, 5, 7 and 9). It usually involved the whole school, or specific year groups.

A variety of approaches to using data was identified in *case study schools* (see examples in school vignettes 1, 3, 6, 8 and 9), including whole school planning, grouping students for learning, and goal setting. School Vignette 8 describes one school's approach in the early years of schooling, well before NAPLAN testing.

6.2.4.1 School vignette 8: government K–10 school in Western Australia

Key themes: backwards mapping; using data to diagnose program weaknesses; and collaborative programming to develop strengths K–3.

The 'backwards mapping' process starts in year 2, where the teacher 'backwards maps' from the year 3 data, then blends that with entry data from year 1, and therefore has data coming in from both the year level above and below. NAPLAN data is used to identify concepts that the year 3 students lacked so that the teacher of the in-coming year 2 children will cover those areas. At the end of the year, the current year 2 students are given the year 3 test and are then tracked to see how they achieved, on the basis of where the school would expect them to be placed on NAPLAN. This tracking is done to ensure that the target groups were sufficiently well identified and also to detect children about whom there were high expectations, but who didn't achieve in line with those expectations. The school uses a case management approach to ensure that every student is catered for appropriately: 'we have an interest in NAPLAN for the entire year assessment and we also have our case management groups in our off years as well, so we have them all the way down to Kindy now where we use on-entry testing'.

In addition to identifying students' needs, NAPLAN data were also used to inform programming. School vignette 9 is one example of addressing a program issue through a whole school commitment to action.

6.2.4.2 School vignette 9: government primary school in Western Australia

Key themes: collaborative planning; whole school program; resource use; and use of NAPLAN data.

Several years ago, the staff identified through NAPLAN that algebra and algebraic thinking was an area of weakness and resolved that it was all based on the notion of pattern. Rather than patching up the issue by teaching fragmented splinter skills in year 5, the school took a more encompassing approach and determined that patterns and algebra needed to be an explicit focus of teaching from the Foundation year upwards. The teachers collegially and collaboratively planned a new school scope and sequence for patterns and algebra. As a group they decided to do intensive and explicit work on patterns from year K to 6. Targeted resources and manipulatives were identified and purchased and included work cards, pattern cards, sets of manipulatives, including sets of different sized and coloured teddies, counters, tiles, shapes and so on. The resources were based in the K and prep rooms initially and teachers of other year levels were able to borrow them as needed. The resources have been very widely used since they were purchased. All the teachers made a commitment to the new program.

In addition to NAPLAN data, teachers in *case study schools* used a variety of data sources, including teacher developed assessments, common tasks, and other forms of testing such as the Progressive Achievement Test - Mathematics (PAT-M) available from the Australian Council of Educational Research. These were used to identify the needs of particular students—not just remedial needs but also extension needs.

Students were regrouped frequently in different ways to address specific requirements for learning. At times the students were clustered in friendship groups, sometimes in like ability groups, sometimes for behaviour management reasons. The groupings varied according to the topic, the class, the school organisation, and teacher availability.

In schools that reported some form of grouping for learning (47/52), one feature of the grouping and regrouping (*flexible grouping* (FG): 19/46, 40%, *mixed ability classes* (MA): 18/46, 38%; mixture of both FG and MA: 10/46, 21%) was that the students were not locked into a level or grouping. Groups were not characterised as high or low achieving so that students' self-perceptions were about learning and succeeding in mathematics.

Where assessment was used prior to teaching, it was used effectively. Students did not repeat material they already understood. The aim of the data use at the student level was to find the critical point where students would make maximum gains by focussed and targeted teaching. Schools recognised that to use data effectively in these ways, teachers required ongoing professional development and conversations. Time was spent on discussing students' work samples and developing moderation tasks to support teachers' decisions, and further develop their mathematical knowledge for teaching.

These strategies were made explicit to students and the school community. In this way there was little stigma attached to being in a particular grouping—it was understood the regrouping was purposeful and about learning. Judgements were objective, based on data, and not fixed for the whole term or year. Students understood this aim, as exemplified by the following quote from a primary student. When asked what happens if they got the pre-test 'right' one student replied: 'Oh then she says you might be a good person to teach other people, so if someone gets half of them wrong, she might bring them down the back with her and get them to work with her. Then someone gets 75% wrong then she'll bring them over to the Educational Assistant (EA) (Year 5 student, provincial primary school)'.

6.2.5 Attitudes to NAPLAN

NAPLAN testing was deliberately under-played in the *case study schools* (45/52, 87%). There was no 'teaching to the test' preparation for NAPLAN was restricted to familiarisation with the format in the week or so leading up to the NAPLAN date. In secondary schools even this low level of preparation was not undertaken everywhere, and NAPLAN seemed to be 'just another activity' as indicated in this typical quote:

> *We had a meeting a few years ago about NAPLAN and decided not to get too paranoid about it … we looked at the structure … and we made sure kids were exposed to those sorts of things but we weren't over paranoid about it so we only give kids in the week leading up to NAPLAN a previous year's NAPLAN to familiarise them with the structure.*

Head of secondary mathematics, Independent Pre-foundation to year 12 school

Despite this low-key approach, there were comments from around the country that the media attention and parent pressure about NAPLAN was not helpful. Some schools described how they deliberately tried to 'protect' the students from the emotional turmoil, by advising parents not to purchase practice materials, and not to over emphasise the importance of NAPLAN to their children. Some students, however, described how they felt about the testing process:

> *It is like you are on a giant roller coaster–your stomach is all twisted.*

Year 5 student, metro primary school

> *When it is finished, it is like a big weight has been lifted off your shoulders.*

Year 5 student, metro primary school

> *My Mum is like really enthusiastic and she like wants me to get the stuff and like get good marks and she gets me these NAPLAN books and you do them and it like gets you up to the actual NAPLAN.*

Year 5 student, provincial combined school

These quotes all came from students in different *case study schools*. Several students from these schools also commented that their teachers helped them to relax. The negative effects of NAPLAN seemed to be greater in primary school students and among primary teachers.

Case study schools did, however, realise that NAPLAN data were helpful. They made good use of the data for considering their whole school programs and to refine their understanding of the students. This dual recognition of the positive and negative aspects of NAPLAN was also identified in the surveys.

6.2.6   Programs and resources used in teaching

Case study schools used a variety of programs, materials and resources to teach mathematics. Concrete materials, such as counters, blocks, Multibase Arithmetic Blocks (MAB), trundle wheels and so on, were available in all schools. Teachers sometimes came to interviews with a collection of resources that they used, but these were idiosyncratic and particular to the individual, and no single program or resource stood out. Where textbooks were used these seemed to come from all the major publishers, and again there was no standout popular text.

A summary of resources mentioned by use in *successful schools* is provided in Table 6.2:4. These findings were taken from both surveys and case studies. No counts are provided for these resources because some schools provided explicit examples of several different resources whereas others simply stated that they had a roomful of mathematics resources without specifying these, or mentioned general resources, such as 'websites'.

Table 6.2:4   Resources used in successful schools based on survey responses and case study observations

Resource use	Texts	Online resources	Concrete materials	Learning management systems (LMS)	Other
Teaching activities		nrich, Scootle, Illuminations	Variety		Maths 300; Origo
Student practice and revision	All major publishers	Khan Academy		Mathletics, Studyladder, Maths Tracker, My Maths Online	
Professional development			CAS calculators		Origo, various consultants, IB training
Planning and programming	AC-M (state versions)	Scootle			Origo
Assessment	Standards in AC-M (state versions)			Some parts of the LMS programs, Improve	PAT Maths, Tests in texts
Other			School farm, local resources	www.amaths dictionaryfor kids.com	

N.B. Respondents could mention more than one resource, and some schools used many different resources whereas others did not respond. Hence no frequencies are provided.

Appendix C2 provides a count of resources used in *successful schools* based on both survey and case study data. It should be noted that this list may not be comprehensive because teachers and leaders in schools visited in case studies sometimes talked about a 'resource room' or indicated that they used a variety of materials, programs and resources without specifying anything in particular.

6.2.7 Assessment and reporting

Despite systems' efforts to provide advice and exemplars of reporting, teachers, as shown by the survey results (Chapter 5), appeared to be making relatively generous judgements of the standard that students were reaching. In particular, they appeared reluctant to use ratings of D and E that are associated with failure. This was reinforced by discussion with teachers in *case study schools*. Only in competitive, high ICSEA schools was there little interest in the form of reporting.

When asked about the reporting standards, a number of teachers criticised the approach. There was a feeling that because the standard changed each year as students moved through school, students who were making good progress in developing mathematical understanding were never able to demonstrate that progress. One teacher described a student in his year 10 class who frequently missed school as saying, 'why should I come to school? I've been at school for 10 years and I'm still a D'.

The A to E reporting specifically expects comparison with a student's peer group and is therefore performance focussed. It does not allow for growth because as weak students improve, so do all others in their peer group. As such, this approach does not encourage mastery learning.

6.3 Approaches to teaching

Approaches to teaching varied in the *case study schools*, from teacher directed traditional, textbook focussed lessons to practical, contextually based approaches, regardless of whether the school was primary or secondary. The school context appeared to make a difference. More traditional lessons seemed to be observed in high ICSEA schools; whereas in low ICSEA schools the approach seemed to be more hands-on. In all schools observed, the teachers understood the mathematics involved, and understood their students, and catered for them accordingly.

6.3.1 Explicit teaching

Explicit teaching is an approach to teaching which has a focus on curriculum content, including having clear goals for every lesson, making connections within and between concepts and monitoring student progress. Explicit teaching can occur with whole class, small groups or individuals as the teacher changes the approach in response to students' feedback. Although many of the observed lessons in this study were teacher directed, students were actively involved in determining the lesson direction. In many observed classes students were encouraged to attempt problems that would challenge them. Teachers were responsive to student questions, and often used these to make a more general point to the whole class. Teachers were excited by the mathematical ideas and how their students responded to these. One Principal commented, 'children should be driving the class agenda at all times'.

School vignette 10 provides one example of explicit teaching that is nevertheless student focussed.

6.3.1.1 School vignette 10: Independent secondary school in the Australian Capital Territory

> Key themes: choosing a good problem; and involving students in solutions.
>
> In one lesson, students were revising integration by substitution. A student asked for a particular example from the text to be explained. It was obvious from the body language that the teacher immediately recognised this as a potentially rich example that would bring out a number of points. Through careful questioning of the students she established that none of them had thought to draw a sketch. The teacher suggested this would be useful, and while they were sketching the curve, prepared a display using Geogebra. She did not immediately share this with the students, but projected the axes on the smartboard.
>
> One student then volunteered to draw the sketch, and the teacher compared this sketch with the one she had drawn on Geogebra. The point was then able to be made, again through some questioning, that finding the area under a curve was not always identical to finding the integral, and that a sketch would help them decide.

Teachers demonstrated deep understanding of their pedagogical approaches, and shared these with the students where appropriate, for example, 'When teaching I will say to a student, 'I am giving you wait time here''. Another example of explicit teaching focussed on understanding came from discussion with the school mathematics leader in a Queensland independent school. It is shown in school vignette 11. This teacher had a deep understanding of the importance of making connections within mathematics and deliberately made these explicit.

6.3.1.2 School vignette 11: Independent secondary school in Queensland

> Key themes: teaching for understanding; and mathematical connections.
>
> The head of mathematics has a pedagogical view that learning is about understanding, and this is more important that memorising or recalling. So while note taking through direct instruction may be useful, if the students understand something, that's more important than them taking notes 'understanding will stick with you rather than memorising'. His view was that 'little learning occurs when teachers fill the board with notes and expect students to copy it down'.
>
> The preferred method of instruction by this teacher is to unpack questions as a class, through questioning and examples, and develop understanding while pointing out the intricacies in solutions. He aims to flag where silly mistakes are made in procedural situations, before mistakes are made. In addition, he recognises the necessity of building connections across mathematical concepts. This personal view is not imposed on the other teachers within the department, as there is recognition that both teaching and learning styles are very individual.

In a large majority of *case study schools* (45/52, 87%) there was a focus on developing understanding in the mathematics classroom rather than on simply developing procedural fluency. This is in line with findings from the surveys (Chapter 5) where students from *successful schools* indicated that their teachers developed a mastery oriented classroom.

6.3.2 Supporting students' mathematical thinking

Students in *case study schools* were encouraged to take risks and 'have a go' but were also provided with strategies for when they had difficulties. Students were able to describe these strategies. When asked what they did when they got stuck on a mathematics problem some typical responses were:

> *We don't ask for help. We find it out for ourselves using different stuff like we have a lot of maths charts in our room and maths dictionaries and she tells us to look at these before we ask her.*

<div align="right">Primary student, Low ICSEA F-12 School</div>

> *I discuss with someone who is also stuck because they might have a bit which I was missing and then we work it out together.*

<div align="right">Primary student, High ICSEA Primary School</div>

Many teachers were explicit about developing independence and confidence in their students so that the students knew that they could do mathematics.

The notion of taking risks in the mathematics classroom and learning from mistakes was identified in 87% (45/52) of *case study schools*. Repeatedly, students *in case study schools* stated their teachers didn't tell them what to do but asked them questions, suggested where they might source information, or provided a specific strategy such as 'reread the problem'. This approach is exemplified in school vignette 12. This school was the only secondary school that explicitly used cross-curriculum integrated approaches.

Across the *case study schools* there was a lack of genuine mathematical inquiry observed or mentioned. Only 21/52 (40%) of *case study schools* indicated that they used mathematical inquiry or mathematical investigations where students were presented with challenging mathematical situations to which they had to formulate a solution. Schools using the IB curriculum were more likely to implement inquiry approaches.

6.3.2.1 School vignette 12: Catholic year 7 to 10 school in Western Australia.

Key themes: classroom risk taking; using different teaching approaches; and cross-curriculum integration.

The school vision is based on a tradition of academic rigour and excellence for all, which aligns well with the strong pastoral focus of the school. Parents seek out the school because of its well rounded approach that includes music, sport and academic studies. The school also caters for a group of special needs students.

Classrooms are places where students feel safe to take risks. One teacher talked about an explicit focus on growth mindsets, and that mistakes are part of learning. Additional help is provided at lunchtime for any student who comes along to ask for support. These comments were borne out by students with one commenting, 'always just really positive in class, and he's always just saying like I want to help you, like I don't want you to necessarily get A's, I just want you to understand it. [He] doesn't care if we get it wrong as long as we understand the process and just keep trying. There's less pressure because if you have that constant pressure of wanting to get things right over and over again it's just gonna [sic] make yourself stumble and get things wrong'.

The school intentionally aims to use a range of approaches and resources when teaching mathematics. Scootle and other online sites are used which are often suggested by students. Textbooks are available but their use depends on individual teachers. Overall, the philosophy is to use a variety of methods.

Cross-curriculum integration of mathematics is encouraged across the school, with some evidence that it is occurring in the senior years as well as in the middle school. The cross-curriculum approach is managed more easily in middle school where teachers have the same students for more than one subject. There are also conversations with different learning area coordinators as the students go into higher year levels, to determine where and how they can support one another. For example, teachers in the legal studies program might ask 'How do we support students in our mathematics program?', and look for teachable moments in the same way as literacy is supported in mathematics. The cross-curriculum approach is increasingly being used in senior classes.

In some *case study schools* (6/52, 12%) there was an agreed set lesson structure. This structure often took the form of a 'whole part-whole' lesson, in which the whole class was presented with some engaging starter, followed by a segment when students worked individually or in small groups on a given task, coming back together for a final summary and reflection. In the *other case study schools*, although the lesson structure was not formally agreed, teachers and students could describe a 'typical' lesson, which was similar to the agreed approach. Students knew what to expect in the classroom.

For example, this description was taken from the case study report from a low ICSEA, provincial primary school:

> *Students are given a topic and a learning goal that everyone is expected to meet, they can make their own learning goal, answer questions: what we know, what we want to know, what we learnt, and provide proof of what they learnt. At the end of the week students write a reflection and at the end of the lesson they have a technique for showing the teacher how they are going by using number of fingers to indicate understanding of topic. Each lesson usually has a session where they learn the new work, then group rotations of activities.*

An example of the use of a lesson structure is provided in school vignette 13.

6.3.2.2 School vignette 13: government primary school in Victoria

Key themes: lesson structure; and learning intentions.

All levels have a 12 month scope and sequence for mathematics, which was designed using the Australian Curriculum. Teachers then plan their lessons using this document.

The classroom teachers provide learning that caters for the needs of the different student levels within all classrooms. The school does not stream. The principal encourages the lesson structure of starting together, and then declaring of the learning intention and success criteria. The students might work on independent tasks while the teacher has a focus group. Students are brought together at the end of the lesson to reflect on their learning. For example, the year 1 and 2 lessons start with a mathematics fluency number activity before every lesson. The prep students focus on kinaesthetic learning that includes touching and hands on experiences. The upper levels also use materials and resources during many of their lessons.

Discussion was an important lesson component. Mathematical language was used accurately and consistently across the schools—in some schools there were deliberate practices around the ways in which language was used so that the words that students met as they moved through the school did not change. Questioning was used effectively:

If you can really fine tune questioning, you are making them think anyway.

Teacher, high ICSEA Primary School

In most classrooms (45/52, 87%) there was a focus on understanding, rather than replicating, procedures. One teacher explained that students who were good at mathematics:

... are kids who are not just able to solve a question but to be able to talk and reason a solution to you; to represent in different ways

Curriculum leader, high ICSEA Primary School

A similar comment was made by another teacher who stated that a good student:

(i)   *was good at unpacking questions;*
(ii) *could order their information; and*
(iii) *and could undertake critical thinking by examining the question from different aspects.*

Primary teacher, high ICSEA primary school

Students recognised teachers wanted more than right answers:

[He] doesn't care if we get it wrong as long as we understand the process and just keep trying.

Secondary school student, average ICSEA secondary school

Teachers also recognised that developing understanding took longer for some students than others, and that it was sometimes counterproductive to try to do everything at once. School Vignette 14 describes an approach to classroom organisation that ensures that all students have dedicated time in small groups with the teacher, during which they are taught at their own level.

6.3.2.3 School vignette 14: government primary school in the Northern Territory

Key themes: lesson structure; classroom talk; focus on strategies; and small group work.

Classes are not streamed. Mathematics is taught in a dedicated one hour lesson every day. In each class the lessons start as a whole group with the teacher. They then break into ability groups. Each group has appropriate activities to do while the teacher explicitly teaches one group at their level. During the teaching episodes there is a focus on and discussion about what strategies the students will use and which one would be the most efficient to be able to solve the problem. Students will talk about why they chose their strategy and they may present their approach to the class. Since taking this approach, children are talking amongst themselves more and the teacher has become more of a facilitator. The groups rotate and a different group works with the teacher. Some classes do two rotations per hour and some three, but over the week they would all rotate through the groups a number of times and all students have dedicated small group time with the teacher.

The school uses the New Zealand developed NumPA one-to-one test/interview to establish a database of children's understanding (see www.nzmaths.co.nz/plan/slb09/numpa). This test is used once a year with children along with a range of more regular specific topic tests. Learning targets are set for each child and these are communicated to the children and their parents to ensure that there is transparency.

The theme of teaching for understanding was universal across all of the schools visited. The stated aim of one teacher was to challenge students to 'build upon and apply knowledge to a variety of situations, not just tick a box'. Similar statements were made frequently, and opportunities were reated to draw on student's experiences through discussion. One teacher described a Year 1 student in her class demonstrating deep understanding:

> One little girl said something like 'I know recess is at 11 o'clock. I know it's 10:30 now. I think recess is in half an hour.' So I felt she had a great understanding.

> Early childhood teacher, low ICSEA, F-10 school.

In the *case study schools*, 87% (45/52) had a focus on classrooms that encouraged questioning and development of understanding through student talk. One principal stated that children best learn through:

> … a lot of discussion … children being able to work independently and teachers in there with them, doing it with them, rather than setting them work and standing back.

> Principal, low ICSEA, provincial primary school

In another school a teacher commented:

> It's about establishing a rapport with them so they're not worried about getting it wrong … having children explain how they got there helps to develop their higher order thinking [as an assessment tool] … it's a lot more effective than pen and paper.

> Year 7 teacher, average ICSEA, F-12 school

Among the *case study schools*, however, there was some imbalance across the curriculum content. Of the 46 lessons where there was explicit mention of the lesson content in the Case Study reports, 61% (28/46) had a focus on the Number and Algebra strand, 28% (13/46) addressed Measurement and Geometry, and 11% (5/46) had a focus on Statistics and Probability. These proportions may be appropriate but are open to discussion. The study took place towards the end of the school year and there is anecdotal evidence that many schools leave teaching geometry and statistics until the final weeks of the year, which is when this study took place. Had the study been conducted early in the school year it is possible that even fewer lessons would have addressed geometry or statistics. The issue of balance across the curriculum may need further exploration.

6.3.3   Differentiating teaching for learning

Over half of *case study schools* (29/52, 56%) reported using at least some flexible groupings to cater for individual student's needs. The flexibility was reported as being important, with opportunities for students to move in or out of groups according to their needs. Some schools targeted groups based not only on assessed mathematical ability but also on the contribution that each student could make to the group, or ways of thinking mathematically. The groupings focussed on developing mathematical thinking—the reasoning and understanding proficiencies of the AC-M; and mathematical challenge—the problem-solving proficiency of the AC-M, rather than on improving fluency in processes and procedures.

Students recognised they were not locked in to particular groupings, and appreciated there were opportunities for both support when needed and for advancement. Some teachers indicated that there were some students who felt safer in lower achieving groups and wanted to stay in these. The teachers reported that part of their job was to develop the students' confidence in mathematics. One teacher stated that he thought that the problems with students taking lower levels of mathematics was not with the material but 'in their heads' with the students' beliefs about mathematics and their capacity to do mathematics. He felt strongly that, although the school was a *case study school*, and therefore performed well in NAPLAN, they should be doing more, and to some extent the school was settling for mediocrity as it was not challenging the students' beliefs.

Schools had a variety of ways of grouping students for learning mathematics. Although many grouped on the basis of ability, in some schools social outcomes were the focus. School vignette 15 provides one example of grouping socially and the adaptations teachers made to accommodate different groups of students.

6.3.3.1   School vignette 15: government primary school in the Northern Territory

Key themes: differentiated teaching; and grouping for learning; teacher enthusiasm.

The school has a high percentage of Indigenous students and students speaking English as a second or third language (about 43% of the enrolment have these backgrounds). There is a fairly high turnover of students as families move in and out of the district. The school has worked with Tyson Yunkaporta to incorporate the *8 Aboriginal Ways of Learning* (http://8ways.wikispaces.com/), and also draws on *Tribes Learning Community* (www.tribes.com) and *Mind Matters* (www.mindmatters.edu.au). A year 5/6 teacher said 'the main priority as a teacher is to have the children gain a thirst for learning, which first starts off with relationships and values …Trust is the first step of building that and once we have that, to help the children take risks … Once I've got them with a thirst for learning, it is easy to teach them … however they need to want and be ready to learn otherwise they can just put blockers on.

Students are grouped for learning socially rather than by ability, but in practice this approach means that high achieving students usually end up in the same group; and the same with low achievers. Teaching is focussed on catering for students' needs and one teacher described how she had to change her approach with different groups. Her current class is mainly disengaged boys 'This class this year is nearly all hands on manipulatives, and a lot of competition. They learn best from working in groups, talking about an answer, not being put on the spot for answers, and using hands-on and competition in lessons'. Her previous class had been the high achieving group and she felt their learning was more about extension and rich tasks where they could work more independently, and that this did not always need teacher assistance. The school draws on many different resources to cater for students' learning needs. In the early years they use *Count Me In Too* (http://www.schools.nsw.edu.au/learning/k_6/maths/prosupport.php) and all new teachers are trained in this

program. For selected students (only in Year 5 and 6) *QuickSmart* (https://simerr.une.edu.au/quicksmart/pages/qsmathematics-intervention.php) is used as an intervention. Other resources mentioned included Peter Sullivan's *Open-Ended Maths Activities* (Sullivan & Lilburn, 2004), *NZ Maths* (https://nzmaths.co.nz/), and *Maths 300* (http://www.maths300.com/).

The school has adopted a consistent method for teaching mathematics to provide continuity for students. This approach involves a clear teaching cycle based on 'switching on', review, explicit teaching, practice, consolidating games, and check-in and reflection. Lessons usually follow this sequence. Teachers plan lessons to use technology, manipulatives and group work so students enjoy learning and it is relevant. There is no room for chalk and talk type lessons in the school.

The students in the focus groups universally stated that they enjoyed mathematics with one year 5 student saying, 'when I walk into my maths class, I see lots of happy people'. They enjoyed the challenge of mathematics but also described how their teachers supported their learning, 'she wouldn't think you're bad, she'd think you'll need a little bit more help. She'll look in your book and she'll find like the pros and cons and she'll normally just focus on the pros … she won't really bother about the cons ... until like find out if you need help with them. If half the class are struggling with that thing she'll make a new lesson out of that'. Their teachers were described as enjoying teaching mathematics, 'yeah, when she's teaching something she's always excited and quite enthusiastic … it helps us learn because she keeps us happy and she always has a smile on her face so we can learn'.

A different approach to differentiating learning was taken by the school showcased in school vignette 16. This was a small rural school, which had limited easy access to additional personnel, in terms of relief teachers or additional staffing. The school provided for students' needs by using a variety of approaches, including learning contracts and inquiry tasks.

6.3.3.2 School vignette 16: government K–10 school in Tasmania.

Key themes: independent learning contracts; problem solving; and inquiry teaching.

The school is situated in a rural area. It is small, and as a result secondary school students (Years 7 to 10) are sometimes grouped into classes across multiple year levels. Teachers teach across the school—the numeracy coordinator teaches a Year 5 and a Year 9 mathematics class. The science teacher, who has a physics background, teaches Year 10 mathematics. One teacher, who retrained as a technical studies teacher from a trades background, has completed a further retraining program to gain a graduate certificate in mathematics teaching for middle years mathematics classes.

The school aims to develop independent learners with a focus on problem solving. In the Year 7/8 class observed, the students were following a 'contract' in which they had to complete negotiated tasks over one week. These tasks included a Study Ladder (studyladder.com.au) task, some problem solving tasks, an investigative task building on work from previous weeks (the 4 Fours puzzle extended to 5 Fives and 6 Sixes), a practice worksheet, and a 'brainteaser' (for example, students were required to design the net of a cube with a Christmas wish or drawing on each face, so that when the net is folded up to form the cube, every picture is up the right way). Examples of students' mathematics work were displayed around the room, including photographs of models of their bodies. This was a mathematics inquiry task in which students were challenged to make a scale model of their own body. During the lesson the teacher worked with small groups of students on specific concepts to extend their understanding of algebra (substitution). The students appeared comfortable with the autonomy they had, and worked in a focussed way on their contract tasks.

The numeracy coordinator was using Maths 300 (http://www.maths300.com/) resources, and used 'Eric the Sheep' as a task for her Year 5 students. The students were obviously familiar with the kind of task, and

willingly used materials to explore the problem. Several began to predict the answers and were working on developing a pattern. As in the older class, there was mathematics work displayed around the classroom.

When the students in the focus groups were asked about their mathematics lessons, they were all enthusiastic about mathematics. They had good strategies for solving problems, and were explicit about these. One Year 3 student described how a visiting numeracy coach had taught the class, and had asked students to share their thinking. The regular teacher had been watching and was now using some similar strategies. This student had particularly enjoyed hearing about other students' approaches and was pleased this idea was being continued.

All of the teachers who were interviewed emphasised the idea of starting where students were confident and building on from that point. They identified students' progress using a variety of strategies including problem-solving reports, short tests—mainly in upper primary and secondary school—and classroom observations. Because of small numbers, grouping across year groups and classes was not possible, but it was evident that grouping did occur within class groups.

6.3.4   Supporting teachers

Some schools had access to a numeracy coach, or had designated a staff position to the role. In one school the coach had been working exclusively within the school for four years. School vignette 17 describes the work of the numeracy coach in one primary school.

6.3.4.1   School vignette 17: government primary school in the Northern Territory

Key themes: whole school focus; changing teaching approaches; and community involvement.

The numeracy coach has been at the school for four years, during which time the NAPLAN results have improved. Both the Principal and numeracy coach have strong mathematics backgrounds; the principal in First Steps in Mathematics (http://det.wa.edu.au/stepsresources/detcms/navigation/first-steps-mathematics/) and the numeracy coach in New Zealand Maths (www.nzmaths.co.nz), both of which have similar philosophies. Initially, they had found a lot of worksheet use, a lot of children doing algorithms and a lot of children working at the same level. They tried to change the approach without having a coach but recognised that change would not come about 'unless we absolutely changed the teaching style and teach the teachers'. They commented how they wanted to change the student's beliefs about mathematics. When the students were asked if they liked mathematics three years ago they said 'No', so they needed to get children enjoying mathematics, believing in themselves and being confident that they can do mathematics. Students had stated that they didn't like mathematics because they couldn't do it. The Principal felt the reason they couldn't do it was because there were a lot of gaps, there was no assessment of children to find out where they were at in order to make teaching decisions, and the students were learning by rote more than by understanding.

A whole-school approach to mathematics was identified as a need and the numeracy coach introduced the numeracy project, a NZ developed program of professional development (www.nzmaths.co.nz). 'It was a professional development for teachers to increase student learning … It raises the students' learning by developing the teachers'. The numeracy coach also initiated a maths day, which was originally designed to bring parents into the school to familiarise them with mathematics and to let them experience how it could be fun. During the event, they experienced mathematics activity rotations, mathematics trails, relay races and number lines of the relay. Over the years, this event has developed and now each teacher organises an activity whereas when it started the numeracy coach initiated most of the activities.

This concept has infiltrated through to all areas of the curriculum, and the school now also runs a science day and a literacy day.

> The key focus of the school is on students gaining an understanding about what they are learning, as well as being challenged by mathematics and 'doing a problem-solving approach'. Mathematics strategies are deliberately and explicitly discussed and students decide which strategies they are going to use. This approach has put control into the hands of students, and they are now having 'a lot more conversations in mathematics'.

Whether there was a coach or not, every *case study school* (52/52, 100%) had a numeracy leader who had input at the school policy making level, and who had carriage of improving the school's mathematics program and outcomes.

6.4   Students' thinking about mathematics in their schools

Where students were interviewed in the *case study school* focus groups, nearly all of them (33/40, 83%) reported that they liked mathematics. In the seven schools where students were not explicit about liking mathematics, it was more that they were equivocal—they enjoyed some aspects of mathematics, but did not like others. In particular students enjoyed the challenge of mathematics:

I like complicated stuff to stretch my brain a bit.

Primary school student, high ICSEA School

I do love maths quite a lot because I have improved in it since I came here in year 4. One reason I love it is because it's fun. It just depends on how you look at it.

Secondary school student, high ICSEA F–12 School

My brain works well in maths.

Secondary school student, low ICSEA F–10 school

It shows that you can work things out.

Secondary school student, low ICSEA F–10 school

The students in *case study school* focus groups varied in their approach when presented with a non-routine problem by the project team—for example, how many squares on a chessboard? This problem was chosen by the project team because although not difficult in itself, there are many ways of approaching the problem, so that it is accessible to primary and secondary school students. Students' responses to the chessboard task varied based on their school. All students appeared to be happy to attempt the task, even when they said that they had not encountered a problem of this type before, suggesting that they were confident to tackle new problems. It was clear some students had been exposed to problem solving strategies, such as 'make a list', as these were called upon in planning an approach to solving the chessboard task. Some students simply took the task at face value and said '64 squares' and even when prompted could not go forward, indicating a fairly fixed view of mathematics. Some began to see that they could count 2 x 2, 3 x 3 and so on, but then disengaged as it seemed like too much work, suggesting that they had had limited exposure to extended problems. Others were keen to finish the task and, where time constraints prevented them from finishing the task, took it back to class.

The different reactions by students to the chessboard task indicate a variety of approaches to mathematics in classrooms. In particular, the idea that mathematics problems have to be solved quickly is a limiting one. It appears that even in schools that are successful in improving mathematics performance based on NAPLAN, not all of the students are being exposed to extended open-ended tasks or inquiry and problem-solving approaches.

In *case study schools* where the data were available, teacher enthusiasm was widely reported by students in the focus groups (36/40, 90%) and sometimes by principals and teachers. Principals, teachers and students all recognised enthusiasm for mathematics and its teaching was important.

The first four sections of this chapter present findings informed by this study. The first section (section 7.1) details three key findings for consideration that could make a lasting, system wide difference. The next three sections (sections 7.2–7.4) provide additional findings at the system, school and classroom levels.

No single *case study school* had every element of every relevant finding in place, but all were actively working to cover key aspects of mathematics. Educators and policymakers should consider the findings holistically, but acknowledge that school and classroom level practices need to be contextualised.

7.1   Key findings

7.1.1   Key finding 1

Schools where mathematics leaders were involved in school policy development and supported by senior leadership had teaching and learning cultures that improved student outcomes.

All *case study schools* had a leader of mathematics who had input into school policy decisions and received support from senior leadership who understood and valued mathematics. This value was reflected by the amount of formal in-school professional development (73% of *case study schools*) and the prevalence of in-school professional development groups (94% of *case study school*s). It is important that principals understand how they can build a culture that improves students' mathematics outcomes (see section 6.2).

Next steps

There is currently a *Principals as Literacy Leaders* programme, which was developed in 2009, and has been widely successful in different jurisdictions and education systems. A *Principals as Leaders of Mathematics* program could follow a similar model. Western Australia piloted a Principals as Numeracy Leaders project in 2012, and has received positive feedback.

7.1.2   Key finding 2

Data can be used to monitor and improve student outcomes and progress in mathematics. Sharing best practice models for using data would benefit all schools.

In 87% of *case study schools* data were used to monitor student progress and change teaching practices (see section 6.2.4). If data can be used to improve student outcomes, then teachers should have access to best practice examples of how to analyse it, and how to use it. Examples are important, because teachers might not have the statistical literacy to interpret relevant datasets (see section 2.2.3.6). Additionally, a recent Grattan Institute report (Goss, Hunter, Romanes, & Parsonage, 2015) suggested that many schools weren't 'collecting the right information at the right time and using it effectively' (see section 2.1). Desktop research indicated that there is little support for teachers to develop skills in collecting and analysing mathematics data from the classroom,

drawing inferences from these data and developing effective teaching programs to develop students' mathematical proficiencies (see section 4.1.4).

The *Dimensions* online portal for mathematics teachers, which is scheduled to go public in 2017, will include evidence based resources and professional development programs. The portal is partly funded by the Australian Government Department of Education, and led by the Australian Association of Mathematics Teachers (AAMT). Resources for data-use could be developed as part of *Dimensions*.

7.1.3   Key finding 3

Across jurisdictions there is duplication and inefficiencies in the development of resources to assist teachers, with varying levels of quality and evaluation.

A 2015 report from the Australian Academy of Sciences (Stacey, Vincent, Stephens, & Holton, 2015) highlighted that teachers lack the time and knowledge to find and evaluate resources; and that planning a coherent program from the wide range of existing resources is difficult and time consuming (see section 2.1). The desktop review revealed that there is duplication across jurisdictions in the nature and type of resources that are developed for teachers. For example, New South Wales has published a *Numeracy Skills Framework,* and Queensland is in the process of developing something similar, drawing on the same research background to a large extent (see section 4.1.2). Duplication is inefficient and avoidable, and points to a need for closer inter-jurisdictional collaboration. While a number of resources were reportedly used in schools (see section 6.2.6), neither the case studies, nor the surveys uncovered particular resources that were associated with *successful schools*.

The quality of mathematics education research in Australia is recognised worldwide. Within the nation, however, it appears to have limited influence on policy and practice. Where research and resources have been developed within a particular state it appears to remain there, even when it is disseminated across the nation. For example, New South Wales has a focus on *Count Me In*, Victoria uses the *Early Years Numeracy Project*, and Western Australia has *First Steps* (see section 4.1.3). Each of these projects and programs has a sound research basis and deserves to be disseminated more generally.

It is important to acknowledge the rights of different states and systems to maintain their own approaches and develop their own resources. However, fragmentation has limitations and means that valuable resources may not be as well used as they might, considering the time, effort, and money that has gone into their development. It would be sensible for education systems to share ideas and resources, and clarify approaches, but this will require formal processes. A national plan and communication between education systems could help to increase efficiency and deliver quality information to teachers nationwide.

Dissemination of mathematics teaching research, resources and programs could be built into *Dimensions* (an online portal for mathematics teachers, which is scheduled to go public in 2017). A national programme for communication between education systems could be implemented through

the Australian Government Department of Education and Training. These findings could be implemented as a part of the National STEM School Education Strategy from the Education Council (Education Council, 2015) which highlights 'increasing teacher capacity and STEM teaching quality' as one of Australia's five key areas for action (p. 6).

7.2 Key findings for systems-level policymakers

7.2.1 Key finding for policymakers 1

There is no nationally consistent approach to the implementation of the mathematics curriculum, and the A to E reporting system often does not adequately support and reflect student learning.

The implementation of the Australian mathematics curriculum (AC-M) is inconsistent across jurisdictions (see section 4.1). This is unlikely to change in the foreseeable future because of the constitutional arrangements for education. In some systems, numeracy appears to have become a de facto replacement for mathematics (see section 4.1). Although numeracy is a powerful and important idea and support for numeracy should be continued, it should not replace mathematics. Although further investigation is required, it is possible that curriculum delivery is unbalanced, with 61% of observed lessons focusing on the Number and Algebra strand of the curriculum (see section 6.3.2). Australia needs a strategic and focussed approach that takes a long-term view of the skills that a well-rounded mathematics education provides. A starting point could be the *Decadal Plan for Mathematics* (Australian Academy of Science, 2016).

The A to E reporting system—in use as a national requirement—has subtly different interpretations in each jurisdiction. Additionally, there is some evidence that teachers appear reluctant to use the full scale, especially the 'failing' grades (see sections 5.1.1.9 and 6.2.7). Some teachers from *case study schools* suggested that the A to E reporting system does not support students' mathematics learning. In addition, several schools that used the International Baccalaureate curriculum indicated that although they reported on an A to E scale, it did not fit with their philosophy and focus (see school vignette 1 for an example).

As with curriculum implementation, it is important that the reporting system is designed to maximise student benefit. To facilitate this, curriculum leaders and mathematics coordinators from each education system should discuss the best approaches to deliver the AC-M.

7.2.2 Key finding for policymakers 2

Evidence-based professional development tailored to the teaching and pedagogy of mathematics leads to better student outcomes.

Mathematics, as with other learning areas, has specific teaching and learning demands and these should be acknowledged in programs designed to improve mathematics outcomes (see section 4.1.2). It should not be assumed that what works in, for example, literacy learning, will be equally effective in mathematics learning. Research indicates that it is particularly important for teachers in the lower secondary years to be able to access quality professional development in mathematics because in these years students move into algebraic thinking that provides the foundation for later mathematics learning (e.g., Siemon, Breed, & Virgona, 2010). Professional development programs

for these years of schooling should have a sound research base that promotes practices that can be used in the context of secondary school classrooms (see sections 5.1.1.1 and 5.1.1.5).

Schools can use existing web based materials for example, the STEMCrAft Project (University of Tasmania, 2015) to evaluate programs and resources. The TEMPEST (Towards Educating Mathematics Professionals Encompassing Science and Technology) project (University of Tasmania, 2016) is also in the process of developing similar materials to evaluate professional learning, and some of these materials will focus on school-based professional learning. These materials will be made available through AAMT's *Dimensions* portal.

Professional development packages should not only address teachers' mathematical and pedagogical content knowledge, but also their attitudes and beliefs. Teachers' enthusiasm for teaching mathematics emerged as a key factor in student engagement (see section 5.1.4). Teachers who were enthusiastic about teaching mathematics were more likely to create mastery learning environments where the focus was on developing understanding. Negative attitudes to mathematics and its teaching must be addressed directly.

7.2.3   Key finding for policymakers 3

Teachers of upper primary and lower secondary years undertake the lowest levels of professional development and may benefit from numeracy and/or mathematics coaches.

Many education systems employ numeracy/mathematics coaches. While these individuals usually have some knowledge of general pedagogical approaches, they often don't have specific expertise in mathematics or numeracy (see section 4.1.2). Although numeracy and mathematics pedagogical content knowledge is included in some coaches' training programs, the time allocated is, of necessity, limited. If a mathematics coach is knowledgeable, and spends sufficient time in a school, the effects can be transformational (see school vignette 17 for an example).

Given the evidence that primary students are beginning to disconnect from mathematics as they move through the school (see section 5.1.4.1), Australia needs solid approaches to teaching middle-school mathematics that will engage students. It is important that students remain engaged as they progress into senior school, however, year 9–10 appears to be the age bracket for which teachers undertake the least amount of professional development (see section 5.1.1.5). Coaches with the relevant mathematical and pedagogical content knowledge could provide useful support for teachers in these classes, particularly those who lack relevant mathematical knowledge.

In addition to addressing mathematics specific pedagogical and content knowledge, programs for coaches also need to consider attitudes and beliefs about mathematics, and ways in which these can be addressed. The finding that teachers' enthusiasm for teaching mathematics is a key factor has implications for professional development programs (see section 5.1.4). Program leaders, such as coaches, need this enthusiasm, as well as Principals and teachers.

This finding aligns with the National STEM School Education Strategy's recommendation to 'support schools to access specialist teachers in mathematics, science and technology' (Education Council, 2015).

7.3   Key findings for school leaders

7.3.1   Key finding for school leaders 1

Student outcomes were improved in schools with staff members who had responsibility for mathematics and school level policy making input.

In every *case study school*, mathematics was led by a member of staff sufficiently senior to be able to have input at the policy level of the school, and to advocate for mathematics (see section 6.2.1). One or two good teachers were not what made the difference in *case study schools*. The culture was created by quality leadership from the principal and numeracy or mathematics leaders who were passionate about mathematics, and teaching mathematics well (see school vignette 17 for an example). Policies and processes to support mathematics teaching were deliberately and carefully built up in the school over time; for this to happen a senior staff member was needed. In a secondary school this person was often an appropriately qualified head of mathematics; in primary schools a curriculum leader or deputy principal took the role. The key aspect was the mathematics leader's focus on quality mathematics teaching, sharing good teaching practices in mathematics, and what the school needed to do to support this development (see section 6.2.1). Without policy influence in a school, it is difficult for a mathematics leader to successfully champion a positive, school-wide mathematics teaching culture.

7.3.2   Key finding for school leaders 2

Schools with a culture of in-house, discipline specific professional development create collegial and non-judgemental environments for both teachers and students.

Case study schools consistently had a culture of in-house professional development for their staff. One avenue for staff development was through professional development communities or similar teacher groups, which were observed in 94% of *case study schools*. Although some professional development communities had a general focus on all subjects, mathematics was addressed explicitly during sessions. The professional development groups held formal meetings, which were sometimes led by numeracy coaches, mathematics leaders, or senior teachers. Formal, in-school professional development for mathematics teachers was reported in 73% of *case study schools*. The requirement for ongoing in-school professional development is supported by the literature (see section 2.2.2.6).

Discussion with 10 different professional development providers indicated that school based professional development is common, so it may be happening in *other schools*, as well as *successful schools*. According to the professional development providers, where external professional development is accessed a typical arrangement is for one or two teachers to attend out-of-school sessions and then share their experiences with all appropriate staff. Principals and professional development providers indicated that this approach can work well, but only if there is sufficient time allocated for the new ideas to be shared and developed. In *successful schools*, this time was available through learning groups.

A standout feature of the *case study schools* was that professional development efforts were genuine, and not tokenistic. Teachers worked hard at improving, and did so willingly and with enjoyment. Processes were in place to support professional learning. For example, time was

allocated, sometimes through timetable arrangements or in staff meetings, with an expectation that staff would engage in professional discourse. 'Creating time for teachers to pursue effective professional learning' was a policy reform identified in a recent National Center on Education and the Economy (NCEE) report (see section 2.2.1).

7.3.3   Key finding for school leaders 3

Targeted, data-driven approaches for planning and delivering mathematics learning and teaching leads to improved student outcomes.

Data can effectively improve students' achievement by helping to refine and target teaching approaches (see section 2.2.3.6). The majority of *case study schools* (87%) used data to understand the progress of individual students, classes or the school as a whole (see section 6.2.4). Different schools used various datasets (e.g. NAPLAN, school-based assessments), for a range of purposes. For example, some schools used NAPLAN data at the item level to identify commonly misunderstood concepts within a cohort, while others used it to inform whole-of-school programming, or to set goals.

Data can also be used to group and regroup students for learning. In *case study schools*, a majority (56%) reported some use of flexible grouping based on both quantitative and qualitative data. These data included formal assessment data such as PAT-M (ACER) and teacher assessments, as well as teacher knowledge of the individual students. These groups aimed to identify the learning needs in mathematics of every student, and to meet these needs (see sections 6.3.2 and 6.3.3).

This finding would be directly supported by and complementary to Key Finding 1. It is important that data use isn't a box ticking exercise: schools should use data strategically.

7.4   Key findings for classroom teachers of mathematics

7.4.1   Key finding for classroom teachers 1

Mathematics taught with enthusiasm, and classrooms focussed on the deep understanding of mathematical concepts and ideas leads to increased student engagement.

For both older and younger students, teachers' enthusiasm for teaching mathematics was associated with a mastery environment, which focussed on developing students' deep understanding of the mathematical ideas, rather than on procedural fluency. For younger students, a mastery environment was associated with students' emotional, and cognitive interest (see section 5.1.4.1). For older students, teacher enthusiasm for teaching mathematics was significantly correlated with reduced costs on the student, including emotional and psychological costs (see section 5.1.2.3). Latent class analysis revealed three subgroups of students within *successful schools* (*engaged, compliant, and disengaged*). *Engaged* students were most likely to perceive a mastery environment and high teacher enthusiasm. *Disengaged* students were least likely to perceive their classrooms as mastery oriented (see section 5.1.4.2), and perceived less teacher enthusiasm. Students with a *compliant* profile fell between these other two groups.

In addition, 87% of the *case study schools* had a focus on developing understanding in the mathematics classroom rather than on simply developing procedural fluency (see section 6.3.1). Furthermore, in 90% of schools where student focus groups were undertaken, students reported that their teacher was enthusiastic about mathematics and its teaching.

7.4.2   Key finding for classroom teachers 2

Students develop better understanding when provided with the opportunity to talk about their mathematics, and to articulate their mathematical thinking and solution strategies.

Students explaining their thinking is recognised as an important factor in mathematics learning, both in the research literature (see section 2.2.1) and by teachers who participated in the survey and case studies. Factor analysis of teachers' perceptions of teaching approaches that led to both mathematics engagement and mathematics achievement identified student talk as a key component (see section 5.1.2.1) in both *successful* and *other schools*. Although there was no statistically significant difference between the two groups of schools, students and teachers from *case study schools* appreciated that by explaining mathematics to someone else and sharing other students' approaches they developed better understanding of mathematics (section 6.3.2). A starting point could be a short 'plenary' session at the end of every class in which students share what they have learned during the lesson (see section 6.3 and associated school vignettes). Talking about mathematics is one important step towards the 'cognitive activation' strategies described by Schleicher (2016) as associated with success in mathematics.

7.5   Limitations of the study

The study was not designed as a 'scientific' study but rather aimed to provide rich information about the practices in schools identified as being successful in mathematics. As such the study was limited in several ways. Samples for both the surveys and the case studies were targeted rather than random, and limited to those who were willing and available to participate. Case study research in particular is not sample research but is designed to uncover detailed information about cases identified using a specific set of criteria.

The survey and case study process took a cross-sectional approach at one point in time (Term 4, 2015). There was no longitudinal tracking of schools across time, which might have provided better information about how schools embed the processes they use into the school culture. Future studies that tracked schools across a school year to identify practices and processes over time would be useful.

Although some comparison schools participated in the survey, there were no comparison schools for the case studies. As such, although every researcher involved could provide anecdotal information about the practices in the *case study schools*, and had stories about schools that were both not successful and using practices very different to those of the *case study schools*, there was no direct evidence. Hence inferences are limited about causes of success.

The timing of the study (Term 4) was not conducive to schools' participation. Teachers and students are generally tired at this time, and looking towards the end of the school year. Further studies should be organised so that data collection is undertaken in Term 1 as far as possible, or sometime shortly after NAPLAN testing.

7.6   Suggestions for future work

The lack of genuine mathematical inquiry and investigations was surprising. Only 40% (21/52) of *case study schools* emphasised inquiry in their classrooms (see Table 6.2:3). Developing conceptual understanding of mathematics is important, but using this understanding creatively to investigate mathematical and real world situations is critical for future development. Where mathematical inquiry was observed, it was supported by clear and explicit strategies that students could use when they had difficulties. There was a sense, however, that the practices in *successful schools*, although of good quality, were to some extent self-limiting in that they tended to have a strong focus on either curriculum achievement at very high levels, or encouraging students to enjoy and appreciate mathematics, through the use of community links and practical activities. These differences are explored in several of the vignettes in Chapter 6. The schools that had a focus on high curriculum achievement might benefit from incorporating some of the inquiry approaches adopted by schools that had a different set of values, including encouraging students to be independent learners who value education. Similarly, many of those schools undertaking practical investigations might benefit from the strong focus on pure mathematical ideas for their own sake observed in some *successful schools*. Students deserve to experience both pure mathematics in all its beauty and elegance, and the powerful uses of mathematics in modelling and solving real world problems.

Many students in the *successful schools* were compliant in mathematics classes, and were not emotionally or cognitively engaged with mathematics. This finding indicates that even in *successful schools* there is room for improvement. The identification of a group of students with a compliant profile of engagement is new and potentially important. Programs designed for disengaged students may not be suitable for compliant students, but if this group does not become emotionally and cognitively engaged with mathematics then it seems unlikely that the trend away from higher levels of mathematics will be reversed. A research agenda is needed to address this issue.

This study only considered schools deemed successful in NAPLAN, using the criterion of growth of + 1 *SD* above the average. A study examining the practices of schools that are well below the average growth would provide a useful comparison. This study should be undertaken in a spirit of improvement by both mapping the current practices in these schools, and then suggesting potentially fruitful interventions.

A further suggestion for future work is to consider whether school and teacher autonomy plays a part in success. For example, there was evidence that schools preferred to employ qualified mathematics teachers, but where schools have no autonomy to choose their staff this may become impossible. The schools in this study were part of almost every state and territory, and from almost all systems with those jurisdictions. Although outside the scope of this study, there were indications of differing levels of autonomy across schools and systems.

This report has presented the findings from a complex study providing a snapshot of practices in Mathematics in *successful schools*. From this report, a series of papers should be developed for different audiences. These should target the three spheres of influence: systems, schools, and classrooms. In addition, there is potentially useful information for professional development providers, curriculum developers, teacher educators, and education consultants. Work such as this could include brief summary papers or one page memos addressing specific aspects of the findings.

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Appendix A

A1. Websites considered for the desktop review

Note: Websites change frequently and some of these may have moved since this study was completed.

System	Home page	Useful URL
TASMANIA		
Department of Education	https://www.education.tas.gov.au/Pages/default.aspx	http://www.education.tas.gov.au/parents_carers/schools-colleges/Programs-Initiatives/Pages/Literacy-and-Numeracy.aspx
		http://www.scootle.edu.au/ec/viewing/S7080/pdf/tls71_raising_the_bar.pdf
Catholic	http://catholic.tas.edu.au/	http://catholic.tas.edu.au/our-schools/curriculum/numeracy-strategy
Independent	http://www.independentschools.tas.edu.au/	
VICTORIA		
Department of Education and Training	http://www.education.vic.gov.au/school/teachers/teachingresources/discipline/maths/Pages/default.aspx	http://www.education.vic.gov.au/school/teachers/teachingresources/discipline/maths/Pages/support.aspx
		http://www.education.vic.gov.au/school/teachers/teachingresources/discipline/maths/continuum/Pages/mathcontin.aspx
		http://www.education.vic.gov.au/school/teachers/teachingresources/discipline/maths/assessment/Pages/mathsassess.aspx
Catholic Victoria	http://www.cecv.catholic.edu.au/	
Catholic Melbourne	http://www.ceomelb.catholic.edu.au/	http://www.ceomelb.catholic.edu.au/learning-teaching/mathematics/vision-for-mathematics/
		http://www.ceomelb.catholic.edu.au/learning-teaching/mathematics/mathematics-projects/
Catholic Ballarat		http://www.ceoballarat.catholic.edu.au/media/uploads/prof_learning_2016/learningteaching/EssentialLearnMaths.pdf
Victorian Curriculum and Assessment Authority	http://www.vcaa.vic.edu.au/	http://ausvels.vcaa.vic.edu.au/
		http://victoriancurriculum.vcaa.vic.edu.au/
NEW SOUTH WALES		
Department of Education and Communities	http://www.dec.nsw.gov.au/	http://www.curriculumsupport.education.nsw.gov.au/policies/numeracy/

		http://www.curriculumsupport.education.nsw.gov.au/primary/mathematics/numeracy/
		http://www.curriculumsupport.education.nsw.gov.au/secondary/mathematics/numeracy/
		http://www.curriculumsupport.education.nsw.gov.au/digital_rev/mathematics/index.htm
		http://www.schools.nsw.edu.au/learning/7-12assessments/naplan/teachstrategies/yr2008/numeracy/NN_Over.htm
		http://www.schools.nsw.edu.au/learning/7-12assessments/naplan/teachstrategies/yr2011/index.php
		http://www.dec.nsw.gov.au/documents/15060385/15385042/implementation2014.pdf
		http://www.schools.nsw.edu.au/learning/7-12assessments/naplan/teachstrategies/yr2013/index.php?id=numeracy/nn_over
		http://www.schools.nsw.edu.au/learning/7-12assessments/smart/What_is_new_in_SMART_NAPLAN_2014.pdf
		http://www.curriculumsupport.education.nsw.gov.au/beststart/ten/index.htm
		http://www.curriculumsupport.education.nsw.gov.au/beststart/lighthouse/general/index.htm
Catholic (also covers ACT)	http://www.catholicschools.nsw.edu.au/home	
Independent	https://www.aisnsw.edu.au/Pages/default.aspx	https://www.aisnsw.edu.au/Services/Partnerships_in_Education/STEM/Pages/default.aspx
Board of Studies, Teaching and Educational Standards	https://www.boardofstudies.nsw.edu.au/	http://syllabus.bostes.nsw.edu.au/mathematics/mathematics-k10/
QUEENSLAND		
Department of Education and Training	http://education.qld.gov.au/	http://education.qld.gov.au/literacyandnumeracy/
		http://education.qld.gov.au/nationalpartnerships/lit-num-national-partnership.html

		http://education.qld.gov.au/naplan/
		http://education.qld.gov.au/schools/grants/state/core/targeted-invervention-grant.html
		http://www.proportionalreasoning.com/queensland-conference-20131.html http://education.qld.gov.au/projects/educationviews/talking-point/2013/jan/numeracy-250113.html
		http://education.qld.gov.au/projects/educationviews/talking-point/2013/may/maths-090513.html
		http://education.qld.gov.au/community/beam/index.html
		http://education.qld.gov.au/stem/pdfs/stem-brochure.pdf
Catholic	http://www.qcec.catholic.edu.au/	http://www.qcec.catholic.edu.au/queensland-catholic-education-commission/responses-reports-and-submissions
		http://www.qcec.catholic.edu.au/queensland-catholic-education-commission/responses-reports-and-submissions
		http://www.qcec.catholic.edu.au/upload/publicsite/Education/Queensland%20Catholic%20Schools%20and%20Curriculum%20February%202008.pdf
Independent	http://www.isq.qld.edu.au/	http://www.isq.qld.edu.au/lnca
		http://isqcollaborate.ning.com/main/authorization/signUp?target=http%3A%2F%2Fisqcollaborate.ning.com%2F%3Fxgi%3D0En9tAttU0gHJh%253EGroups%253E%2BLNCA%2BGroup%26xgkc%3D1
		http://www.isq.qld.edu.au/files/file/News%20and%20Media/Publications/SISBrochureJan2015.pdf
		http://www.isq.qld.edu.au/using-data-in-schools
Queensland Curriculum and Assessment Authority	https://www.qcaa.qld.edu.au/	https://www.qcaa.qld.edu.au/p-10/aciq/p-10-mathematics
ACT		
Education and Training Directorate	http://www.det.act.gov.au/	http://www.det.act.gov.au/teaching_and_learning/literacy_and_numeracy#n
		http://www.curriculumsupport.education.nsw.gov.au/countmein/
		www.det.act.gov.au/__data/assets/.../Middle_Years_Mental_Computation.doc

Catholic	http://www.catholicschools.nsw.edu.au/home	
Independent	http://ais.act.edu.au/	http://ais.act.edu.au/?s=numeracy
NORTHERN TERRITORY		
Department of Education	http://www.education.nt.gov.au/	http://www.education.nt.gov.au/teachers-educators/literacy-numeracy/evidence-based-literacy-numeracy-practices-framework/principles
		http://www.education.nt.gov.au/teachers-educators/literacy-numeracy/evidence-based-literacy-numeracy-practices-framework
		http://www.education.nt.gov.au/media-releases/media-releases/2012/june/new-resources-to-help-parents-and-families
		http://www.education.nt.gov.au/parents-community/assessment-reporting/diagnostic-assessments/sena-cmit
		http://www.education.nt.gov.au/__data/assets/pdf_file/0011/38369/Northern-Territory-Literacy-and-Numeracy-Panel-Report-2014.pdf
Catholic	http://www.ceont.catholic.edu.au/	http://www.ceont.catholic.edu.au/learning-teaching/student-support/literacy-numeracy
Independent	http://www.aisnt.asn.au/	
WESTERN AUSTRALIA		
Department of Education	http://www.education.wa.edu.au/home/detcms/portal/	http://portal.det.wa.edu.au/portal/page?_pageid=803,886439&_dad=portal&_schema=PORTAL
Catholic	http://internet.ceo.wa.edu.au/Pages/default.aspx	http://internet.ceo.wa.edu.au/ReligiousEducationCurriculum/CurriculumK-12/Pages/Initiatives.aspx
Independent	http://www.ais.wa.edu.au/	
WA School Curriculum and Standards Authority	http://www.scsa.wa.edu.au/	http://k10outline.scsa.wa.edu.au/home/p-10-curriculum/curriculum-browser/mathematics-v8
SOUTH AUSTRALIA		
Department for Education and Child Development	http://www.decd.sa.gov.au/	http://www.decd.sa.gov.au/docs/documents/1/numeracyliteracystrategy.pdf

		http://www.decd.sa.gov.au/portal/aboutdept.asp?group=reports&id=numeracyliteracy
		http://www.decd.sa.gov.au/numeracy/files/links/team_details.pdf
		http://www.decd.sa.gov.au/vocationalpathways/files/links/leadertool_13_v1.pdf
		http://www.decd.sa.gov.au/accountability/a8_publish/modules/publish/content.asp?id=37723&navgrp=3763
		http://www.decd.sa.gov.au/mediacentre/files/pages/linked/numeracyliteracy_initiativ.pdf
		www.decd.sa.gov.au/numeracy/files/links/the_year_8_project.docx
		www.decd.sa.gov.au/mediacentre/files/pages/linked/mike_chartres_all_27_oct.docx
Catholic	http://www.cesa.catholic.edu.au/	http://www.cesa.catholic.edu.au/about/support-we-provide/educational-support-services#2891
		http://www.cesa.catholic.edu.au/our-schools/learning-teaching/assessment-reporting
Independent schools	http://www.ais.sa.edu.au/	http://www.ais.sa.edu.au/teaching-learning/australian-curriculum/support-and-resources#170051
		http://www.ais.sa.edu.au/teaching-learning/australian-curriculum/support-and-resources#170051
		http://www.ais.sa.edu.au/teaching-learning/numeracy

A2. Survey instruments

Survey instruments were mostly taken from existing validated instruments (see details in Chapter 2) and where these were used the original question structure was used to maintain the integrity of the instrument.

Four surveys were used, each of which was tailored to the target group of respondents. In some instances questions were not presented depending on responses to prior questions. Survey questions, target constructs, and response codes are provided here, together with links to the online surveys.

School leaders' survey

A link to the survey can be accessed here: [Best practice leaders' survey](#)

Focus LEADERS	Construct/item	Question
	Name	Create personal ID
Demographics	Name of school	To be removed when School ID assigned
	Sex	MALE=1 FEMALE=2
	DOBDAY	date of birth - day
	DOBMONTH	date of birth - month
	DOBYEAR	date of birth - year
	Time teaching	How long have you worked in schools in total?
	Time as principal/leader	How long have you worked in schools as a leader?
	Time at this school as principal/leader	How long have you worked in this school as a leader?
	Major teaching area	What is your major teaching area? 1 (Generalist), 2 (Sciences), 3 (Mathematics), 4 (English and/or languages), 5 (social sciences), Other (please specify):
	Mathematics qualifications	What formal qualifications do you have in mathematics? 1 (none), 2 (one semester of tertiary level study), 3 (1 year of tertiary level study), 4 (undergraduate major), Other (please specify)
	Education qualifications	What qualifications do you have in teaching and/or education, please tick all that apply? 1 (certificate in education) 2 (diploma in education), 3 (bachelor in education), 4 (master in education), 5 (doctorate in education).
School level factors	School population	How many students are currently enrolled in this school?
	Number of teachers	How many teachers are currently employed in this school (including part-time, but not casual)?
For secondary only	Number of maths teachers	How many teachers in this school currently teach mathematics?
For secondary only	Number of out-of-field teachers	How many teachers currently teaching mathematics classes do not have tertiary qualifications (a major) in mathematics?
Time spent in maths	Lessons/week teaching maths	How many hours per week are scheduled for the teaching of mathematics in: (a) Year 3 (b) Year 4 (c) Year 5 (d) Year 6 OR (a) Year 7 (b) Year 8 (c) Year 9 (c) Year 10
	Staff turnover	How many teachers left this school in: (a) 2012 (b) 2013 (c) 2014
		How many teachers joined the school in: (a) 2012 (b) 2013 (c) 2014.
	Collective efficacy	Teachers in this school are able to get through to difficult students.1 (strongly disagree) to 5 (strongly agree).

		Teachers here are confident they will be able to motivate their students
		Teachers in this school really believe every child can learn.
		If a child doesn't want to learn teachers here give up.
		Teachers here don't have the skills needed to produce meaningful student learning
		These students come to school ready to learn.
		Homelife provides so many advantages the students here are bound to learn.
		Students here just aren't motivated to learn.
		The opportunities in this community help ensure that these students will learn.
		Learning is more difficult at this school because students are worried about their safety.
		Drug and alcohol abuse in the community make learning difficult for students here.
		teachers in this school do not have the skills to deal with student disciplinary problems.
	School climate (PISA)	**In your school, to what extent is the learning of students hindered by the following?** **1 (not at all) to 4 (a lot).**
		Student truancy.
		Students skipping classes
		Students arriving late for school
		Students not attending compulsory school events (e.g. School assemblies) or excursions
		Students lacking respect for teachers
		Disruption of classes by students
		Student use of alcohol or illegal drugs
		Students intimidating or bullying other students
		Students not being encouraged to achieve their full potential
		Poor student-teacher relations
		Teachers having to teach students of heterogeneous ability levels within the same class
		Teachers having to teach students of diverse ethnic backgrounds (i.e. language, culture) within the same class
		Teachers' low expectations of students
		Teachers not meeting individual students' needs
		Teacher absenteeism
		Staff resisting change
		Teachers being too strict with students

		Teachers being late for class
		Teachers not being well prepared for classes
	NAPLAN	In this school, the implementation of NAPLAN has… 1 (strongly disagree) to 5 (strongly agree)
		...improved whole school coordination in numeracy.
		...led to increased opportunities for collaboration and sharing of resources.
		...supported teacher and school assessments.
		...helped students get better at test-taking practices.
		...helped promote desirable student attributes such as planning, goal setting and engagement, through preparing for NAPLAN tests.
		...allowed for better monitoring of student progress over time.
		…had a negative impact on learning through a narrow focus.
		…negatively impacted student learning through lack of relevance.
		…been disconnected from the mathematics that students do in my class.
		...increased the stress and pressure on students.
		...increased the stress and pressure on teachers.
		...led to a greater prevalence of 'teaching to the test'.
		…interfered with a balanced and effective curriculum.
Curriculum leadership	ACM documentation	Is there a school level document that is derived from the Australian Curriculum Mathematics? (e.g. Mathematics program that reflects the curriculum). Yes/No
	Homework	How many hours per week are students required to do maths homework in: (a) Year 3 (b) Year 4 (c) Year 5 OR (a) Year 7 (b) Year 8 (c) Year 9: 1 (none), 2 (less than 2 hours), 3 (More than 2 hours but less than 5 hours), 4 (more than 5 hours but less than 10 hours), 5 (more than 10 hours), 6 (Don't know).
Optimal mathematics teacher practices	Student engagement	From the list below, rate how much you believe each contributes to increased student **engagement** in mathematics (1=not at all, 7=extremely)
		a) Playing maths games (including computer games)
		b) Teacher giving clear explanations
		c) Students explaining their own thinking (either verbally or written)
		d) Students listening to and questioning other students' thinking

		e) Students have opportunities to work in groups
		f) Positive reinforcement (smiles, encouraging words)
		g) Opportunity for students to work by themselves
		h) Working on tasks students see as challenging
		i) Using concrete materials and manipulatives
		j) Practising skills they have already been taught
		k) Extrinsic rewards (lollies, less homework)
		l) Students working with others of different levels of achievement
		m) Students working with others of similar levels of achievement
		n) Students working with digital technologies (e.g. computer, iPads, internet IWB)
		o) Students using calculators
		p) Students know the purpose and intent of the lesson
		q) Students choosing their own strategy for solving the task
		r) Having tasks that are set in contexts relevant to their lives
		s) Students learning rules and procedures.
Optimal mathematics teacher practices	Student achievement	From the list below, rate how much you believe each contributes to increased student **achievement** in mathematics (1=not at all, 7=extremely)
		a) Playing maths games (including computer games)
		b) Teacher giving clear explanations
		c) Students explaining their own thinking (either verbally or written)
		d) Students listening to and questioning other students' thinking
		e) Students have opportunities to work in groups
		f) Positive reinforcement (smiles, encouraging words)
		g) Opportunity for students to work by themselves
		h) Working on tasks students see as challenging
		i) Using concrete materials and manipulatives
		j) Practising skills they have already been taught
		k) Extrinsic rewards (lollies, less homework)

		l) Students working with others of different levels of achievement
		m) Students working with others of similar levels of achievement
		n) Students working with digital technologies (e.g. computer, iPads, internet IWB)
		o) Students using calculators
		p) Students know the purpose and intent of the lesson
		q) Students choosing their own strategy for solving the task
		r) Having tasks that are set in contexts relevant to their lives
		s) Students learning rules and procedures.
Individual level factors	Hours worked/week	Approximately how many hours per week do you work on school related matters?
		Approximately how many hours per week do spend teaching?
Health and well-being	Hours worked/weekend	Approximately how many hours do you work (on school related matters) over the weekend?
	Emotional exhaustion	I feel emotionally drained from my work . 1 (strongly disagree) to 5 (strongly agree)
		I feel used up at the end of the workday
		I feel fatigued when I get up in the morning and have to face another day on the job
		Working with people all day is really a strain for me
		I feel burned out from my work
		I feel frustrated by my job
		I feel I'm working too hard on my job
		Working with people directly puts too much stress on me
		I feel like I'm at the end of my rope
	Depersonalisation	I feel I treat some students as if they were impersonal 'objects'
		I've become more callous toward people since I took this job
		I worry that this job is hardening me emotionally
		I don't really care what happens to some students
		I feel students blame me for some of their problems
Teacher mind-set	Incremental	You have a certain amount of intelligence and really can't do much to change it. 1 (strongly disagree) to 6 (strongly agree)
	Entity	Your intelligence is something about you that can't change very much.
		You can learn new things but you can't really change your basic intelligence.

Leadership style	Management	Below are statements about your management of this school. Please indicate the frequency of the following activities and behaviours in your school during the 2014 academic year. 1 (did not occur), 2 (1–2 times during the year), 3 (3–4 times during the year), 4 (once a month), 5 (once a week), 6 (more than once a week).
		I worked to enhance the school's reputation in the community. 1
		I used student performance results to develop the school's educational goals.
		I made sure that the professional development activities of teachers were in accordance with the teaching goals of the school.
		I ensured that teachers worked according to the school's educational goals.
		I promoted teaching practices that were based on educational research.
		I praised teachers whose students were actively participating in learning.
		When a teacher had problems in his/her classroom, I took the initiative to discuss matters.
		I drew teachers' attention to the importance of students' development of critical and social capabilities.
		I paid attention to disruptive behavior in classrooms.
		I provided staff with opportunities to participate in school decision making.
		I engaged teachers to help build a school culture of continuous improvement.
		I asked teachers to participate in reviewing management practices.
		When a teacher brought up a classroom problem, we solved the problem together.
		I discussed the school's academic goals with teachers at faculty meetings.
		I referred to the school's academic goals when making curricular decisions with teachers.
		I discussed academic performance results with faculty to identify curricular strengths and weaknesses.
		I led or attended in-service activities concerned with instruction.
		I set aside time at faculty meetings for teachers to share ideas or information from in-service activities.
		I conducted informal observations in classrooms on a regular basis (informal observations are unscheduled, last at least 5 minutes, and may or may not involve written feedback or a formal conference).
		I reviewed work produced by students when evaluating classroom instruction.
		I evaluated the performance of staff.
Leader's perception of schools' goal orientation	Mastery	**In this school: 1 (not at all true) to 5 (very true)**
		The importance of trying hard is really stressed to students.

		Students are told that making mistakes is OK as long as they are learning and improving.
		A lot of the work students do is boring and repetitious.
		Students are frequently told that learning should be fun.
		The emphasis is on really understanding schoolwork, not just memorizing it.
		A real effort is made to recognise students for effort and improvement.
		A real effort is made to show students how the work they do in school is related to their lives outside of school.
	Performance	It's easy to tell which students get the highest grades and which get the lowest grades.
		Students who get good grades are pointed out as an example to others.
		Students hear a lot about the importance of getting high test scores.
		Grades and test scores are not talked about a lot.
		Students hear a lot about the importance of making the honor roll or being recognised at honour assemblies.
		Students are encouraged to compete with each other academically.
Responsibility		**Regarding your school, who has considerable responsibility for the following tasks? (Please check all that apply)** **1 (Principal), 2 (Teachers), 3 (School-level governing board), 4 (Local education agency), 5 (State education agency).**
		Selecting teachers for hire.
		Firing teachers.
		Establishing teachers' starting salaries.
		Determining teachers' salary increases.
		Formulating the school budget.
		Deciding on budget allocations within the school.
		Establishing student assessment policies.
		Approving students for admission to the school.
		Choosing which textbooks are used.
		Determining course content.
		Deciding which courses are offered.
Self-efficacy for leaders		**In your current role as principal, to what extent can you:** **1 (none at all), 3 (very little), 5 (some degree), 7 (quite a bit), 9 (a great deal)**
	Instructional	Motivate teachers.
		Generate enthusiasm for a shared vision for the school.
		Manage change in your school.

		Create a positive learning environment in your school.
		Facilitate student learning in your school.
		Raise student achievement on standardised tests.
	Moral leadership	Promote acceptable behavior among students
		Promote school spirit among a large majority of the student population
		Handle effectively the discipline of students in your school.
		Promote a positive image of your school with the media.
		Promote the prevailing values of the community in your school.
		Promote ethical behavior among school personnel.
Teacher enthusiasm	Teaching enthusiasm	I teach with great enthusiasm.
		I really enjoy teaching.
		I always enjoy teaching students new things.
		I enjoy interacting with students in classes.
		It's a pleasure to teach.
	Identification with school	I like to work in this school. 1 (completely disagree) to 5 (completely agree)
		I have a strong sense of belonging to this school.
		Being a member of this school gives me a sense of pride.
		I enjoy being involved in activities in this school.

Teachers' survey

A link to the survey can be accessed here: [Best practice teachers' survey](#)

Focus TEACHERS	Construct/item	Question
	Name	Create personal ID
Demographics	Name of school	To be removed after School Id assigned
	Sex	male=1 female=2
	DOBDAY	date of birth - day
	DOBMONTH	date of birth - month
	DOBYEAR	date of birth - year
	Years & months teaching	__ Years & __ Months (fill in blank numeric fields)
	Years & months teaching at this school	__ Years & __ Months (fill in blank numeric fields)
	Mathematics qualifications	1. No maths background; 2. One semester of tertiary level maths; 3. One year of tertiary level maths; 4. Undergraduate degree in maths.
	Education qualifications	1. Certificate in Education/Teaching; 2. Diploma in Education/Teaching; 3. Bachelor in Education/Teaching; 4. Master in Education/Teaching
School-level factors		
Time spent teaching	Lessons/week teaching	How many hours per week do you spend teaching?
Time spent teaching maths	Lessons/week teaching maths	How many hours per week do you spend teaching mathematics? none; 0 to 2 hours; 3 to 5 hours; 6 to 8 hours; 9 to 11 hours; 12 to 14 hours; more than 14 hours.
	Hours worked/week	How many hours per week do you spend on teaching and related matters during the week? 0 to 8 hours; 9 to 16 hours; 17 to 24 hours; 25 to 32 hours; 33 to 40 hours; more than 40 hours.
	Hours worked/weekend	How many hours do you typically work (on teaching-related matters) over the weekend? None; 0 to 2 hours; 3 to 4 hours; 5 to 6 hours; 7 to 8 hours; more than 8 hours.
Professional learning	Last maths PD taken	How much structured professional learning about mathematics teaching did you undertake in the last 12 months? 1 (nothing), 2 (a session or two), 3 (about a day), 4 (two or three days); 5 (more than 3 days).
	Impact on teaching	What year levels did it target? 1 (K-3), 2 (4 - 6), 3 (7 - 8), 4 (9 - 10), 5 (11 - 12) 0 (none of them)
		What aspects of your mathematics teaching, if any, did it impact on? 1 (teaching particular content; if so what is it?) 2(assessment practices), 3 (problem-solving), 4 OTHER - PLS SPECIFY____(TEXT)

Teacher perception of schools' goal orientation	Mastery	**In this school:** **1 (not at all true) to 5 (very true)**
		The importance of trying hard is really stressed to students.
		Students are told that making mistakes is OK as long as they are learning and improving.
		A lot of the work students do is boring and repetitious.
		Students are frequently told that learning should be fun.
		The emphasis is on really understanding schoolwork, not just memorising it.
		A real effort is made to recognise students for effort and improvement.
		A real effort is made to show students how the work they do in school is related to their lives outside of school.
	Performance	It's easy to tell which students get the highest grades and which get the lowest grades.
		Students who get good grades are pointed out as an example to others.
		Students hear a lot about the importance of getting high test scores.
		Grades and test scores are not talked about a lot.
		Students hear a lot about the importance of making the honour roll or being recognised at honour assemblies.
		Students are encouraged to compete with each other academically.
	Communication with parents	In the last four weeks have you contacted any parents regarding their child? Yes/No
		If yes, approximately how many times (in total) did this occur?
		In the last four weeks have you contacted any parents regarding the mathematical progress of their child? Yes/No
		If yes, approximately how many times (in total) did this occur?
School climate	Collective efficacy	Teachers in this school are able to get through to difficult students.1 (strongly disagree) to 5 (strongly agree).
		Teachers here are confident they will be able to motivate their students
		Teachers in this school really believe every child can learn.
		If a child doesn't want to learn teachers here give up.
		Teachers here don't have the skills needed to produce meaningful student learning
		These students come to school ready to learn.
		Home life provides so many advantages the students here are bound to learn.
		Students here just aren't motivated to learn.
		The opportunities in this community help ensure that these students will learn.
		Learning is more difficult at this school because students are worried about their safety.

		Drug and alcohol abuse in the community make learning difficult for students here.
		Teachers in this school do not have the skills to deal with student disciplinary problems.
	Professional interactions	1. Teachers in this school can rely on their colleagues for support and assistance when needed . 1 (strongly disagree) to 5 (strongly agree).
		2. Teachers frequently discuss and share teaching methods and strategies with each other.
		3. I receive support from my colleagues.
		4. Teachers consult with each other about their teaching and curriculum.
	Supportive leadership	1. There is support from the administration in this school . 1 (strongly disagree) to 5 (strongly agree).
		2. There is good communication between teachers and the administration in this school.
		3. The administration in this school can be relied upon when things get tough.
		4. I am able to approach the administration in this school to discuss concerns or grievances.
		5. The school's administrators don't really know the problems faced by teachers.
Influence of NAPLAN		In this school, the implementation of NAPLAN has… 1 (strongly disagree) to 5 (strongly agree)
		...improved whole school coordination in numeracy.
		...led to increased opportunities for collaboration and sharing of resources.
		...supported teacher and school assessments.
		...helped students get better at test-taking practices.
		...helped promote desirable student attributes such as planning, goal setting and engagement, through preparing for NAPLAN tests.
		...allowed for better monitoring of student progress over time.
		…had a negative impact on learning through a narrow focus.
		…negatively impacted student learning through lack of relevance.
		…been disconnected from the mathematics that students do in my class.
		...increased the stress and pressure on students.
		...increased the stress and pressure on teachers.
		...led to a greater prevalence of 'teaching to the test'.
		…interfered with a balanced and effective curriculum.
Teacher-level factors		
	Performance pressure	The principal assesses teachers mainly by their students' performance. 1- 6 (strongly disagree, strongly agree)

		The principal puts pressure on teachers to achieve high student grades.
		The principal creates a climate of pressure and criticism.
		The principal often compares our achievements to those of other schools.
Burnout Emotional exhaustion		1 (strongly disagree) to 5 (strongly agree)
	Secondary Teachers Only	I feel emotionally drained from my work.
	Secondary Teachers Only	I feel used up at the end of the workday
	Secondary Teachers Only	I feel fatigued when I get up in the morning and have to face another day on the job
		Working with people all day is really a strain for me
	Secondary Teachers Only	I feel burned out from my work
		I feel frustrated by my job
		I feel I'm working too hard on my job
		Working with people directly puts too much stress on me
	Secondary Teachers Only	I feel like I'm at the end of my rope
Depersonalisation		I feel I treat some students as if they were impersonal 'objects'
	Secondary Teachers Only	I worry that this job is hardening me emotionally
		I don't really care what happens to some students
		I feel students blame me for some of their problems
Work satisfaction		I look forward to coming to work
		I enjoy the challenges I meet at work
		Work is satisfying for me
		I feel the students learn because of my leadership
		I want all students to learn
Homework	Frequency expected	How often do you expect your students to do homework? 0 (never), 1 (rarely), 2 (Only when it is necessary), 3 (every week night)
	Hours per week	How many hours of homework per week do you expect students to do? 1 (none), 2 (less than 2 hours), 3 (More than 2 hours but less than 5 hours), 4 (more than 5 hours but less than 10 hours), 5 (more than 10 hours), 6 (Don't know).

	Reason HW set	Why do you set homework? 1 (it is school policy) 2 (parents expect it to be set), 3 (because I believe it helps them learn), 4 (other): Pls specify___(text)
		In regards to the Australian Curriculum Mathematics (ACM), how knowledgeable are you about its:
Knowledge of ACM	Content descriptors	....content descriptors? 1 (not at all knowledgeable), 5 (very knowledgeable)
	Proficiency strands	...proficiency strands? 1 (not at all knowledgeable), 5 (very knowledgeable)
	Assessment	...assessment requirements? 1 (not at all knowledgeable), 5 (very knowledgeable)
Impact of ACM		To what exent is the planning of your maths lessons influenced by the ACM's… 1 (not at all) to 5 (very much).
Impact of ACM	Content descriptors	...content descriptors? 1 (not at all) to 5 (very much).
	Proficiency strands	...proficiency strands? 1 (not at all) to 5 (very much).
	Assessment	...assessment requirements? 1 (not at all) to 5 (very much).
Approaches to instruction	Mastery	I make a special effort to recognise students' individual progress, even if they are below grade level.1 (not at all true) to 5 (very true)
		During class, I often provide several activities so that students can choose among them.(not at all true) to 5 (very true)
		I consider how much students have improved when I give them report card grades.(not at all true) to 5 (very true)
		I give a wide range of assignments, matched to students' needs and skill level.(not at all true) to 5 (very true)
	Performance	I give special privileges to students who do the best work.(not at all true) to 5 (very true)
		I display the work of the highest achieving students as an example.(not at all true) to 5 (very true)
		I help students understand how their performance compares to others.(not at all true) to 5 (very true)
		I encourage students to compete with each other.(not at all true) to 5 (very true)
		I point out those students who do well as a model for the other students.(not at all true) to 5 (very true)
Teachers' goal orientation		**I would feel that I had a successful day at school if: 1 (strongly disagree) to 5 (strongly agree).**
	Ability approach	1. The principal commended me for having a higher teaching ability than most of my colleagues.
		2. My classes did better than those of other teachers on an exam.
		3. The principal said I was one of his or her best teachers.
		4. In a comparison of lesson plans, mine was considered the best.
	Mastery approach	5. I learned something new about teaching or myself as a teacher.
		6. After finishing a class I wanted to learn more about the topic that had been taught.
		7. One of my pupil's questions really made me think.

		8. I saw that I was developing professionally and teaching more effectively than in the past.
	Ability avoidance	9. None of my students asked me a question that I couldn't do.
		10. My class did no worse than those of other teachers in an exam.
		11. The principal did not identify me as one of his or her low performing teachers.
		12. At a staff meeting none of my classes were identified as being furthest behind.
	Work avoidance	13. Some of my classes were cancelled because students were on a school trip.
		14. The material was easy and I did not have to prepare lessons.
		15. I was able to get through the day without working too hard.
		16. I didn't have to do or take home any marking.
	Relational	1 (strongly disagree) to 5 (strongly agree).
		I would feel most successful as a teacher if I saw that I was developing closer and better relationships with my students.
		My main goal as a teacher is to show my students that I care about them.
		More than anything, I aspire to create deep personal relationships with each and every student.
		As a teacher, building relationships with students is most important for me.
Teacher's views of intelligence	Incremental	You have a certain amount of intelligence and really can't do much to change it. 1 (strongly disagree) to 6 (strongly agree)
	Entity	Your intelligence is something about you that can't change very much.
		You can learn new things but you can't really change your basic intelligence.
Teacher confidence	Confidence	Please rate your confidence to teach mathematics at the grade levels that you teach. 1 Not at all confident -> 5 Completely confident
Class composition	Ability grouping	Are mathematics classes in your school grouped by student ability? 1 (none), 2 (some), 3 (all).
		Are English classes in your school grouped by student ability? 1 (none), 2 (some), 3 (all).
Teacher practices	Student engagement	From the list below, rate how much you believe each contributes to increased student engagement in mathematics (1=not at all, 7=extremely)
		a) Playing maths games (including computer games)
		b) Teacher giving clear explanations
		c) Students explaining their own thinking (either verbally or written)
		d) Students listening to and questioning other students' thinking
		e) Students have opportunities to work in groups
		f) Positive reinforcement (smiles, encouraging words)

		g) Opportunity for students to work by themselves
		h) Working on tasks students see as challenging
		i) Using concrete materials and manipulatives
		j) Practising skills they have already been taught
		k) Extrinsic rewards (lollies, less homework)
		l) Students working with others of different levels of achievement
		m) Students working with others of similar levels of achievement
		n) Students working with digital technologies (e.g. computer, iPads, internet IWB)
		o) Students using calculators
		p) Students know the purpose and intent of the lesson
		q) Students choosing their own strategy for solving the task
		r) Having tasks that are set in contexts relevant to their lives
		s) Students learning rules and procedures
Teacher practices	Student achievement	From the list below, rate how much you believe each contributes to increased student **achievment** in mathematics (1=not at all, 7=extremely)
		a) Playing maths games (including computer games)
		b) Teacher giving clear explanations
		c) Students explaining their own thinking (either verbally or written)
		d) Students listening to and questioning other students' thinking
		e) Students have opportunities to work in groups
		f) Positive reinforcement (smiles, encouraging words)
		g) Opportunity for students to work by themselves
		h) Working on tasks students see as challenging
		i) Using concrete materials and manipulatives
		j) Practising skills they have already been taught
		k) Extrinsic rewards (lollies, less homework)
		l) Students working with others of different levels of achievement
		m) Students working with others of similar levels of achievement
		n) Students working with digital technologies (e.g. computer, iPads, internet IWB)
		o) Students using calculators

		p) Students know the purpose and intent of the lesson
		q) Students choosing their own strategy for solving the task
		r) Having tasks that are set in contexts relevant to their lives
		s) Students learning rules and procedures
Teachers' Sense of Efficacy Scale (specified for Maths)		**Thinking about your mathematics lessons -- 1 (nothing), 3 (very little), 5 (some influence), 7 (quite a bit), 9 (a great deal)**
		To what extent can you use a variety of assessment strategies?
		To what extent can you provide an alternative explanation or example when students are confused?
		To what extent can you craft good questions for your students?
		How well can you implement alternative strategies in your classroom?
		How much can you do to control disruptive behaviour in the classroom?
		How much can you do to get children to follow classroom rules?
		How much can you do to calm a student who is disruptive or noisy?
		How well can you establish a classroom management system with each group of students?
		How much can you do to get students to believe they can do well in maths?
		How much can you do to help students value learning of mathematics?
		How much can you do to motivate students who show low interest in maths?
		How much can you assist families in helping their children do well in maths?
Teacher Responsibility Scale		**Imagine that the following situations would occur in your class. To what extent would you feel PERSONALLY responsible that you should have prevented each of the following? 0 (Not at all) to 6 (Completely)**
		A student of mine was not interested in the mathematics I taught.
		A student of mine did not value learning the mathematics I taught.
		A student of mine disliked the mathematics I was teaching.
		A student of mine failed to make excellent progress throughout the school year.
		A student of mine failed to to learn the required material.
		A student of mine have very low achievement.
		A student of mine failed my class.
		A student of mine thought he/she could not count on me when he/she needed help with something.
		A student of mine did not think that he/she could trust me with his/her problems in or outside of school.
		A student of mine did not believe that I truly cared about him/her.

		A lesson I taught failed to reflect my highest ability as a teacher.
		A lesson I taught was not as effective for student learning as I could have possibly made it.
		A lesson I taught was not as engaging for students as I could have possibly made it.
Teacher enthusiasm	Subject enthusiasm	Even now, I am still enthusiastic about mathematics.
		I find mathematics exciting and try to convey my enthusiasm to students.
		Engaging in mathematics is one of my favourite activities.
		I engage in mathematics because I enjoy it.
		Because engaging in mathematics is fun, I wouldn't want to give it up.
	Teaching enthusiasm	I teach mathematics with great enthusiasm
		I really enjoy teaching mathematics.
		I always enjoy teaching students new things in maths.
		I enjoy interacting with students in maths classes.
		It's a pleasure to teach mathematics.
Instructional practices	Promotion of surface learning	In order to consolidate a newly taught procedure in maths, I set a lot of tasks that are only slightly different from the initial one. 1 (not true at all) to 4 (absolutely true).
		I let students work on as many tasks as possible independently and quietly during the lesson in order to consolidate a newly taught mathematical procedure or concept.
		I let students solve as many tasks as possible from a textbook or worksheet in order to reinforce a newly taught procedure or concept.
		I make students repeat rules and formulas so that they become sure of them.
	Comprehensive learning	If students make a mistake when working on a new topic, I first accept their suggestions without comment, and then later follow up on the consequences with them until their mistake becomes obvious.
		I sometimes consciously mislead students until they notice that something is not right.
		I act on students' mathematical misconceptions and run through the consequences of these until the students recognise striking inconsistencies.
	Discipline	I attach importance to doing things absolutely quietly in maths lessons.
		When taking a class, I commence by making it unmistakably clear which rules must be kept in the lesson.
		When I enter a classroom, the lesson starts immediately and quietly.
	Social orientation	I discuss general or current topics with the students even if the subject matter has to take a back seat.

		Personal relationships are more important to me than progressing quickly with the learning material.
		I also take time for personal and social matters in lessons.

Secondary (older) students' survey

A link to the survey can be accessed here: Best practice secondary (older) students' survey

Construct/item	Stem (if applicable)	Question	Response options
ID			4-DIGIT NUMERIC
MCLASS			4-DIGIT NUMERIC
MTEACHER			4-DIGIT NUMERIC
SCHOOL		Write the name of your school in the box	TEXT
SCHOOL_PCODE		Write the postcode of your school in the box	4-DIGIT NUMERIC
GENDER		gender	1 = boy 2 = girl
DOBDAY		date of birth - day	2-DIGIT NUMERIC
DOBMONTH		date of birth - month	2-DIGIT NUMERIC
DOBYEAR		date of birth - year	2-DIGIT NUMERIC
BIRTHCOUNTRY		What country were you born in?	Drop down menu
HOMELANG		What language is mostly spoken at home?	TEXT
MUMBIRTH	about your mother	What country was she born in?	Drop down menu
MEDN		What level of education does she have?	1 = university 2 = college or TAFE 3 = completed high school 4 = partly completed high school 5 = don't know
DADBIRTH	about your father	What country was he born in?	Drop down menu

FEDN		What level of education does he have?	1 = university 2 = college or TAFE 3 = completed high school 4 = partly completed high school 5 = don't know
MTEACHER1		Who is your main teacher for maths?	TEXT
YEAR_LEVEL		What year level are you in at school? Year 7; Year 8; Year 9; Year 10	7 = year 7 8 = year 8 9 = year 9 10 = year 10
Maths mark	Grade	What grade did you get in your last report for maths? (A,B,C, D, or E)	1 = A 2 = B 3 = C 4 = D 5 = E
Maths level		What level maths class are you in? 1. Top 2. Middle 3. Lower. 4 All classes are at the same level.	1 = Top 2 = Middle 3 = Lower 4 = All classes are same level
Maths Class Mastery Climate'.	Our maths teacher…	really wants us to enjoy learning new things	1 = not at all-->7 = extremely
		recognises us for trying hard	1 = not at all-->7 = extremely
		wants us to understand our work, not just memorise it	1 = not at all-->7 = extremely
Maths Class Performance Climate'.		tells us how we compare to other students	1 = not at all-->7 = extremely
		points out those students who get good grades as an example to all of us	1 = not at all-->7 = extremely
		lets is know which students get the highest scores on tests	1 = not at all-->7 = extremely
Teacher subject enthusiasm'		is enthusiastic about maths.	1 = not at all-->7 = extremely

		finds maths exciting	1 = not at all-->7 = extremely
		finds maths one of her/his favourite activities.	1 = not at all-->7 = extremely
		engages in maths because s/he enjoys it.	1 = not at all-->7 = extremely
		finds maths fun, and wouldn't want to give it up.	1 = not at all-->7 = extremely
Teacher maths teaching enthusiasm		teaches maths with great enthusiasm	1 = not at all-->7 = extremely
		really enjoys teaching maths.	1 = not at all-->7 = extremely
		always enjoys teaching us new things in maths.	1 = not at all-->7 = extremely
		enjoys interacting with us in maths classes.	1 = not at all-->7 = extremely
		finds it a pleasure to teach maths.	1 = not at all-->7 = extremely
Peers Maths Views'	This section is about what your friends think about maths	My friends find working on maths assignments boring	1 (strongly disagree) 7 (strongly agree).
		My friends are interested in maths.	1 (strongly disagree) 7 (strongly agree).
		My friends like maths more than other subjects.	1 (strongly disagree) 7 (strongly agree).
		My friends wish that they were doing something else when they do maths.	1 (strongly disagree) 7 (strongly agree).
NAPLAN	Think back to May this year (or last year), when you did the NAPLAN maths tests and answer the following questions.	1. We did a lot of practice maths questions in class before the NAPLAN test.	1 (strongly disagree) 7 (strongly agree).
		2. The maths questions covered in the NAPLAN test were different to the work we normally cover in maths classes.	1 (strongly disagree) 7 (strongly agree).
		3. Doing the NAPLAN test was quite stressful for me.	1 (strongly disagree) 7 (strongly agree).
		4. I was uptight before the NAPLAN test.	1 (strongly disagree) 7 (strongly agree).
Homework		How often does your maths teacher assign maths homework?	1 = never-->7 = every class

	How many hours do you spend on maths homework?	On weekdays	1 = I don't do homework 2 = A few minutes 3 = About half an hour 4 = About an hour 5 = More than one hour
		On weekends	1 = I don't do homework 2 = A few minutes 3 = About half an hour 4 = About an hour 5 = More than one hour
Maths Cost - Effort'.	Please click on the button that best describes what you think about maths.	When I think about the hard work needed to get through in maths, I am not sure that it is going to be worth it in the end.	1 = strongly disagree -->7 = strongly agree
		Considering what I want to do with my life, studying maths is just not worth the effort	1 = strongly disagree -->7 = strongly agree
		Achieving in maths sounds like it really requires more effort than I'm willing to put into it.	1 = strongly disagree -->7 = strongly agree
Maths Cost - Psychological'.		It frightens me that maths courses are harder that other courses	1 = strongly disagree -->7 = strongly agree
		I'm concerned that I won't be able to handle the stress that goes along with studying maths	1 = strongly disagree -->7 = strongly agree
Maths Cost - Social'.		I'm concerned that working hard in maths classes might mean I lose some of my close friends	1 = strongly disagree -->7 = strongly agree
		I worry about losing some vauable friendships if I'm studying maths and my friends are not	1 = strongly disagree -->7 = strongly agree
Maths Difficulty'.		To what extent do you consider maths to be a tough subject?	1 = not at all-->7 = extremely
		How complicated is maths for you?	1 = not at all-->7 = extremely
		Compared to most other students in your class, how difficult do you think maths is?	1 = not at all-->7 = extremely
Maths Effort Exerted'.		How hard do you work at maths?	1 = not at all-->7 = extremely

		How much effort do you put into maths?	1 = not at all-->7 = extremely
Maths self-concept (talent)'		Compared with other students in your Year, how talented do you consider yourself to be at maths?	1 = not at all-->7 = extremely
		Compared with your friends, how talented do you consider yourself to be at maths?	1 = not at all-->7 = extremely
		Compared with other subjects at school, how talented do you consider yourself to be at maths?	1 = not at all-->7 = extremely
Maths behavioural interest/engagement .		Making an effort in maths is worth it because this will help me in the work I want to do later on.	1 = not at all-->7 = extremely
		What I learn in maths is important for me because I need this for what I want to study later on.	1 = not at all-->7 = extremely
		I study maths because I know it is useful for me.	1 = not at all-->7 = extremely
		Studying maths is worthwhile for me because what I learn will improve my career prospects	1 = not at all-->7 = extremely
		I will learn many things in maths that will help me get a job	1 = not at all-->7 = extremely
Maths emotional interest/engagement .		I like maths more than other subjects.	1 = not at all-->7 = extremely
		I find maths interesting.	1 = not at all-->7 = extremely
		I find maths enjoyable.	1 = not at all-->7 = extremely
Maths cognitive interest/engagement		After a math class, I am often curious about what we are going to do in the next lesson.	1 = not at all-->7 = extremely
		I would like to find out more about some of the things we deal with in our maths class.	1 = not at all-->7 = extremely
		I want to know all about maths.	1 = not at all-->7 = extremely
Maths Attainment Value'.		Being someone who is good at maths is important to me.	1 = not at all-->7 = extremely
		Being good at maths is an important part of who I am.	1 = not at all-->7 = extremely
		It is important for me to be someone who is good at solving maths problems.	1 = not at all-->7 = extremely

Maths Sex-typing.	These questions are about boys and girls doing maths	Are boys better than girls at maths?	1 = boys better --> 4 = equally --> 7 = girls better
		Do boys or girls work harder in maths?	1 = boys better --> 4 = equally --> 7 = girls better
		How gifted are boys compared with girls at maths?	1 = boys better --> 4 = equally --> 7 = girls better
		Do other people think boys are better than girls at maths?	1 = boys better --> 4 = equally --> 7 = girls better
Personal mastery goal		It's important to me that I learn a lot of new concepts this year in maths.	1 = not at all true --> 3 = somewhat true --> 5 = very true
		One of my goals in maths is to learn as much as I can.	1 = not at all true --> 3 = somewhat true --> 5 = very true
		One of my goals in maths is to master a lot of new skills this year.	1 = not at all true --> 3 = somewhat true --> 5 = very true
		It's important to me that I thoroughly understand my maths.	1 = not at all true --> 3 = somewhat true --> 5 = very true
		It's important to me that I improve my skills in maths this year.	1 = not at all true --> 3 = somewhat true --> 5 = very true
Personal performance approach goal'		It's important to me that other students in my class think I am good at maths.	1 = not at all true --> 3 = somewhat true --> 5 = very true
		One of my goals is to show others that I'm good at maths.	1 = not at all true --> 3 = somewhat true --> 5 = very true
		One of my goals is to show others that maths work is easy for me.	1 = not at all true --> 3 = somewhat true --> 5 = very true
		One of my goals is to look smart in comparison to the other students in maths.	1 = not at all true --> 3 = somewhat true --> 5 = very true
		It's important to me that I look smart compared to others in maths.	1 = not at all true --> 3 = somewhat true --> 5 = very true

Personal performance avoidance goal'		It's important to me that I don't look stupid in maths lessons.	1 = not at all true --> 3 = somewhat true --> 5 = very true
		One of my goals is to keep others from thinking I'm not smart in maths classes.	1 = not at all true --> 3 = somewhat true --> 5 = very true
		It's important to me that my teacher doesn't think that I know less than others in maths.	1 = not at all true --> 3 = somewhat true --> 5 = very true
		One of my goals in maths lessons is to avoid looking like I have trouble doing the work.	1 = not at all true --> 3 = somewhat true --> 5 = very true
Student mindset	Incremental	You have a certain amount of intelligence and really can't do much to change it.	1 (strongly disagree) to 6 (strongly agree)
	Entity	Your intelligence is something about you that can't change very much.	1 (strongly disagree) to 6 (strongly agree)
		You can learn new things but you can't really change your basic intelligence.	1 (strongly disagree) to 6 (strongly agree)
School caring	These questions are about your school.	The teachers here respect me	1 = not at all true -->7 = completely true
		Most teachers at this school are interested in me	1 = not at all true -->7 = completely true
		There's at least one teacher or other adult in this school I can talk to if I have a problem	1 = not at all true -->7 = completely true
		Teachers here are not interested in people like me	1 = not at all true -->7 = completely true
	Your maths teacher's views about you	How talented does you teacher think you are at maths?	1 = not at all-->7 = extremely
		How well does your teacher expect you to do at maths in high school?	1 = not at all-->7 = extremely
		How difficult does your teacher think you find maths?	1 = not at all-->7 = extremely
		How much effort does your teacher think you need to put into maths in order to do well?	1 = not at all-->7 = extremely
		How interested does your teacher think you are in maths?	1 = not at all-->7 = extremely

		How useful does your teacher believe maths is?	1 = not at all-->7 = extremely
		How high in prestige/status does your teacher think maths is, compared with other school subjects?	1 = not at all-->7 = extremely
		Does your teacher think maths is more suited to males?	1 = not at all-->7 = extremely
		How well do you and your teacher relate to each other?	1 = not at all-->7 = extremely
Student attitudes to school	These questions are about how you feel about school.	I feel overwhelmed by my schoolwork	1 2 3 4 5 6: Completely disagree, Partly disagree, Disagree, Partly agree, Agree, Completely agree
		I often sleep badly because of matters related to my schoolwork.	1 2 3 4 5 6: Completely disagree, Partly disagree, Disagree, Partly agree, Agree, Completely agree
		I brood over matters related to my schoolwork a lot during my free time	1 2 3 4 5 6: Completely disagree, Partly disagree, Disagree, Partly agree, Agree, Completely agree
		The pressure of my schoolwork causes me problems in my close relationships with others	1 2 3 4 5 6: Completely disagree, Partly disagree, Disagree, Partly agree, Agree, Completely agree
		I feel a lack of motivation in my schoolwork and often think of giving up	1 2 3 4 5 6: Completely disagree, Partly disagree, Disagree, Partly agree, Agree, Completely agree
		I feel that I am losing interest in my schoolwork	1 2 3 4 5 6: Completely disagree, Partly disagree, Disagree, Partly agree, Agree, Completely agree
		I'm continually wondering whether my schoolwork has any meaning	1 2 3 4 5 6: Completely disagree, Partly disagree, Disagree, Partly agree, Agree, Completely agree
		I often have feelings of inadequacy in my schoolwork	1 2 3 4 5 6: Completely disagree, Partly disagree, Disagree, Partly agree, Agree, Completely agree

		I used to have higher expectations of my schoolwork than I do now	1 2 3 4 5 6: Completely disagree, Partly disagree, Disagree, Partly agree, Agree, Completely agree
CAREER		How much would you like to have a maths-related career?	1 = not at all-->7 = extremely
MCAREERWHY		Why/why not?	TEXT
CDECISION		Have you decided what career you plan to pursue?	2 = yes 1 = somewhat 0 = no
CAREER		What job would you like to have in the future?	TEXT
CAREERWHY		Why would you like to have this job?	TEXT

Primary (younger) students' survey

A link to the survey can be accessed here: [Best practice primary (younger) students' survey](#)

Focus primary students	Construct/item	Question	Response options
Unique numeric identifier created	ID		4-DIGIT NUMERIC
	MCLASS		4-DIGIT NUMERIC
	MTEACHER		4-DIGIT NUMERIC
	SCHOOL	Write the name of your school in the box	TEXT
	SCHOOL_PCODE	Write the postcode of your school in the box	4-DIGIT NUMERIC
These questions are about you.			
	GENDER	gender	1 = boy 2 = girl
	DOBDAY	date of birth - day	2-DIGIT NUMERIC
	DOBMONTH	date of birth - month	2-DIGIT NUMERIC
	DOBYEAR	date of birth - year	2-DIGIT NUMERIC
	BIRTHCOUNTRY	What country were you born in?	Drop down menu
	HOMELANG	What language is mostly spoken at home?	TEXT
Maths class			
	MTEACHER1	Who is your main teacher for maths?	TEXT
	YEAR_LEVEL	What year level are you in at school?	3 = year 3 4 = year 4 5 = year 5 6 = year 6
	Maths_mark	What grade did you get in your last report for maths? (A,B,C, D, or E)	1 = A 2 = B 3 = C 4 = D

			5 = E
Mastery classroom environment'	Our maths teacher…	really wants us to enjoy learning new things	1 = not at all-->7 = extremely
		recognises us for trying hard	1☹ = not at all-->7 ☺= extremely
		wants us to understand our maths, not just memorise it	1☹ = not at all-->7 ☺= extremely
Performance classroom environment'		tells us how we compare to other students	1☹ = not at all-->7 ☺= extremely
		points out those students who get good grades as an example	1☹ = not at all-->7 ☺= extremely
		lets us know which students get the highest scores	1☹ = not at all-->7 ☺= extremely
Teacher enthusiasm -		teaches maths with great enthusiasm	1☹ = not at all-->7 ☺= extremely
		really enjoys teaching maths	1☹ = not at all-->7 ☺= extremely
		likes teaching us new things in maths	1☹ = not at all-->7 ☺= extremely
		enjoys talking with us in maths classes	1☹ = not at all-->7 ☺= extremely
		thinks it's fun to teach maths	1☹ = not at all-->7 ☺= extremely
		teaches maths with great enthusiasm	1☹ = not at all-->7 ☺= extremely
		always enjoys teaching us new things in maths.	1☹ = not at all-->7 ☺= extremely
		enjoys interacting with us in maths classes.	1☹ = not at all-->7 ☺= extremely
		finds it a pleasure to teach maths.	1☹ = not at all-->7 ☺= extremely
School caring environment	These questions are about your school.	The teachers here respect me	1 ☹ = not at all true -->7 = ☺ completely true
		Most teachers at this school are interested in me	1 ☹ = not at all true -->7 = ☺ completely true

		There's at least one teacher or other adult in this school I can talk to if I have a problem	1 ☹ = not at all true -->7 = ☺ completely true
NAPLAN	Think back to May this year (or last year), when you did the NAPLAN maths tests and answer the following questions.	1. We did a lot of practice maths questions in class before the NAPLAN test.	1 (☹ strongly disagree) -> ☺7 (strongly agree).
		2. The maths questions covered in the NAPLAN test were different to the work we normally cover in maths classes.	1 (☹ strongly disagree) -> ☺7 (strongly agree).
		3. Doing the NAPLAN test was quite stressful for me.	1 (☹ strongly disagree) -> ☺7 (strongly agree).
		4. I was uptight before the NAPLAN test.	1 (☹ strongly disagree) -> ☺7 (strongly agree).
		How often does your maths teacher assign maths homework?	1 = never-->7 = every class
Homework	How many hours do you spend on maths homework?	On weekdays	1 = I don't do homework 2 = A few minutes 3 = About half an hour 4 = About an hour 5 = More than one hour
		On weekends	1 = I don't do homework 2 = A few minutes 3 = About half an hour 4 = About an hour 5 = More than one hour
Maths motivations & perceptions			
*Maths costs	Mathematics difficulty	Maths is difficult for me.	1 (☹ strongly disagree) -> ☺7 (strongly agree).
		I find maths more difficult than other people in my year.	1 (☹ strongly disagree) -> ☺7 (strongly agree).
	Mathematics effort	I work hard in maths.	1 (☹ strongly disagree) -> ☺7 (strongly agree).

		I try hard to do maths.	1 (☹ strongly disagree) -> ☺7 (strongly agree).
	Mathematics talent	I think I am gifted in maths compared with my class.	1 (☹ strongly disagree) -> ☺7 (strongly agree).
		I think I am gifted in maths compared to my friends.	1 (☹ strongly disagree) -> ☺7 (strongly agree).
		I think I am more gifted in maths than I am at other subjects.	1 (☹ strongly disagree) -> ☺7 (strongly agree).
	Emotional interest/engagement	I like maths more than my other subjects at school,	1☹ = not at all-->7 ☺= extremely
		I find maths interesting.	1☹ = not at all-->7 ☺= extremely
		I enjoy maths.	1☹ = not at all-->7 ☺= extremely
	Cogntive interest/engagement	After a maths class, I am curious about what we are going to do in the next lesson	1☹ = not at all-->7 ☺= extremely
		I want to know all about maths.	1☹ = not at all-->7 ☺= extremely
		I would like to find out more about some of the things we deal with maths.	1☹ = not at all-->7 ☺= extremely
Maths values	Behavioural interest/engagement	Working hard in maths is worth it because it will help me later on in life.	1☹ = not at all-->7 ☺= extremely
		Learning maths is important because I will need it for later study at school.	1☹ = not at all-->7 ☺= extremely
		I study maths because I know it is useful for me.	1☹ = not at all-->7 ☺= extremely
		Studying maths is worthwhile because it will help me get a better job.	1☹ = not at all-->7 ☺= extremely
		A lot of the things I learn in maths will help me get a job.	1☹ = not at all-->7 ☺= extremely
	Attainment value	Being good at maths is important to me.	1☹ = not at all-->7 ☺= extremely
		Being good at maths is an important part of who I am.	1☹ = not at all-->7 ☺= extremely
		It is important for me to be good at solving mathematical problems.	1☹ = not at all-->7 ☺= extremely

Student mastery goal orientation'	These questions are about your aims in maths	It's important to me that I learn a lot of new things this year in maths.	1☹ = not at all-->7 ☺= extremely
		I aim to learn as much maths as I can.	1☹ = not at all-->7 ☺= extremely
		I aim to master a lot of new maths skills this year.	1☹ = not at all-->7 ☺= extremely
		It's important to me that I thoroughly understand my maths.	1☹ = not at all-->7 ☺= extremely
		It's important to me that I improve my skills in maths this year.	1☹ = not at all-->7 ☺= extremely
Student performance approach goal orientation	Performance approach goal orientation	It's important to me that other students in my class think I am good at maths.	1☹ = not at all-->7 ☺= extremely
		I aim to show others that I'm good at maths.	1☹ = not at all-->7 ☺= extremely
		I aim to look smart in comparison to the other students in maths.	1☹ = not at all-->7 ☺= extremely
Student performance avoidance goal orientation	Performance avoidance goal orientation	It's important to me that I don't look stupid in maths lessons.	1☹ = not at all-->7 ☺= extremely
		I aim to keep others from thinking I'm not smart in maths.	1☹ = not at all-->7 ☺= extremely
	Performance avoidance goal orientation	It's important to me that my teacher doesn't think that I can't do maths.	1☹ = not at all-->7 ☺= extremely
	Performance approach goal orientation	I aim to look as though I know what I am doing in maths.	1☹ = not at all-->7 ☺= extremely
	Student mastery goal orientation	It's important to me to understand maths.	1☹ = not at all-->7 ☺= extremely
	Student mastery goal orientation'	I try to make sense of maths.	1☹ = not at all-->7 ☺= extremely
Theory of intelligence		You have a certain amount of brainpower and really can't do much to change it.	1☹ = not at all-->7 ☺= extremely
		Your brainpower is something about you that can't change very much.	1☹ = not at all-->7 ☺= extremely
		You can learn new things but you can't really change your basic brainpower.	1☹ = not at all-->7 ☺= extremely

Maths sex-typing		Are boys better than girls at maths?	1 = boys better --> 4 = equally --> 7 = girls better
		Do boys or girls work harder in maths?	1 = boys better --> 4 = equally --> 7 = girls better
		How gifted are boys compared with girls at maths?	1 = boys better --> 4 = equally --> 7 = girls better
		Do other people think boys are better than girls at maths?	1 = boys better --> 4 = equally --> 7 = girls better

A3.   Case study instruments

Instructions for Conducting a Case Study for Case Study Researchers (CSR)

Before the school visit

Contact your Hub Research Assistant (RA), who will provide you with the scheduled date and time of visit, your school contact person and any information pertinent to your case study school and visit.

The school will have been sent an information pack which contains information sheets, consent forms and a school permission form. They will have also been sent out a link to an online survey to complete.

When visiting

Take with you:
- The individual system's approval letter which will be provided to you by your Hub RA.
- Working with children/good character check or equivalent.
- This pack which contains spare information and consent forms and information about undertaking the research.

Process:
- On arrival, notify school office and meet with contact person (this name will be provided by the Hub RA).
- Before commencing interviews, check that participants have signed a consent form. If necessary, use the forms in your pack. Collect signed forms.
- Conduct interviews:
  - Principal (1)
  - Curriculum leader/mathematics coordinator (1)
  - Teachers (as organised by the school)
- Conduct classroom observation(s) (1–2 classes, as organised by the school)
- Facilitate focus groups
  - Student (1 focus group of 4–6 students)
  - Parent (1 focus group of 4–6 participants) – Optional.

On leaving:

Remind the school representative about the survey link and thank the school for its cooperation and time. For any other questions, refer the school to the Hub RA.

Post visit
- As soon as possible after the visit, send the completed report and all notes and raw data including audio files to the hub coordinator.
  This may include:
  - All participant consent forms
  - Field Notes
  - Completed reporting template
  - All audio tapes and any transcriptions
  - Hard copies of any other material (if relevant)

Use the pre-paid envelope provided to send any hard copy materials to your hub and send electronic copies where relevant.

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CASE STUDY REPORT TEMPLATE

School:	Location:
Dates:	Case Study Reporter:

NB: This document should be no more than 5–6 pages in length.

Context/Background
School physical environment; general information such as school mission, history; size of school; public statements of curriculum approach; perception of social environment

Policy level (What characterises policy contexts in mathematics in schools with high NAPLAN numeracy results?)
Attitudes to achievement/performance (both Naplan and non-Naplan); Direction wrt approaches/practices/pedagogies; degree of school autonomy; perspectives on "latest trends"; broader state/national/international influences; assessment

School level (What characterises schools with high NAPLAN numeracy results?)
Nature of school leadership (Whole school, department, other); Structures and organisation including hours of maths; Programs and policy including assessment and reporting, curriculum; Professional learning; Community involvement; influence of scale (size); Staffing, staff turnover, out-of-field teaching; School climate/culture/shared values, collective efficacy; Resourcing; Attendance to health and well-being (also hours worked, weekdays and weekends); Degree of teacher autonomy; homework; assessment

Class level (What characterises mathematics teachers and teaching in schools with high NAPLAN numeracy results?)

Teacher qualifications; Class composition (ability grouped, friendship groups); Class resources and use of these eg ipads, IWB etc; Homework; Teacher organisation and planning; Goal emphasis; Teaching style – positive expectations for achievement, positive expectations for behaviour, caring (relationships), negativity, structure (agreed understanding); Teacher knowledge, beliefs, mind set; Teacher enthusiasm; Teacher stress; Teacher values; Teacher practices; Responsibility for student motivation, achievement, relationships with students, teaching; Teacher flexibility and responsiveness; Teaching maths cf other subjects (primary); Impact of NAPLAN on teachers; assessment

Student level (What characterises students and learning in mathematics in schools with high NAPLAN numeracy results?)

Perceptions and experiences of teaching; Previous experiences cf now; Impact of NAPLAN on students; Beliefs and attitudes; Self efficacy, interest, utility, aspirations; Attributions; Perceptions of teacher beliefs and values; Homework; What class – link to teacher; assessment; Student chessboard problem response.

Summary

Who did you work with at this school?

Name	Role

Cohort (Student year level /parent group)	Number

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CURRICULUM LEADER/MATHEMATICS COORDINATOR INTERVIEW SCHEDULE

Context & background

1. Tell me about your school.
   - Does the school have a mission statement that incorporates specific ideas about mathematics?
   - If you have a specific curriculum statement for mathematics, what does it look like?

2. What is the level of involvement of the community in your school, regarding mathematics? How do you inform parents about the mathematical practices in your school?
   - Prompts: Supporting students' learning; funding resources; specific events, parent mathematics evenings, reporting, newsletter, homework

Policy level

3. What do you see as the current broad curriculum agendas about mathematics nationally and at state level and how do these influence what happens at your school?
   - Prompts: What directives are you receiving? What trends are you responding to?

School level

4. Your school has been identified as a high gains school in NAPLAN.
   - How do you manage the NAPLAN process?
   - What do you attribute your success to?
   - What expectations do you feel there are around your school's performance in NAPLAN?
   - Can you tell me about your personal perspective on the role of NAPLAN?
   - How is information around NAPLAN disseminated, discussed and used?
   - To what extent (and how) do you use the data collected from NAPLAN to inform mathematics teaching/program in your school

5. What importance do you place on mathematics in your school?
   - Please expand your answer.

6. How is mathematics organised and managed in your school?
   - Prompt: streamed classes, textbook program, ICT based program
   - Who is responsible for it?
   - What role does the individual teacher have for organising and planning curriculum?
   - What processes for mentoring, regarding the teaching of mathematics, are in your school? (e.g, supporting out-of-field teachers)

- What is the approach for budget allocation for mathematics resources in your school?

7. What opportunities are there for professional learning about mathematics in your school?
   - Prompts: access, nature, in/out of school, uptake; new teachers, graduate teachers

8. This set of questions is about the AC in your school.
   - Has your school adopted the AC: M (or state curriculum) entirely?
   - Has the AC: M been adapted in any way? If so, how and why?
     o Prompts: Whole school approach, numeracy policy; characteristics of students; socio-economic status.

9. What are the best identifiers of student achievement in mathematics and numeracy?
   - Describe how they are reflected in the planning and teaching of mathematics at your school.

10. How is student learning in mathematics assessed at your school?
    - How feedback provided to students?
    - How feedback provided to parents?

11. Do you think there is a difference between mathematics and numeracy?
    - Please expand your answer and give examples.

Class level

12. What characterises an effective mathematics teacher?
    - Describe some teachers of mathematics who have made a positive difference to mathematical learning and attainment in your school?
    - If you are looking at a mathematics classroom form the outside, what might be an indication that the students are learning

13. What are the characteristics of a successful mathematics lesson?
    - Prompts include: mastery, performance, understanding, engagement.

14. How do you think students best learn mathematics concepts?

15. How is individual difference catered for in the teaching and learning of mathematics?
    - What student support structures exist?
    - Prompt: School based support program; special needs teacher/s; IEPs; open tasks; collaborative learning; positive classroom environments; homework program

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PRINCIPAL INTERVIEW SCHEDULE

Context & background

1. Tell me about your school.
   - When was it established? How many staff do you have?
     - Prompts: Stable staff over past 5 years?
   - Does the school have a mission statement?
     - How is this integrated into the school?
     - Prompts: Does it incorporate specific ideas about mathematics? How is this enacted in the school program?

2. What is the level of involvement of the community in your school, regarding mathematics? How do you inform parents about the mathematical practices in your school?
   - Prompts: Supporting students' learning; funding resources; specific events, parent mathematics evenings, reporting, newsletter, homework

Policy level

3. What do you see as the current broad curriculum agendas nationally and at state level and how do these influence what happens at your school?
   - Prompts: What directives are you receiving? What trends are you responding to?

School level

4. Your school has been identified as a high gains school in NAPLAN.
   - How do you manage the NAPLAN process?
   - What do you attribute your success to?
   - What expectations do you feel there are around your school's performance in NAPLAN?
   - Can you tell me about your personal perspective on the role of NAPLAN?
   - How is information around NAPLAN disseminated, discussed and used?
   - To what extent (and how) do you use the data collected from NAPLAN to inform mathematics teaching/program in your school

5. What importance do you place on mathematics in your school?
   - Please expand your answer.

6. How is mathematics organised and managed in your school?
   - Prompt: streamed classes, textbook program, ICT based program
   - Who is responsible for it?

- What is the approach for budget allocation for mathematics resources in your school?

7. What opportunities are there for professional learning about mathematics in your school?
   - Prompts: access, nature, in/out of school, uptake; new teachers, graduate teachers
   - What processes for appraisal and mentoring, regarding the teaching of mathematics, are in your school? (e.g, supporting out-of-field teachers)

8. This set of questions is about the Australian Curriculum at your school.
   - Has your school adopted the AC: M (or state curriculum) entirely?
   - Has the AC: M been adapted in any way? If so, how and why?
       o Prompts: Whole school approach, numeracy policy; characteristics of students; socio-economic status

9. What are the best identifiers of student achievement in mathematics and numeracy?
   - Describe how they are reflected in the planning and teaching of mathematics at your school.

10. How is student learning in mathematics assessed at your school?
    - How is feedback provided to students?
    - How is feedback provided to parents?

11. Do you think there is a difference between mathematics and numeracy?
    - Please expand your answer and give examples.

Class level

12. What characterises an effective mathematics teacher?
    - Describe some teachers of mathematics who have made a positive difference to mathematical learning and attainment in your school?
    - If you are looking at a mathematics classroom form the outside, what might be an indication that the students are learning

13. What are the characteristics of a successful mathematics lesson?
    - Prompts include: mastery, performance, understanding, engagement.

14. How do you think students best learn mathematics concepts?

15. How is individual difference catered for in the teaching and learning of mathematics?
    - What student support structures exist?
    - Prompt: School based support program; special needs teacher/s; IEPs; open tasks; collaborative learning; positive classroom environments; homework program

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STUDENT INTERVIEW SCHEDULE

Student level

1. What do you think of when you hear the word mathematics?
   - Do you like it or not?
   - Do you like learning about maths

2. Do you think maths is important?
   - Why?
   - Do you think it is useful?
   - When do you use mathematics outside of school?

3. How good do you think you are at mathematics?
   - What parts of maths are you good at?

4. Describe a typical maths lesson that you had this week
   - Probes: Do you use open-ended tasks, use of textbook, worksheets, concrete materials, ICT, calculators, game
   - What do you mostly do in maths lessons?

5. Tell me about a maths lesson that you really enjoyed.
   - What made it enjoyable?
   - Have you had mathematics lessons like that in the past

6. Tell me about a maths lesson where you learnt something new.
   - What did you learn? What helped you to learn it?

7. Tell me about someone in your class who is good at maths.
   - What makes them good at maths?
   - What are they good at doing in maths?

8. Do you think your teacher likes mathematics? Do you think that s/he thinks it is important?

9. What do you do when you don't know how to work out a maths problem?
   - What helps you the most?
   - Probe : How does your teacher help you? Do you work with a friend?

10. Can you remember taking the NAPLAN tests?
    - Can you tell me about how you felt about taking the tests?

11. How does your teacher find out what you know about maths?

- Probe: Tests, assignments, problem solving, puzzles

12. Do you do any maths at home?
- Do have set maths homework? How long does it take? What sort of maths do you do for homework?
- Do your parents help you with maths at home?

Task:

- How many squares on the chessboard?
  - Instructions
    - Look at the problem individually for 2–3 minutes and have a go at solving it or thinking about how you would solve it.
    - Then talk about it and work on solving as a group.

- Observe how they approached the task, entered the task, solved the task
- Use a protocol sheet for student 1, 2, 3, 4 – then overall comment on group outcome

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TEACHER INTERVIEW SCHEDULE

School level

1. This set of questions is about the AC in your school
   a. How do you incorporate it into your planning?
   b. Have you adapted it or modified it? In what ways?
   c. What other documents do you use in your planning?

Class level

2. What do you think mathematics is?
   - Why is it important?

2. How do you think students best learn mathematics concepts?
   - Prompts include: resources; hands-on; use of manipulatives; open tasks; problem solving; collaborative work.

3. Tell me about how you organize and plan your mathematics program and lessons.
   - Prompts include: whole school/individual; autonomous or directed; term, daily, yearly; reference points such as AC: M, textbooks, colleagues; other documents; resources; hands-on; use of manipulatives; open tasks; problem solving.
   - How important do you see planning

4. In what ways, if any, does your planning and teaching change around NAPLAN?
   - How do you prepare children for it?
   - What is your view of NAPLAN?
     o Prompts include: valuable; time-consuming; informs teaching
   - How do you use NAPLAN data?

5. Describe a typical recent mathematics lesson you taught including resources and how they were used.
   - Prompts include: how often do you use open-ended tasks; use of textbook; worksheets; concrete materials; ICT

6. What are the characteristics of a successful mathematics lesson?
   - Prompts include: mastery, performance, understanding, engagement.

7. How do you accommodate individual differences in your mathematics lessons?
   - Prompts include: group work, individualised programs; open tasks; extending and simplifying; enabling prompts

8. Tell me about someone in your class who is good at maths.

- What makes that person good at maths?
- What are that person good at doing in maths?

9. How do you assess student learning?
    - How do you provide feedback to students?
    - How do you provide feedback to parents?

10. Do you think there is a difference between mathematics and numeracy?
    - Please expand your answer and give examples.

11. What are the best identifiers of student achievement in mathematics and numeracy?
    - Describe how they are reflected in your planning and teaching.

12. Describe any recent professional learning in mathematics in which you were involved

General information/demographic (class, teacher, no of students)

Task 1 Time Resources	Task 2 Time	Task 3 Time

Time	Teacher actions/activity	Student actions/activity	Comments

Look for:

- Classroom organisation/environment (physical)
- organisation of desks, etc,
- resources,
- How the teacher structured the lesson
- Evidence of engagement

- Degree of student/student; student/teacher interaction; balance of interactions; quality of interactions; types and qualities of questions
- Copy of lesson plan
- Lesson conclusion/reflection
- Nature and quality of feedback
- Teachable moments (e.g., contingency)
- Use of resources (appropriate, effective)
- Task quality (degree of challenge, accessibility, examples selected)

Appendix B

Details of the ACARA sample of superior gain schools and the survey samples of schools

Characteristics of the ACARA sample of superior gain schools

Two initial data sets were provided by ACARA as a basis for identifying *successful schools*. These data sets identified schools that had gain scores from Year 3 to Year 5 or from Year 7 to Year 9 that were 1 standard deviation (SD) above the average gain for all schools in Australia.

The two sets included gains from 2011–2013 and 2012–2014, the only gain score sets available at the time of the project. Each set included slightly different data. 2011–2013 (Set A) included start and end scores (i.e., Year 3 or Year 7 scores 2011 and Year 5 or Year 9 2013), but did not indicate which aspects of NAPLAN (numeracy or reading) provided the gain. The assumption was made that these gains were in Numeracy only. The Set A data consisted of 307 different schools, with 10 schools included twice, that is in each of the year ranges Year 3 to Year 5 and Year 7 to Year 9, providing 317 data points.

2012–2014 (Set B) did not include start and end scores, but did include information about whether the school had gained in numeracy, reading or both NAPLAN assessed areas. All schools that had gained only in reading were deleted from the data set. The Numeracy only data set consisted of 204 schools with 1 school included twice—that is in each of the year ranges Year 3 to Year 5 and Year 7 to Year 9, providing 205 data points.

For this school level analysis, Set A and Set B (Numeracy only) were combined to form a single ACARA data set of 522 schools. Duplicate schools were then removed from the data set, but schools that included high gain in both year ranges, Year 3 to Year 5 and Year 7 to Year 9, were included for each year range, that is they appeared twice. The final data set of combined ACARA high gain schools was 493 schools. The analyses reported here are based on this combined data set.

It should be noted that very limited information about gain from Year 7 to Year 9 was available from Queensland, South Australia and West Australia because Year 7 was not undertaken in high schools, although some schools in WA had begun to make this shift. In Queensland and WA this change occurred in 2015, the year in which the study was conducted. The lack of gain scores in secondary schools in these three states does skew the distribution of schools. All analyses should be considered with this caveat in mind.

Distribution across jurisdictions

Table B1 shows the distribution of *successful schools* across states, broken down by the two year ranges, Year 3 to Year 5 and Year 7 to Year 9 in each state, together with the overall distribution across states.

Table B1: Superior gain schools in ACARA sample by state

State	Yr3–Yr5	Yr3–Yr5 %	Yr7–Yr9	Yr7–Yr9 %	Total	% of high gain schools
ACT	12	66.7	6	33.3	18	3.7
NSW	79	51.3	75	48.7	154	31.2
NT	7	77.8	2	22.2	9	2.8
QLD*	86	93.5	6	6.5	92	18.7
SA*	40	83.3	8	16.7	48	9.7
TAS	6	50.0	6	50.0	12	2.4
VIC	49	65.3	26	34.7	75	15.2
WA*	60	70.6	25	29.4	85	17.2
Total	339	68.8	154	31.21	493	100.0

* Denotes majority of Year 7 students in primary school so limited gain data available in Year 7 to Year 9

Distribution across sectors

Table B2 shows the distribution of superior gain schools across sectors (Catholic, Government and Independent), broken down by the two year ranges, year 3 to year 5 and year 7 to year 9 in each sector, together with the overall distribution across sectors.

Table B2: Superior gain schools in ACARA sample by sector

	Yr3–Yr5	Yr3–Yr5 %	Yr7–Yr9	Yr7–Yr9 %	Overall	% high gain schools
Catholic	108	85.7	18	14.3	126	25.6
Government	194	78.5	53	21.5	247	50.1
Independent	37	30.8	83	69.2	120	24.3
Total	339	68.8	154	31.2	493	100

Distribution across school type

Table B3 shows the distribution of superior gain schools across school type (combined, primary, secondary), broken down by the two year ranges, year 3 to year 5 and year 7 to year 9 in each sector, together with the overall distribution across school type.

Table B3: Schools in ACARA sample by school type

	Yr3–Yr5	Yr3–Yr5 %	Yr7–Yr9	Yr7–Yr9 %	Overall	% high gain schools
Combined	49	34.3	94	65.7	143	29.0
Primary	290	100			290	58.8
High			60	100	60	12.1

Distribution across geolocation

ACARA defines four categories of geolocation: metropolitan, provincial, remote, and very remote. No schools designated very remote were in the ACARA superior gain data set. Table B4 shows the distribution of high gain schools across geolocation (Metropolitan, Provincial, Remote), broken down by the two year ranges, Year 3 to Year 5 and Year 7 to Yearrose 9 in each type, together with the overall distribution across geolocation. No details were provided by ACARA about these geolocation categories. The information provided is included in the glossary.

Table B4: Superior gain schools in ACARA sample by geolocation

	Yr3–Yr5	Yr3–Yr5 %	Yr7–Yr9	Yr7–Yr9 %	Overall	% high gain schools
Metropolitan	249	66.0	128	34.0	377	76.5
Provincial	85	79.4	22	20.6	107	21.7
Remote	5	55.6	4	44.4	9	1.8

ICSEA

The average ICSEA value was calculated for schools in the ACARA sample. The mean ICSEA value was 1068, with a standard deviation of 77.5. The lowest ICSEA was 859 and the highest was 1309.

Characteristics of schools that undertook the surveys

Data were collected through four different surveys: school leaders, teachers, older students (secondary students), and younger students (primary students). For the purpose of establishing the nature of the schools involved, these surveys were combined into two datasets, leader/teacher and all students.

Characteristics of the respondents to these surveys are provided in Chapter 3. These additional analyses are at the school level. In every case, results are presented as from the category of success and other. *Successful schools* were those included in the combined ACARA dataset and one high performance school. This school was retained in the comparison dataset because it met the success criteria for this study.

Characteristics of survey schools in which school leaders and teachers responded

The survey responses from school teachers and leaders came from 121 schools. The analyses presented are taken from these schools.

Distribution across jurisdictions

Table B5 shows the distribution of teacher/leader schools across states, broken down by categories of success and other in each state, together with the overall distribution across states.

Table B5: Schools in teacher/leader survey sample by jurisdiction

State	Success	Success %	Other	Other %	Total	% of sample
ACT	3	75.0	1	25.0	4	3.3
NSW	4	13.3	26	86.7	30	24.8
NT	3	27.3	8	72.7	11	9.1
QLD	3	16.7	15	83.3	18	14.9
SA	5	23.8	16	76.1	21	17.4
TAS	4	40.0	6	60.0	10	8.3
VIC	6	31.6	13	69.4	19	15.7
WA	4	50.0	4	50.0	8	6.6
Total	32	26.4	89	73.6	121	100

Distribution across sectors

Table B6 shows the distribution of teacher/leader schools across sectors (Catholic, Government and Independent), broken down by the categories of success and other, in each sector, together with the overall distribution across sectors.

Table B6: Schools in teacher/leader survey sample by sector

Sector	Success	Success % of sector	Other	Other % of sector	Total	% of sample
Catholic	3	33.3	6	66.7	9	7.4
Government	19	19.1	70	70.7	99	73.6
Independent	10	43.5	13	56.5	23	19.0
Total	32		89		121	100

Distribution across school type

Table B7 shows the distribution of teacher/leader survey schools across school type (Combined, Primary, Secondary), broken down by the two categories of success and other together with the overall distribution across school type.

Table B7: Schools in teacher/leader survey sample by school type

	Success	Success % by school type	Other	Other % by school type	Overall	% of sample
Combined	13	41.9	18	58.0	31	25.6
Primary	13	20.6	50	79.4	63	52.1
Secondary	6	22.2	21	77.9	27	22.3

Distribution across geolocation

ACARA defines four categories of geolocation: metropolitan, provincial, remote, and very remote. No schools designated very remote were in the student survey data set. Table B8 shows the distribution of high gain schools across geolocation (metropolitan, provincial, remote), broken down by the categories of success and other together with the overall distribution across geolocation.

Table B8: Schools in teacher/leader survey sample by geolocation

	Success	*Success % by geolocation*	*Other*	*Other* % by geolocation	Overall	% of sample
Metropolitan	20	26.7	55	73.3	75	62.0
Provincial	10	27.0	27	73.0	37	30.6
Remote	2	66.7	1	33.3	3	2.5
Very Remote			6	100	6	5.0

ICSEA

The average ICSEA value was calculated for *successful* and *other schools* from which teachers and leaders responded. Table B9 shows the results together with the statistics from a t-test of statistical significance. There was a statistically significant difference between the average ICSEA values of the two groups, with the *other schools* group having a lower ICSEA than the *successful schools* group.

Table B9: Comparison of average ICSEA for schools in teacher/leader survey sample

	n	Average ICSEA	ICSEA *SD*	*t*	*p*
Success	32	1075	91	3.81	0.00
Other	89	982	126		

Comparison between the ACARA superior gain sample and *successful schools* from which leaders and teachers responded

A series of comparisons was carried out to establish the similarity between the *successful schools* in which leaders and teachers responded to the survey and the ACARA superior gain data set. It should be noted that the *successful schools* in the survey sample included one high performance school where gain scores were not available.

In all of the following sections, results are shown as percentages of schools from the ACARA sample of Superior Gain Schools and of *successful schools* in which Leader and Teacher survey respondents were located.

Distribution across states and territories

Figure B1 shows a comparison between the distribution by state and territory of ACARA superior gain schools and the sample of identified *successful schools* that had responses from leaders and teachers. Among the survey schools, New South Wales and Queensland were underrepresented, whereas the Australian Capital Territory, South Australia, Tasmania and the Northern Territory were overrepresented. Because these states are the smallest jurisdictions, the actual number of schools involved was small. The variation was caused more by the relative lack of participation by schools in New South Wales and Queensland.
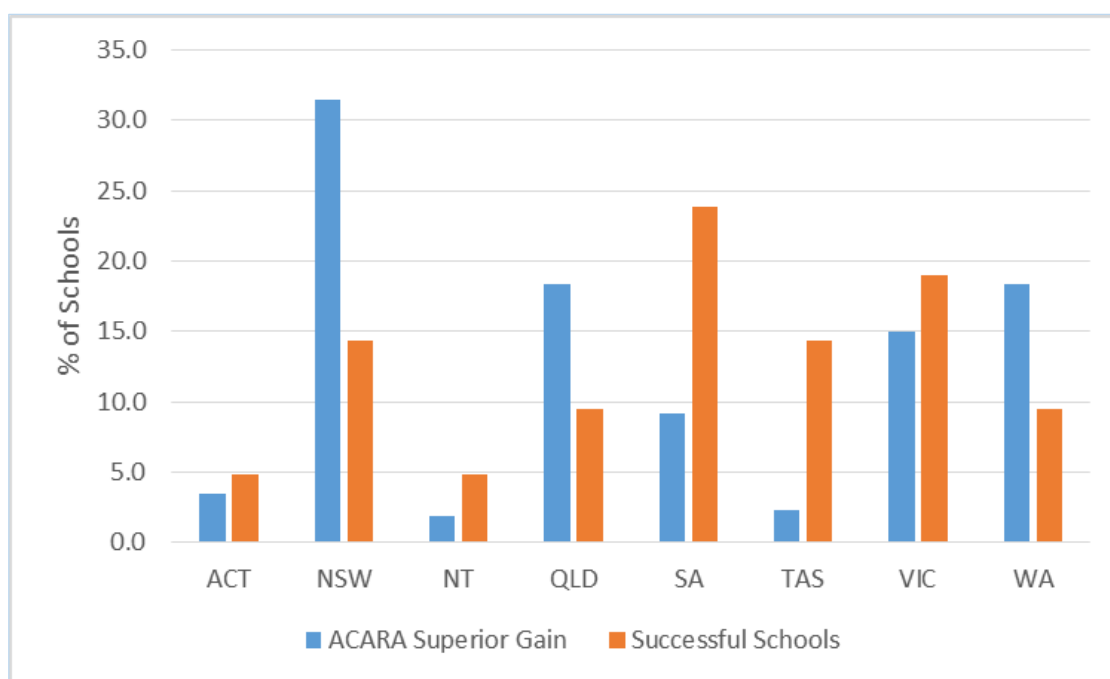
Figure B1: Comparison of the distribution of schools across states

Distribution across sectors

When considered across sectors, there was a relative lack of participation by Catholic sector schools. Results are summarised in Figure B2. The relatively low participation by Catholic schools may have been due to the time of year. Surveys were sent out as soon as possible after permission was received by the various jurisdictions. One Catholic diocese declined to participate. By the time

permissions were received and surveys sent out, it was Term 4 and many schools, especially Catholic schools, had increased commitments leading up to Christmas. These commitments may have affected the response rates from schools.

Figure B2: Comparison of schools by sector

Distribution across school type

The distribution across school type showed a lower participation from primary schools, as shown in Figure B3. It is possible that primary teachers were involved in more extra-curricular activities towards Christmas, affecting the participation rate.

Figure B3: Comparison of schools by school type

Distribution across geolocation

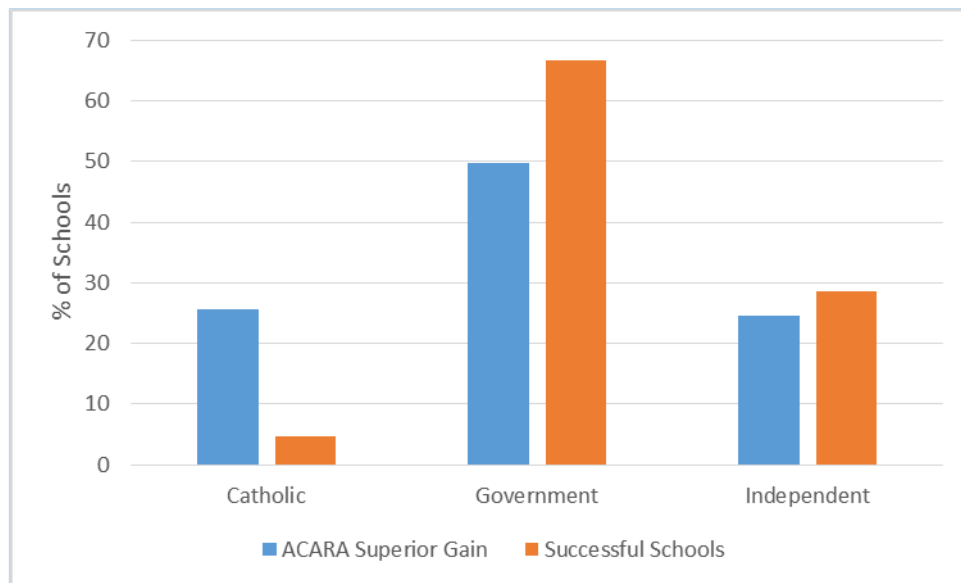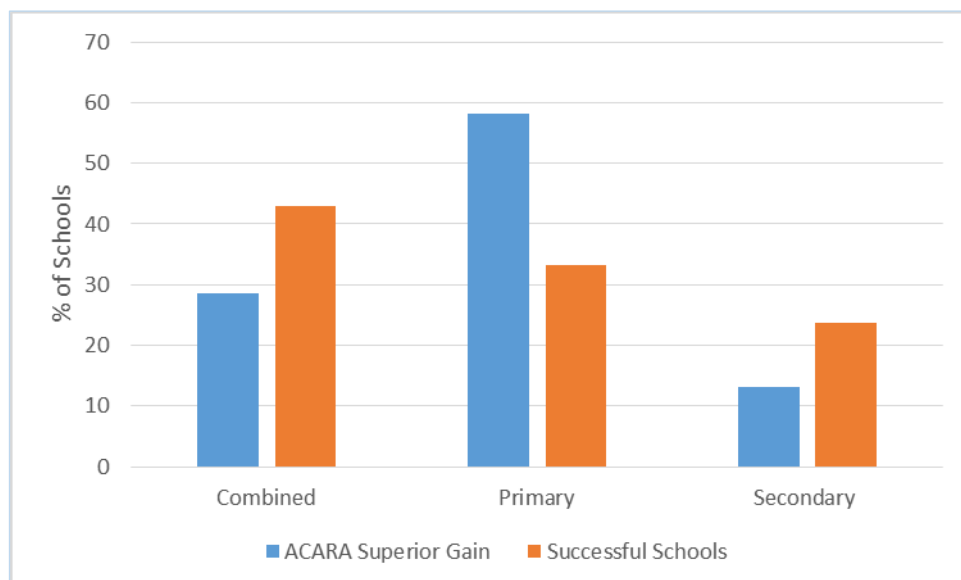The comparison by geolocation showed a similar pattern in both ACARA and survey sample schools. Metropolitan schools predominated with few remote schools. The findings are summarised in Figure B4.
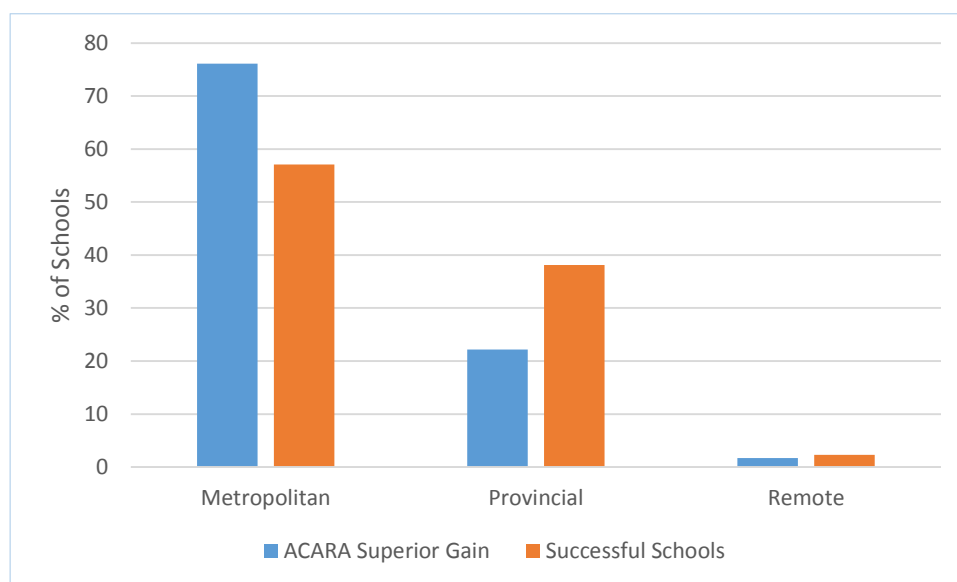
Figure B4: Comparison of schools by geolocation

ICSEA

The ACARA dataset had a mean ICSEA value of 1068, with a standard deviation of 77.5. The mean ICSEA from the *successful* survey *schools* was 1075, with a standard deviation of 91. There was no statistically significant difference between the two groups.

Given that the survey was delivered online, and participants self-selected to take part, as is the situation with all online surveys, the survey schools were reasonably representative of the ACARA high gain schools. The relatively low participation of New South Wales and Queensland, and of Catholic schools was also reflected in the case study sample, indicating that the issue may had had more to do with local events than the study. ICSEA is generally identified as the factor that makes the most difference to educational outcomes (OECD, 2012), and on this measure there was no significant difference.

Characteristics of survey schools from which students responded

The survey responses from primary and secondary students came from 35 schools, of which two combined schools appeared twice because they provided responses from both primary and secondary students. The duplications were removed leave a dataset of 33 schools. No student responses were received from any schools in the Australian Capital Territory. The analyses presented are taken from the 33 schools providing student respondents.

Distribution across jurisdictions

Table B10 shows the distribution of student sample schools across jurisdictions, broken down by categories of *successful schools* and *other schools*, together with the overall distribution.

Table B10: Schools in student survey sample by jurisdiction

State	Success	Success %	Other	Other %	Total	% of sample
ACT						
NSW	6	85.7	1	14.3	7	21.2
NT	0	0	1	100	1	3.0
QLD	2	50.0	2	50.0	4	12.1
SA	4	50.0	4	50.0	8	24.2
TAS	2	33.3	2	66.7	4	12.1
VIC	1	20.0	4	80.0	5	15.2
WA	3	75.0	1	25.0	4	12.1
Total	18	51.4	17	48.6	33	100.0

Distribution across sectors

Table B11 shows the distribution of student sample schools across sectors (Catholic, Government and Independent), broken down by the categories of *successful schools* and *other schools*, in each sector, together with the overall distribution across sectors.

Table B11: Schools in student survey sample by sector

Sector	Success	Success % of sector	Other	Other % of sector	Total	% of sample
Catholic	1	25.0	3	75.0	4	12.1
Government	8	42.9	12	57.1	20	60.6
Independent	6	70.0	3	30.0	10	27.3
Total	15		18		35	100

Distribution across school type

Table B12 shows the distribution of student survey' schools across school type (combined, primary, secondary), broken down by the two categories of *successful schools* and *other schools* together with the overall distribution across school type.

Table B12: Schools in student survey sample by school type

	Success	*Success* % by school type	*Other*	*Other* % by school type	Overall	% of sample
Combined	8	66.7	5	33.3	13	39.4
Primary	5	33.3	10	66.7	15	45.5
Secondary	2	40.0	3	60.0	5	15.2

Distribution across geolocation

ACARA defines four categories of geolocation: metropolitan, provincial, remote, and very remote. No schools designated very remote were in the student survey data set. Table B13 shows the distribution of high gain schools across geolocation (metropolitan, provincial, remote), broken down by the categories of *successful schools* and *other schools* together with the overall distribution across geolocation.

Table B13: Schools in student survey sample by geolocation

	Success	*Success* % by geolocation	*Other*	*Other* % by geolocation	Overall	% of sample
Metropolitan	8	38.1	13	61.9	21	63.6
Provincial	5	50.0	5	50.0	10	30.3
Remote	2	100	0	0	2	6.1

ICSEA

The average ICSEA value was calculated for *successful* and *other schools* from which students responded. Table B14 shows the results together with the statistics from a *t*-test of statistical significance. There was no statistically significant difference between the average ICSEA values of the two groups.

Table B14: Comparison of average ICSEA for schools in student survey sample

	n	Average ICSEA	ICSEA *SD*	*t*	*p*
Successful schools	15	1057	94	1.64	0.11
Other schools	18	1008	75		

Appendix C

Professional learning (professional development) and commercial programs and resources that influence teaching in *successful schools*

C1. Professional learning (professional development) focus

Content focus	Number of mentions
Mathematics (unspecified content)	12
New year 11/12 curriculum	8
Problem solving	2
Mathematical investigations and applications	2
Data analysis (using data)	3
General pedagogy	1
Peer Observation	1
Dyscalculia	1
School based program	1

C2. Commercial resources mentioned by survey and case study respondents

It should be noted that this study does not endorse any commercial or other programs or resources, and does not claim that this list is a complete list of programs or resources used across Australia.

Only commercially available programs or resources are provided here because in order to use these programs or resources, schools need to commit their own financial or personnel resource. Teachers also use a very wide range of resources in addition to those mentioned here. The nature and types of resources used by teachers is idiosyncratic in that every teacher builds up a resource bank on which he/she draws in planning for teaching. No attempt has been made to document these personal teaching resources.

It should be noted that this list may not be comprehensive because teachers and leaders in schools visited in case studies sometimes talked about a 'resource room' or indicated that they used a variety of materials, programs and resources without specifying anything in particular.

Where there were mentions by multiple teachers from one school, or teachers from the same school mentioned a resource in both survey and case study, the program or resource has been counted once only to avoid over-inflating the figures.

Commercial resources	Number of distinct mentions
Mathletics	10
ORIGO Stepping Stones and Go Maths	8
Jacaranda Maths	3
New Wave mental maths (RIC)	1
Pearson Maths	3
Oxford	1
Nelson Maths	1
Maths 300	3
IB	3
First Steps Maths	1
iMaths	2
Direct Instruction Maths	1
PAT Maths	12
Studyladder	1
My Maths Online	1
Maths Tracker (WA)	1
Improve	1
Other commercial texts not specified above	unknown number

Other resources mentioned, such as nrich, were freely available through systems' websites or through the internet, and required no financial commitments from schools.

Appendix D

Technical details of survey analyses

This appendix provides details on the analyses used in sections 5.1.1, 5.1.2, 5.1.3, 5.1.4 and 5.5 of the report.

Standard analysis techniques such as those used to compare two groups with continuous (t-test) and discrete (X^2) are commonly used techniques. This appendix is limited to Structural Equation Modelling and Latent Class Analysis.

Exploratory factor analysis (section 5.1.1 and section 5.1.2)

Exploratory factor analysis was undertaken to identify underlying factors for both attitudes to NAPLAN and to teachers' perceptions of teaching approaches that would lead to student achievement and student engagement. The analyses were completed using IBM SPSS 22. The identified factors were interpreted by considering the items that loaded onto each factor, paying particular attention to those items contributing highly to each factor.

NAPLAN (section 5.1.1)

Principal Components Analysis (PCA) with varimax rotation identified two NAPLAN factors, together explaining 66.0% of the variance. Factor 1 explained 37.8% and Factor 2 explained 28.2% of the variance. The rotated factor loadings are shown in Table D1.

Table D1:   Rotated factor loadings

	Factor 1	Factor 2
NAPLAN has-improved whole school coordination in numeracy.	.832	
NAPLAN has-led to increased opportunities for collaboration and sharing of resources	.880	
NAPLAN has-supported teacher and school assessments.	.841	
NAPLAN has-helped students get better at test-taking practices.	.762	
NAPLAN has-helped promote desirable student attributes such as planning, goal set	.832	
NAPLAN has-for better monitoring of student progress over time.	.757	
NAPLAN has-had a negative impact on learning through a narrow focus.		.788
NAPLAN has-negatively impacted student learning through lack of relevance.		.766
NAPLAN has-been disconnected from the mathematics that students do in my class.	-.458	.317
NAPLAN has-increased the stress and pressure on students.		.839
NAPLAN has-increased the stress and pressure on teachers.		.883
NAPLAN has-led to a greater prevalence of 'teaching to the test'.		.793
NAPLAN has-interfered with a balanced and effective curriculum.		.839

Achievement and engagement factors (section 5.1.2)

Principal Components Analysis (PCA) with varimax rotation identified four achievement factors, together explaining 60.3% of the variance. Factor 1 explained 34.3% of the variance, with the remaining three factors explaining 11.0%, 8.5% and 6.5% respectively. The rotated factor loadings are shown in Table D2.

Table D2:   Rotated factor loadings for teaching approaches leading to student achievement

	Factor 1	Factor 2	Factor 3	Factor 4
Playing maths games (including computer games)		.692	.397	
Teacher giving clear explanations	.428			.573
Students explaining their own thinking (either verbally or written)	.837			
Students listening to and questioning other students' thinking	.853			
Students have opportunities to work in groups	.630	.361	.390	
Positive reinforcement (smiles, encouraging words)	.408		.517	
Opportunity for students to work by themselves	.318			.701

Working on tasks students see as challenging	.601			.447
Using concrete materials and manipulatives	.368	.687		
Practising skills they have already been taught.		.559		.615
Extrinsic rewards (lollies, less homework)			.780	
Students working with others of different levels of achievement		.627		
Students working with others of similar levels of achievement		.464	.352	
Students working with digital technologies (e.g. computer, tablets, internet IWB)		.548	.540	
Students using calculators			.679	
Students knowing the purpose and intent of the lesson	.600	.425		
Students choosing their own strategy for solving the task	.594	.486		
Having tasks that are set in contexts relevant to students' lives	.624	.486		
Students learning rules and procedures				.717

Principal Components Analysis (PCA) with varimax rotation identified four Engagement factors, together explaining 61.5% of the variance. Factor 1 explained 37.7% of the variance, with the remaining three factors explaining 11.0%, 7.2% and 5.5% respectively. The rotated factor loadings are shown in Table D3.

Table D3:   Rotated factor loadings for teaching approaches leading to student engagement

	Factor 1	Factor 2	Factor 3	Factor 4
Playing maths games (including computer games)			.738	.318
Teacher giving clear explanations	.343	.699		
Students explaining their own thinking (either verbally or written)	.716	.345		
Students listening to and questioning other students' thinking	.759			
Students have opportunities to work in groups	.518		.450	
Positive reinforcement (smiles, encouraging words)	.698			.347
Opportunity for students to work by themselves	.616	.368		
Working on tasks students see as challenging	.625	.305		
Using concrete materials and manipulatives			.705	
Practising skills they have already been taught.		.742		
Extrinsic rewards (lollies, less homework)				.712
Students working with others of different levels of achievement		.698	.316	
Students working with others of similar levels of achievement		.624		
Students working with digital technologies (e.g. computer, tablets, internet IWB)			.662	.495
Students using calculators	.346			.462
Students knowing the purpose and intent of the lesson	.331	.637	.333	
Students choosing their own strategy for solving the task	.398	.438	.605	
Having tasks that are set in contexts relevant to students' lives	.313		.691	
Students learning rules and procedures		.575		.482

Structural equation model (section 5.1.4)

The analysis first investigated the factor structure of the interest dimensions; confirmatory factor analyses examined whether a two-dimensional structure of interest—Students' Emotional Interest (SEI) and Students' Cognitive Interest (SCI)—was superior to a single interest factor. Associations between key variables and constructs were then examined, commencing with student-level and then teacher-level variables. Then the associations among teacher-level and student-level variables were examined. This latter analysis, based on calculated factor scores, involved the calculation of Pearson correlation coefficients and then for significant associations, the use of linear multi-level regression models to control for key demographic factors, such as ICSEA.

An hypothesised model was tested using multilevel structural equation models (Muthén & Asparouhov, 2010) to accommodate the nested nature of these data. Because of the lack of statistical power, teacher variables were not included into a teacher-level model in this analysis. The models were estimated using the option "type = MULTILEVEL" of MPlus version 7 (Muthén & Muthén 2012). Missing data at the student level were imputed using Bayesian analysis as described in the MPlus manual (Muthén & Muthén 2012). Evaluation of the model was based on the comparative fit index (CFI, Bentler 1990), the root mean square error of approximation (RMSEA, Hu & Bentler 1999) and the standardised root mean square residual at both the within (SRMRw) and between (SRMRb) levels. Acceptable fit is demonstrated when the CFI > 0.9 and the remaining indices are less than 0.05 (Byrne, 2012).

Latent class analysis (section 5.1.4)

Scores for each dimension of engagement—behavioural, emotional, and cognitive—were calculated from nine engagement items that were similar or identical on the two versions of the student survey. Where the wording was slightly different, the changes had been made to improve readability and understanding for younger students. The items were judged to address the same underlying ideas in both surveys. Items that did not have an equivalent in both surveys were not used in this analysis. The items used are shown in Table D4.

Table D4:   Items used to create factor scores for latent class analysis.

Construct	Secondary Survey	Primary Survey
Emotional interest/engagement	I like maths more than other subjects.	I like maths more than my other subjects at school.
	I find maths interesting.	I find maths interesting.
	I find maths enjoyable.	I enjoy maths.
Cognitive interest/engagement	After a math class, I am often curious about what we are going to do in the next lesson.	After a maths class, I am curious about what we are going to do in the next lesson
	I want to know all about maths.	I want to know all about maths.
	I would like to find out more about some of the things we deal with in our maths class.	I would like to find out more about some of the things we deal with in maths.
Behavioural interest/engagement	Making an effort in maths is worth it because this will help me in the work I want to do later on.	Working hard in maths is worth it because it will help me later on in life.
	What I learn in maths is important for me because I need this for what I want to study later on.	Learning maths is important because I will need it for later study at school.
	I study maths because I know it is useful for me.	I study maths because I know it is useful for me.

Based on the dimension scores for each of three engagement dimensions (emotional, cognitive, and behavioural), multilevel latent class analysis (LCA) identified distinct profiles of students: Disengaged, Compliant and Engaged. LCA assumes that rather than being selected from one population, students have in fact been drawn from a number of hidden (latent) classes. Mean environmental scores for each of the profiles were then compared. The non-independence of these data, reflecting students within mathematics classrooms, was modelled using the option "type = COMPLEX MIXTURE" of Mplus as described in Muthén and Muthén (2012). This option generates estimates corrected for nested data that are robust to violations in normality, and utilises all data during model estimation with full information maximum likelihood (FIML).

The Mplus code used is shown below:

TITLE: This model conducts an LCA of engagement dimensions;

 DATA:

        FILE IS ClusterData.dat;

 VARIABLE:

        NAMES = ID SID TID Eff Int Cog CME CPE TE SC Age Male Grade;

        USEVARIABLES = Eff Int Cog; ! Engagement dimension variables.

        IDVARIABLE = ID;

        AUXILIARY = (e) CME CPE TE SC Age Male Grade;

        MISSING = ALL (999);

        CLUSTER = TID; ! class identifier.

        CLASSES = C(3);

 ANALYSIS: TYPE = MIXTURE COMPLEX;

        STARTS = 1000 250;

        STITERATIONS=20;

         !LRTBOOTSTRAP=200; !For calculating BLRT with type=Mixture

         !LRTSTARTS=20 5 200 50;! For calculating BLRT with type=Mixture

         !OPTSEED = 939709; !For calculating BLRT with type=Mixture

 MODEL:

        %OVERALL%

        %C#1%

        %C#2%

        %C#3%

 OUTPUT: SAMP TECH11;!TECH14;! for BLRT calculation

Appendix D References

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Byrne, B. M. (2012). *Structural Equation Modeling with Mplus*. New York, NY: Routledge.

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Muthén, B., & Asparouhov, T. (2010). Beyond multilevel regression modeling: Multilevel analysis in a general latent variable framework. In J. Hox & J. K. Roberts (Eds.), *The Handbook of Advanced Multilevel Analysis* (pp. 15–40). New York: Taylor and Francis.

Muthén, L. K., & Muthén, B. (2012). *Mplus User's Guide* (Seventh ed.). Los Angeles, CA: Muthén & Muthén.