Although numeracy has become a major focus of government policy in recent years generating a significant number of numeracy-related projects in all States and Territories, relatively few have focussed on the middle years of schooling or collected large-scale data on student numeracy performance at this level. This paper will provide an overview of the Middle Years Numeracy Research Project conducted in Victoria from 1999 to 2000. The paper will report on the implications of the data collected from 7000 Year 5 to 9 students in a representative sample of Victorian schools and the 16 Trial Schools who participated in a follow-up action research approach to improving numeracy outcomes in the middle years of schooling. Data from the final stage of the project indicates that teachers working in professional teams in a coordinated and purposeful way do make a difference, resulting in improved numeracy outcomes for the majority of students. However, evidence from individual interviews with a sample of ‘at-risk’ students suggest that schools still face a significant challenge in recognising and dealing with the very large range of individual learning needs at this level. Implications for further research and current practice will be discussed.

Numeracy has become a major priority area for all Federal, State and Territory governments in recent years. This is most clearly seen in the National Goals for Schooling in the Twenty First Century, which includes the goal "that every student should be numerate and be able to read, write, spell and communicate at an appropriate level" (MCEETYA, 1999). It is also evident in the National Literacy and Numeracy Plan (DEETYA, 1998) and the National Literacy and Numeracy Benchmarks for Years 3, 5 and 7 (National Numeracy Benchmarks Taskforce, 1997). While literacy has always been a high priority of government, the focus on numeracy is relatively recent. Prior to the 1990s, numeracy was primarily viewed as a subset of literacy and largely confined to the non-school sector (that is, industry training, adult education and labour market programs). This heritage is reflected in Being numerate – What counts? (Willis, 1990) and Numeracy in Focus, a joint publication of the Adult Literacy Information Office and the Adult Basic Education Resource and Information Service (Riordan & Tout, 1995).

While the first use of the term numeracy, is generally credited to the authors of the Crowther Report in 1959 (Cockroft, 1982), current Australian usage owes more to the view presented in the Cockcroft Report (p.11, 1982) than it does to the views expressed in the Crowther Report or the more recent United Kingdom National Numeracy Strategy, which quite clearly privileges number over other aspects of mathematics.
Numeracy is defined as more than knowing about numbers and number operations. It includes an ability and inclination to solve numerical problems, including those involving money and measurement. It also demands familiarity with the ways in which numerical information is gathered by counting and measuring, and is presented in graphs, charts and tables (quoted in Rhodes et al, 1998).

In Australia, a broader, more encompassing notion of numeracy is evident in *Numeracy = Everyone’s Business* (AAMT, 1997), the Report of the Numeracy Education Strategy Development Conference held in Perth in February 1997. This view builds on the generally accepted view which positions numeracy as an end result (for example, National Benchmarking Taskforce, 1997), to say something about what numeracy might mean in the context of schooling.

To be numerate is to use mathematics effectively to meet the general demands of life at home, in paid work and for participation in community and civic life. In school education, numeracy is a fundamental component of learning, performance, discourse and critique across all areas of the curriculum. It involves the disposition to use, in context, a combination of: underpinning mathematical concepts and skills from across the discipline (numerical, spatial, graphical, statistical and algebraic); mathematical thinking and strategies; general thinking skills; and a grounded appreciation of context (AAMT, 1997, p.15).

This suggests that numeracy involves a much broader range of knowledge skills and attributes than can be simply characterised as "basic number facts and skills", that numeracy is simultaneously both bigger than and smaller than school mathematics, and that numeracy has a powerful role to play in facilitating communication and decision making. Perhaps more importantly, it acknowledges that numeracy is relative to context. That is, an individual is neither numerate nor innumerate, simply more or less numerate depending on the context in which he/she is expected to operate (Willis, cited in AAMT, 1997). This suggests that different views of numeracy requiring different approaches and assumptions will be needed for different levels of schooling and contexts (Scott, 1999).

In the early years, the focus is strongly (but not exclusively) on the development of counting and number; especially the development of place-value understanding, and the disposition and strategies needed to apply these ideas and skills in relevant contexts, for example, *Count Me in Too* (NSW), the *First Steps Program* (WA), and the *Early Years Numeracy Research Project* (Victoria). Although some of these key ideas and strategies need to be consolidated and extended in Years 5 to 9 (eg, to support an appreciation of fractions and decimals), numeracy education at this level needs to focus on the development of a broader repertoire of mathematical knowledge, skills and dispositions. It needs to equip students to deal effectively with a much larger range of complex problems involving applications of measurement, data, chance and space. At this stage, cross curriculum links and cross curriculum learning become more relevant in developing strong foundations in numeracy.

Different approaches and assumptions are also needed as the social and cultural context of teaching and learning in the middle years is substantially different to the early years (see Hill & Russell, 1999). Disengagement, low-self-esteem, absenteeism, and poor learning behaviours, concomitant with the pressures of adolescence and school transition, present significant challenges to teachers in the middle years. Trying to uncover what works and does not work in this context is also compounded by the enormous variation in student (and to some extent teacher) knowledge and confidence. Attempts to improve numeracy in the middle years will need to consider not only the contribution that school mathematics might make but also how to impact entrenched classroom cultures, scaffold discourse elements
and engage learners more effectively. While existing research in mathematics education provides some guidelines, translating these into consistent, coherent advice appears to be more problematic than it does in the early years.

In Victoria, as in other Australian States and Territories, there has been a significant increase in government funded literacy and numeracy projects in recent years. The success of the Early Literacy Research Project (1995-97) in adopting a coherent, school-wide approach based on the design elements described in the General Model of School Improvement in Literacy (Hill & Crevola, 1997) led to the requirement that similar projects be framed in terms of the nine design elements of the model. That is, beliefs and understandings, leadership and coordination, school and classroom organisation, structured classroom teaching program, standards and targets, monitoring and assessment, intervention and special assistance, home, school and community partnerships and professional learning teams.

The Middle Years Numeracy Research Project: 5-9 (MYNRP) was commissioned by the Victorian Department of Education (now DEET), in partnership with the Catholic Education Commission of Victoria (CECV) and the Association of Independent Schools of Victoria (AISV) in June, 1999. The project was one of a number of other projects commissioned between 1998 and 1999 under the auspices of the DEETYA funded Successful Interventions: A Secondary Literacy and Numeracy Initiative. Within this context, the MYNRP was conceptualised on the basis of an environmental scan conducted by the Mathematical Association of Victoria which revealed that there were very few, well-coordinated intervention programs at the school level and very few common features across school programs. The aims of the project were to:

- provide advice to DEET, CECV and AISV which will lead to the development of a coordinated and strategic plan for numeracy improvement;
- trial and evaluate the proposed approaches in selected Victorian schools; and
- identify and document what works and does not work in numeracy teaching particularly in relation to those students who fall behind.

Given this focus, the MYNRP was essentially designed as an ascertaining study not an implementation study. That is, it was primarily concerned with collecting quantitative and qualitative data about what appeared to be working in Victorian schools to improve numeracy outcomes, not implementing and evaluating a range of proven, research-based strategies. This approach was adopted for two reasons. Firstly, what constitutes numeracy at this level and how improvements in numeracy might be recognised were by no means trivial questions. And secondly, there remains a paucity of numeracy-specific research at this level although there is a growing body of research related to the middle years of schooling more generally (for example, see Hill & Russell, 1997).

In addressing the project aims, the MYNRP was specifically required to investigate the role of four of the nine design elements of the Hill and Crevola (1997) model of whole school improvement. Specifically, the role of structured mainstream classroom programs, additional assistance, parents, mentors and peers, and professional development, in improving numeracy outcomes at this level. Key research questions included the following.

- To what extent can numeracy be assessed by the use of structured, rich assessment tasks involving teacher judgements?
- What aspects of current practice appear to be associated with successful and unsuccessful numeracy performance at this level?
- To what extent does the implementation of the Draft Numeracy Strategy contribute to improved numeracy performance?
• What characterises the numeracy learning experiences of 'at-risk' students?

Research Design and Methodology

Given the duration and largely explorative nature of the project, it was felt that the most appropriate research design was a quasi pre-post design involving a representative sample and a structured sub-sample. In this case, data was collected from a relatively large sample at the outset to obtain baseline data on student numeracy and some insights into what appeared likely to impact numeracy performance at this level. A structured sub-sample was selected to participate in a year-long, action research phase aimed at identifying ways to improve student numeracy performance. This sample was selected on the basis of the initial student numeracy data (high and low) and the extent of evidence concerning supportive school-wide policies and practices (rich and poor) with a view to determining what worked, where and why. Students in Years 5 to 9 in the structured sub-sample of schools were given a parallel version of the initial assessment in November 2000.

To achieve the aims and address the research questions described above, the MYNRP was designed in terms of three broad phases involving the collection of quantitative and qualitative data and the development, implementation, trial and evaluation of a Draft Numeracy Strategy. The three phases are briefly described below.

Phase 1: Benchmarking and Development Phase (October – December 1999)

The aim of this phase was to build on the environmental scan (MAV, 1998) by collecting large-scale, sample data on student numeracy performance as well as data related to the design elements under consideration. This phase also included a review of relevant literature and related policies and projects, particularly the Early Years Numeracy Research Project (ENRP) and the Middle Years Research and Development Project (MYRAD). A formal expression of interest process was used to select a structured, representative sample of 47 schools (27 Primary and 20 Secondary) to participate in the first phase of the project.

The numeracy assessment instruments were developed on the basis of the National Numeracy Benchmarks for Years 5 and 7 and recognised ‘best-practice’ models of assessment, that is, ‘rich assessment tasks’ (e.g., Clarke et al, 1996) and performance assessment (Callingham, 1999; Griffin, 1998). Tasks were sourced to reflect the three strands of the Benchmarks and chosen or adapted to ensure they provided an opportunity to demonstrate both content and process outcomes. While the majority of the short tasks were sourced and/or adapted from Effective Assessment in Mathematics (Beesey et al, 1998), task-specific scoring rubrics were developed by the project team. Parallel forms of a written test comprising 5 open-ended tasks were developed for Years 5-6 and Years 7-9 respectively. For further discussion and examples of these tasks, see Siemon & Stephens, 2001. An extended classroom task aimed at evaluating all students’ understanding of pattern and relationships, Street Party, was sourced from the Tasmanian INISS Project (see Callingham, 1999). Teachers administered the Student Numeracy Profile (i.e., a form of the written test and the extended classroom task) over two 40 to 50 minute sessions. Scoring rubrics were provided for all tasks and teachers were asked to assess the student’s responses using a computer-readable score sheet. An initial professional development day was held to introduce school contact people to the project and to provide some training in the use of scoring rubrics. Complete data sets were obtained from just 7000 students.

Data related to the design elements described in Hill & Crevola (1997) were gathered via an auditing process, that is, school principals were asked to complete a questionnaire and then meet with project team members to verify and/or clarify the school’s response as relevant.
Schools were invited to submit a portfolio of relevant policies and programs if they desired. Complete data sets were obtained from all 47 schools.

This initial data was collected to provide an objective basis for determining what appeared to be working in relation to numeracy and for examining the extent to which school-wide policies and practices contributed to numeracy performance. This data was also collected to provide base-line data to examine the effectiveness of the school-based action plans aimed at improving numeracy performance in the Trial Phase. Draft advice for trial schools about what appeared to be working in relation to numeracy education in Years 5 to 9 was prepared on the basis of a literature review and the data obtained from Phase 1. This advice was framed in terms of the nine design elements of the Hill and Crevola (1997) model for whole school improvement. A Briefing Conference for Trial Schools was held in February 2000 to elaborate the advice and introduce the trial phase of the project including the action planning process to be used. Twenty schools, a sub-set of the original sample of 47 schools, were selected to participate in the Trial Phase on the basis described earlier.

Phase 2: Trial Phase (March – December 2000)

The aim of this phase of the project was to evaluate the effectiveness of the Draft Numeracy Strategy by monitoring the design, implementation and effectiveness of the school-based action plans in relation to student numeracy performance. This was done by the collection of ‘missing cohort’ data in March and whole cohort data in November 2000 using parallel forms of the Student Numeracy Profile. Complete data sets were obtained from 2900 students in Years 5 to 9. This data supported some within-school and between school comparisons. School visits, teacher journals, classroom observations and student reflections were used to monitor the implementation of school-based Action Plans. Individual interviews involving a sample of ‘at risk’ students were also conducted during this phase to explore the specific classroom factors that impact numeracy performance. Trial Schools were asked to complete a Survey as well as a detailed Action Plan Report in November. Trial School teachers were also asked to complete a survey on the basis of their experience. Complete data sets were obtained from all 20 Trial Schools.

Phase 3: Reporting Phase (November 2000 – May 2001)

The aim of this phase of the MYNRP was to analyse all of the data derived from Phase 3 with a view to preparing advice to inform the development of a strategic plan to improve student numeracy outcomes in the middle years of schooling. This phase of the project resulted in the Final Report (Siemon, Virgona & Cornelle, 2001), the Executive summary of which is available on the sofweb site sponsored by the Victorian Department of Education, Employment and Training.

Analysis

The Student numeracy data was analysed using SPSS and Quest, a Rasch modelling tool developed by Adams & Khoo (1993). Of all the short assessment tasks used, only one task, How Far to Walk, lay outside the boundaries set by the Rasch item fit analysis suggesting that all the others were measuring a similar construct. This outcome is heartening as it suggests it is possible to measure a complex construct such as numeracy using rich assessment tasks that incorporate performance measures of content knowledge and process (general thinking skills and strategies) across a range of topic areas. It also suggests that the use of teachers-as assessors is a valid measurement procedure. Another encouraging feature of the overall item analysis is that the degree of difficulty of the tasks chosen was appropriate for the cohort tested (see Siemon & Griffin, 2000).
All other data was analysed qualitatively by means of category analysis. That is, by an examination of the data sets for patterns, relative frequencies and/or relationships to demographic and/or student numeracy data.

**Main Findings**

The following summary is derived from the *Final Report of the Middle Years Numeracy Research Project* (Siemon, Virgona & Corneille, 2001). The findings were based on an analysis of the relevant literature, the school surveys, the student numeracy performance data, the individual interviews of a selected sample of students, the Trial School Action Plans, and the teacher journals and surveys. They are presented in relation to the research questions that framed the study.

**What is already known about numeracy and numeracy education at this level?**

The literature review and the analysis of current policy documents and reports indicate that numeracy in the middle years of schooling has received relatively little attention until fairly recently. This is in marked contrast to the adult education sector where numeracy as 'critical mathematics' has been recognised for some time (for example, see Yasukawa, 1995) and the early years of schooling, where numeracy has also been recognised for some time in terms of key underpinning mathematical ideas and strategies.

The development of *National Numeracy Benchmarks at Years 5 and 7* (National Numeracy Benchmarks Taskforce, 1997) brought the issue of numeracy in the middle years of schooling to public and professional notice. Referring to the contribution that school mathematics and other areas of the curriculum make to students' numeracy, the Taskforce refers to the development of students' "understanding and competence with number and quantity (that is, measurement), shape, location and the handling and interpretation of quantitative data". Interpreted in relation to the Taskforce's view of numeracy as the "effective use of mathematics to meet the general demands of life, at home, in paid work, and for participation in community and civic life", numeracy needs to be seen as a dynamic, evolving aggregation of mathematically related knowledge, skills and dispositions which will vary with different levels of schooling and the changing demands on individuals.

The fact that numeracy has become a major priority area for all Federal, State and Territory governments in recent years has lead some to conclude that school mathematics is somehow being diminished or devalued. To be numerate, however, involves not only a capacity for informed, critical, reflective thought that draws on whatever level of mathematical knowledge and skills an individual possesses, but also the disposition to use and appreciate all that is powerful and beautiful in mathematics. In much the same way that literacy enables us to engage with the powerful and beautiful ideas expressed in literature or art. Far from being some sort of minimalising threat to the sanctity of mathematics, numeracy is the most potent force for enhancing and expanding what we do in the name of school mathematics – it is about providing the means and the opportunity to engage with the very tools and ideas that make mathematics learning possible, purposeful and enjoyable.

Numeracy, like literacy, is fundamentally about access to the means by which individuals can engage productively and responsibly with others as informed, critical members of various communities. As reading, writing, speaking, listening and visualising are to literacy; so Bishop’s (1988) six universal mathematical activities of counting, measuring, locating, designing, explaining and playing are to numeracy. These are essential practices without which individuals are denied access to further study, meaningful employment, independent living and a range of social and cultural pursuits.
For the purposes of the MYNRP the view of numeracy adopted by the National Benchmarking Taskforce (1997) together with view espoused by AAMT above were used to inform the design and implementation of the project. This meant that numeracy in the middle years was seen to involve

- core mathematical knowledge (in this case, *number sense, measurement and data sense* and *spatial sense* as elaborated in the National Numeracy Benchmarks for Years 5 and 7 (1997));
- the capacity to critically apply what is known in a particular context to achieve a desired purpose; and the
- actual processes and strategies needed to communicate what was done and why.

In relation to the middle years of schooling, the most appropriate springboard for improving numeracy education at the present time is school mathematics. In particular, mathematics teaching and learning which recognises that the capacity to interpret, apply and communicate one’s mathematical knowledge, use technology in creative ways to solve problems, and access a range of higher order cognitive skills and dispositions are now regarded as key outcomes of school mathematics (eg, Victorian Curriculum and Standards Framework II (CSFII), 2000; National Statement on Mathematics for Australian Schools, 1992).

While cross curriculum links and cross curriculum learning would appear to offer considerable scope for the development and application of numeracy-related skills and dispositions in the middle years, the evidence to date would suggest that schools and teachers are still some way from seeing this as a reality.

A specific issue in relation to numeracy education in the middle years of schooling is that the already significant challenges of teaching and learning at this level (see Hill & Russell, 1999) are compounded by the enormous variation in student (and to some extent teacher) knowledge and confidence in relation to key mathematical underpinnings. For numeracy education to be effective in the middle years of schooling, those responsible must be equipped to scaffold the particular, numeracy-related learning needs of all students as well as the discourse elements they need to interpret, apply and communicate their thinking.

While existing research in mathematics education provides some guidelines, translating these into practice is not as straightforward as it appears to be in the early years where there is a much greater shared understanding of what works and student engagement is less of an issue.

**To what extent can numeracy be assessed by the use of structured, rich assessment tasks involving teachers as assessors?**

The Rasch analysis of the *Student Numeracy Profile* (SNP) confirms that it is possible to assess a complex construct such as numeracy using 'rich assessment tasks' involving aspects of number sense, measurement and data sense and/or space sense across a variety of Year levels. This outcome is heartening as it suggests it is possible to use performance-based measures to assess numeracy-related general thinking skills and strategies in addition to content knowledge and skills along a single continuum.

<p>| H | Well established in the use of fractions/ratio. Able to generalise and apply number relationships to solve problems. Monitors cognitive actions and goals (ie, almost always evaluates what they are doing for meaning and relevance to problem |</p>
<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>Established in using and interpreting data and/or information appropriate to context, fraction representations, and in describing patterns and relationships. Able to explain solutions to problems.</td>
</tr>
<tr>
<td>F</td>
<td>Consolidating use of data and information appropriate to context. Established in recognising 2D representations of simple 3D space. Beginning to monitor cognitive goals as well as actions (i.e., evaluates what they are doing for sense and relevance).</td>
</tr>
<tr>
<td>E</td>
<td>Consolidating fraction and % knowledge. Monitors cognitive actions (for 1-2 step problems). Little/no monitoring of cognitive goals (that is, checks procedures but not their meaningfulness and/or appropriateness to problem context and/or conditions).</td>
</tr>
<tr>
<td>D</td>
<td>Beginning to understand and represent simple fraction situations. Generally solves one-step problems involving 3-digit whole numbers, ones and tenths. Describes simple patterns.</td>
</tr>
<tr>
<td>C</td>
<td>Able to use a number pattern to solve a problem. Monitors cognitive actions and/or goals some of the time (e.g., recognises relevant information but unable to use it effectively).</td>
</tr>
<tr>
<td>B</td>
<td>Recognises a number pattern and represents it in one way. Makes judgements about data more on the basis of perception than analysis. Little evidence of cognitive monitoring, e.g., estimates or calculates without regard for meaning or applicability.</td>
</tr>
<tr>
<td>A</td>
<td>Uses make-all, count-all strategies to solve a simple number pattern problem</td>
</tr>
</tbody>
</table>

Table 1. The MYNRP Emergent Numeracy Profile

Although further trialing is recommended to establish the reliability and validity of the SNP instruments over time, the extensive use of the tasks and rubrics as models by Trial School teachers suggests that this form of assessment is highly valued. To the extent that assessment serves to shape teaching, assessment tasks of the kind used in the study could play a powerful role in helping shift perceptions of what is valued in relation to school mathematics and numeracy. In particular, they would help amplify the point that understanding as well as competence is needed to be numerate.

The most promising result however, is that the item scaling suggested that it was possible to generate a Numeracy Profile with rich descriptions of distinct developmental levels of numeracy performance based on the content and process analysis of the items included in the SNP (see Table 1 above). This has important implications for the design of structured, numeracy-specific teaching and learning materials which not only support students to acquire the necessary content knowledge and skills but also scaffold a hierarchy of skills, strategies and dispositions concerned with mathematical thinking and problem solving. As the development of the Emergent Numeracy Profile is a major outcome of the project it is
What does the [initial] data indicate about student numeracy performance in the middle years of schooling?

As the Phase 1 data collection represents the first large-scale attempt to evaluate numeracy not only in terms of the National Numeracy Benchmarks for Years 5 and 7 but also students’ capacity to interpret, apply and justify their mathematical thinking and/or decision making, it is difficult to gauge the significance of an overall result (logit mean score equivalent to 53.9%). Given the emphasis on mathematical problem solving and the use of mathematical tools and procedures over the last ten to fifteen years, this result at least suggests that there is scope for improvement in terms of the Emergent Numeracy Profile.

<table>
<thead>
<tr>
<th>Total Phase 1</th>
<th>Year 5</th>
<th>Year 6</th>
<th>Year 7</th>
<th>Year 8</th>
<th>Year 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Score: 53.9%</td>
<td>50.3%</td>
<td>55.7%</td>
<td>52.7%</td>
<td>54.7%</td>
<td>55.9%</td>
</tr>
<tr>
<td>Std. Dev. 11.2</td>
<td>10.5</td>
<td>11.0</td>
<td>10.9</td>
<td>11.1</td>
<td>11.8</td>
</tr>
<tr>
<td>N = 6859</td>
<td>1314</td>
<td>1318</td>
<td>1467</td>
<td>1484</td>
<td>1276</td>
</tr>
</tbody>
</table>

Table 2. Phase 1 Mean Percentage Scores of Student Numeracy Performance by Year Level

The statistically significant ‘dip’ in numeracy performance between Years 6 and 7 (Table 2) is consistent with similar data reported in relation to literacy performance in the middle years of schooling (Hill & Russell, 1999). While there are many other contributing factors, such as the transition from primary to secondary school and a range of social and emotional issues associated with emerging adolescence, it appears that at least some of the variance may be due to the relatively lower expectations of Year 7 students by their teachers.

A major factor affecting overall performance generally and the significant difference in Year 5 to Year 6 performance in particular, is the differential performance on tasks concerned with the use of rational number. ‘Hotspots’ identified by the initial data collection indicated that a significant number of students in Years 5 to 9 have difficulty with some or all of the following.

- Explaining and justifying their mathematical thinking
- Reading, renaming, ordering, interpreting and applying common fractions, particularly those greater than 1.
- Reading, renaming, ordering, interpreting and applying decimal fractions in context.
- Recognising the applicability of ratio and proportion and justifying this mathematically in terms of fractions, percentage or written ratios.
- Generalising a simple pattern and applying the generalisation to solve a related problem.
- Working with formula and solving multiple steps problems.
- Writing mathematically correct statements using recognised symbols and conventions.
- Connecting the results of calculations to the realities of the situation, interpreting results in context, and checking the meaningfulness of conclusions.
- Maintaining their levels of performance over the transition years.
• Working confidently, efficiently and flexibly with numbers: place-value knowledge, mental strategies, basic facts (from subsequent case-study interviews).

There were significant differences in student numeracy performance by sector where students from independent and catholic schools generally outperformed their state school peers. However, this data needs to be interpreted with some care. Given the smaller number of Catholic and Independent schools included in the sample, it is possible that they were less representative of the full range of schools in those sectors than the State schools. It is also possible that there was a bias in the sampling as selections were made from those schools that expressed interest in being involved in the sample. The generally higher socio-economic status of students attending independent schools is also a factor to be kept in mind.

There were some interesting differences with respect to location where it appears that the ‘dip’ between Year 6 and 7 performance was more marked in urban areas than regional and/or rural settings. In fact, in regional and/or rural areas the Year 7 mean actually represents an increase in performance. Taken together with the sectoral data above, this suggests that ‘cultural connectedness’ may be a factor in relatively lower levels of student numeracy performance of Year 7 students in state schools.

The distribution of students across the Emergent Profile Levels in each of Years 5 to 9 supports the phenomenon observed in the First International Mathematics and Science Study (eg, Keeves & Radford, 1969) of the ‘seven-year gap’ in mathematics performance of students in the middle years of schooling. This suggests that in any one, ‘mixed-ability’ class from Year 5 to 9 there is as much variation in performance as there is in the whole of Years 5 to 9. While this does not shed any light on how to optimise learning opportunities in the middle years of schooling, it does suggest that something quite radical needs to be done if the learning needs of individual students are to be adequately addressed.

To what extent have Trial Schools succeeded in improving student numeracy outcomes?

Teachers and targeted programs make a difference to student numeracy outcomes. There was a significant improvement in Trial School student numeracy performance means from Phase 1 to Phase 2 for 18 of the 20 schools. All of the increases in student numeracy performance in each year level between Phase 1 and Phase 2 data are significant (p<.05). However, it would appear that the ‘transition dip’ was ‘deepened’.

<table>
<thead>
<tr>
<th>Trial Phase 1</th>
<th>Year 5</th>
<th>Year 6</th>
<th>Year 7</th>
<th>Year 8</th>
<th>Year 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Score: 48.9%</td>
<td>42.5%</td>
<td>49.4%</td>
<td>47.7%</td>
<td>52.6%</td>
<td>52.4%</td>
</tr>
<tr>
<td>Std. Dev. 12.9</td>
<td>12.98</td>
<td>11.4</td>
<td>12.2</td>
<td>11.8</td>
<td>13.7</td>
</tr>
<tr>
<td>N = 2899</td>
<td>540</td>
<td>513</td>
<td>690</td>
<td>603</td>
<td>553</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Trial Phase 2</th>
<th>Year 5</th>
<th>Year 6</th>
<th>Year 7</th>
<th>Year 8</th>
<th>Year 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Score: 55.3%</td>
<td>52%</td>
<td>57.4%</td>
<td>53.7%</td>
<td>56.3%</td>
<td>57.6%</td>
</tr>
<tr>
<td>Std. Dev. 11.8</td>
<td>10.0</td>
<td>10.7</td>
<td>11.3</td>
<td>13.5</td>
<td>13.5</td>
</tr>
</tbody>
</table>
Table 3. Phase 1 and 2 Mean Percentage Scores of Student Numeracy Performance by Year Level for Trial Schools

As for Phase 1, there were significant differences between Years 5 and 6, Years 6 and 7, and Years 7 and 8 in the Phase 2 data (p<.001). In contrast to Phase 1, there was no significant difference between Year 8 and Year 9.

The item analysis suggests that the tasks associated with the most significant improvements in numeracy performance could be summarised as tasks involving a capacity to read and interpret everyday mathematical representations. There was also considerable improvement on tasks that required students to monitor and regulate their cognitive behaviour. The ability to represent fractions and decimals in a variety of forms, interpret data relevant to context, perform mental calculations and recognise, describe and use patterns were also areas where student numeracy performance improved. The ‘hotspots’ identified by the Phase 1 data remained relatively ‘hot’ despite the overall improvement in these aspects as well as others.

To some extent it would appear that simply being engaged in a project of this type has been sufficient to lead to improvements in student numeracy outcomes. However, there is sufficient difference between Trial Schools to suggest that something more was responsible for the improved performance.

Trial School data were grouped and analysed according to the two sampling criteria at the end of Phase 1. That is, the level of student numeracy performance (High Numeracy/Low Numeracy) and the extent to which schools were already implementing a range of school-wide policies and practices that might be conducive to school improvement more generally (Design Element Rich/Design Element Poor).

With respect to pre-existing levels of student numeracy the main findings were as follows.

- Students in those schools with the ‘furthest to go’, that is, with lower Phase 1 student numeracy performance scores, generally made the greatest improvements.
- Lower performing secondary schools did not improve as much as the lower performing primary schools, but they were starting from a higher base. While this reflects the particular challenges of teaching and learning in Years 7 to 9, it also suggests that there may be something about the culture and organisation of primary schools that is more conducive to supporting change initiatives.
- The relatively small improvement in numeracy for students at higher performing schools suggests that the implicit ‘standard’ set by the assessment task criteria is appropriate to the population being studied. It also suggests that some sort of temporary ‘ceiling’ may have been reached that requires a more radical and longer-term focus to ‘break through’.

With respect to the extent that schools had a range of school-wide policies and practices in place at the outset, the main findings were as follows.

- Schools that had already embraced a range of school-wide policies and practices in relation to school improvement (Design Element Rich) were among those schools that made the highest mean gains. However, lower numeracy performance appeared
to be a stronger factor in mean gain than the status of school-wide policies and practices at the start of the program.

- Schools that had the ‘furtherest to go’ in relation to school-wide policies and planning (Design Element Poor), generally made the most significant improvements in student numeracy performance, particularly those starting from a relatively lower numeracy base (LNP schools).
- With the exception of one school, High Numeracy/Design Element Poor schools (identified as HNP) were among the schools who demonstrated the least improvement in student numeracy performance. This is possibly due to the ‘ceiling’ effect described above, but it is more likely due to the particular socio-cultural/policy context of these schools, where the need for change may not be as apparent as it is in some other settings and staff are generally satisfied with ‘current’ practice.
- The relative spread of schools in the High Numeracy/Design Element Rich category (HNR) appears to be associated with key changes in leadership and/or coordination but it may also have something to do with ‘reform fatigue’. That is, schools committed to a range of policy initiatives for some time can reach a point where there is simply too much change.
- Changes in leadership would also appear to explain the apparent differential performance of Schools 5 and 12 in relation to the remaining LNR schools (4, 14 and 13) while ‘reform fatigue’ may be an additional factor in relation to School 12 which is recognised as an innovative school.

The differences between the mean student numeracy performance measure for Phases 1 & 2 show that the greatest gains were for schools in the LNR category. The mean is significantly higher ($p<.05$) than the next highest gain group LNP. A major factor contributing to this difference is the relatively large gains made by Year 5 groups in LNR and LNP schools possibly because of the increased focus on the means to interpret, apply and communicate one’s mathematical thinking.

**Class by class performance** - Analysed within school on a class by class basis, the student numeracy performance data suggests that there is as much difference within schools as between schools. This supports similar observations reported by Hill et al (1999) in relation to the middle years of schooling more generally.

A more detailed, multi-level analysis would be needed to determine the extent of this variation. However, a tally of the number of year level cohorts within which there is evident variation reveals that there is almost double the incidence of variation in student performance across classes in secondary schools compared to primary schools (approximately 50%-60% and 30% respectfully). Furthermore, the larger the school the more evident the variation. While in some instances the level of variation may be due to ability grouping and/or inter-marker reliability, the widespread prevalence of within cohort variation across the sample underlines the crucial importance of teachers to student learning.

**Gender** - In the Phase 1 testing there was no significant difference between performance of males and females but there was a significant gender difference in Phase 2 in favour of the females. One possible explanation for the significant difference could be that girls, who generally out-perform boys in relation to literacy in the middle years, might be more likely to benefit from an increased focus on the discourse elements required by the particular form of assessment.

**Emergent Numeracy Profile Shifts** - Not surprisingly, given the overall increase in student numeracy performance, there was a significant shift in the relative proportions of students at each level of the Emergent Numeracy Profile from Phase 1 to Phase 2 (see Table 4). This is indicated by the fact that in November 1999, just over 61% of the students in Years 5 to 9
were performing at or above Level D on the Emergent Numeracy Profile, while in November 2000 this proportion had risen to just under 80%. The mean shift across all Year levels was 1.52 Profile levels.

<table>
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<th>Total</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
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</table>

Table 4. Proportion of Trial School Students by Profile Level for Phase 1 and 2

It is clear from the improvements in student numeracy performance achieved by all Trial Schools that teachers and targeted programs make a difference and, in particular, that a whole-school approach to numeracy improvement is a key element in achieving success.

*What can we learn from interviews with students identified as ‘at risk’ about their experience of learning school mathematics? What contribution do other subject areas and reported ‘out-of-school’ experiences have on student numeracy achievement?*

‘Typically weak’ or ‘at risk’ students expect school mathematics to equip them for the future. They believe that mathematics is important and that teachers of mathematics are primarily responsible for ensuring that they have access to opportunities to learn mathematics. For students who ‘fall behind’, the quality of teacher explanations is seen to be one of the most important factors affecting their learning of mathematics. However, the quality of explanations depends as much on the listener as the speaker. To participate in the conversation, to appreciate what is being said, students need to be able to access relevant prior knowledge and be disposed to engage in the conversation.

Engagement is a consequence, not a cause, of understanding. It is also closely related to past success. That is, students are willing to engage in the task of learning and applying mathematics to the extent that they believe they understand what is required of them and they experience some success. This suggests that inviting engagement is more about meeting students ‘where they are at’, than providing ‘more of the same’. To be able to do this teachers need accurate and reliable knowledge of students, what they know and how they know it, and a deep understanding of the pedagogical tools needed to involve students in the enterprise of learning mathematics.

The distinction observed by Marr (2001) in relation to talk in adult numeracy classrooms, that is, the *opportunity to speak* and the *means to speak* appears to be relevant to the issue of student engagement. While schools and teachers need to ensure students are given the *opportunity to engage* through the selection of appropriate content and the use of a variety of teaching approaches, this on its own is insufficient. Students also need access to the *means to engage*. That is, how to read, write and speak mathematically, how to participate in the conversation and text of mathematics. While this requires some focussed attention on the key underpinning ideas such as place-value and part-whole relationships, teachers also need to deal directly and overtly with the ways in which mathematics is represented and communicated, the models and symbols used to explicate mathematics.
From the students' point of view, the most important contribution teachers can make is to communicate mathematical ideas and texts effectively to them, on a one-to-one basis where needed, to help them build shared meaning. This message is overwhelming and cannot be ignored.

Because disengagement tends to be associated with poor learning outcomes, it is often assumed that engagement will lead to improved outcomes and that engagement in mathematics learning is about making maths fun, relevant and "not boring." While adopting an expanded range of non-text based teaching approaches is clearly favoured by these students and more likely to engage them as learners, this on its own is insufficient if it does not address, support and enhance student understanding.

Disengagement is a consequence of not understanding the task and lack of confidence derived from the experience of repeated failure. This suggests that mathematics teaching and learning needs to focus more on opportunity to engage through negotiating the means to understand the texts of mathematics, and by knowing where students are at and how to scaffold and extend their understanding. The focus should not be on ‘relevance’ or ‘fun’ for its own sake. Rather, the focus should be on ensuring students understand and they experience some success.

The following propositions were derived from the student interview data with respect to students ‘who fall behind’. They have been loosely grouped into statements about students, teachers and teaching.

- Students believe that mathematics is important and relevant.
- Students generally want to learn and be able to apply mathematics.
- Mathematics is not perceived to be as ‘boring’ or irrelevant as is often assumed.
- Students are prepared to accept some of the responsibility for learning.
- The most critical element in their learning from the students’ perspective is the quality of teacher explanations, in particular, the capacity of teachers to connect with their level of understanding and communicate effectively.
- The teaching focus needs to be on identifying and scaffolding student’s learning needs.
- Accurate and reliable assessment is essential to identify where to start teaching.
- Extensive professional development is needed to equip teachers of mathematics with knowledge and skills to probe students understanding, support conversations about the ways in which mathematics is represented and used and to scaffold students’ mathematical thinking.
- ‘Traditional’ text-only based approaches are seen as a major impediment to engagement and successful learning.
- Student engagement is related to capacity to read, write, speak and listen to mathematical texts (communicative competence). That is, capacity to understand and access the forms of communication used in mathematics.
- Success is crucial to engagement.
- Students would prefer more one-on-one assistance.
- Students prefer mathematics classes to be activity-based (that is, games, manipulatives, investigations), deliver success, involve problem solving, and be conducted in a constructive and positive manner.
- Relevance is about connectedness, it is not necessarily about immediately applicable, ‘real-world’ tasks, although this is important. It is, at least in part, about being able to access what is seen to translate to further opportunities to study mathematics, ‘real’ maths, and access to ‘good’ jobs.
- Given the areas students find ‘hard’ are loosely connected to the same ‘big ideas’, specifically, place-value and multiplicative thinking, a logical starting point would
appear to be to build on students’ ideas about addition and whole number using applications in measurement to justify and extend students’ thinking.

Student’s decisions about their learning also effect engagement and performance. The Project to Enhance Effective Learning (PEEL, eg, Baird & Northfield, 1992), a longitudinal project aimed at increasing student’s knowledge of and responsibility for their own learning across all key learning areas, has identified a number of poor learning habits that cause learners to make inappropriate decisions about their learning.

- **Impulsive attention**: patchy attention to the information. Some parts of the information are thought about, other parts are ignored.
- **Superficial attention**: skimming over or scanning the information without making an effort to process and understand it.
- **Inappropriate application**: applying remembered procedures blindly, in the hope that they will give the correct answer.
- **Inadequate monitoring**: often seen as the learner getting "stuck' in a problem or exercise, and being unable to get ‘unstuck’ without help.
- **Premature closure**: not checking to ensure that work done has complied with the task set, leading to an incorrect or inadequate answer.
- **Ineffective restructuring**: for example – as a result of teaching, a student recognises that he or she has a misconception and comprehends an alternative idea, yet later reverts back to the original misconception.
- **Lack of reflective thinking**: information learned is in little boxes relatively unrelated to each other. Students do not look for any connection between one activity or lesson and another – they are discrete, unrelated events (Mitchell, 1999)

This suggests that focussing on changing poor learning behaviours/habits **rather than ability**, is a powerful way to address a number of the difficulties and challenges presented by the middle years of schooling.

**What characterises the practice of those schools that made the most improvement in student numeracy performance and/or sustained relatively high levels of student numeracy performance? How do these practices relate to the Design Elements under consideration and more generally?**

The Action Plans and Final Reports of those schools that made the most improvement in student numeracy performance and/or sustained relatively high levels of student numeracy performance were found to be remarkably convergent. The distribution of strategies providing strong support for the Hill and Crévola (1997)*General Model of School Improvement* as a framework for designing school-based action plans. The following **Blueprint for Action** summarises the strategies found to be associated with improvements in student numeracy performance in Trial Schools. It needs to be remembered that not all schools exhibited all strategies.

**A Blueprint for Action**

**Beliefs and understandings**

- There are established processes for reviewing, deciding and documenting what teachers, and the school community more generally, jointly believe and understand to be best practice in relation to the teaching and learning of school mathematics and numeracy education.
Leadership and coordination

- The school appoints a coordinator with responsibility for middle years' numeracy.
- Active and committed support is provided by senior school leadership.
- Numeracy improvement is formally recognised as a major goal of schooling and is a school priority.

School and classroom organisation

- Regular, sustained periods of uninterrupted time are provided for mathematics.
- Mathematics class sizes are varied on a regular basis to achieve specific purposes.
- A conscious effort is made to use a common, structured lesson format.
- Classroom teaching resources are reviewed, expanded and managed to maximise sharing.
- A wider range of flexible groupings is employed within classrooms and additional support is provided where possible.

Classroom teaching strategies

- Regular and systematic use is made of open-ended questions, games, authentic problems, and extended investigations to enhance students’ mathematics learning and capacity to apply what they know.
- Teaching strategies are focused on connections and strategies for making connections.
- Students are actively engaged in conversations and texts that encouraged them to reflect on their learning and explain and justify their thinking.
- Special attention is given to the literacy aspects of mathematical texts and representations.
- Learning activities are designed or chosen appropriate to learners’ needs and interests and use a balance of teacher-directed and student-centred approaches.
- Opportunities are provided for meaningful and enjoyable practice of essential knowledge and skills.

Professional learning teams

- Teams meet regularly to review and plan classroom learning activities, discuss student work samples, consider classroom structures, share ideas and resources, discuss issues relevant to numeracy education.
- Targeted professional development is provided.
- Interested others are invited to numeracy-related meetings.
- Teacher and student reflections are used to inform the development of shared teaching resources and approaches.
- Associated schools are approached with a view to exploring joint opportunities for numeracy related activities.

Monitoring and assessment

- A range of assessment strategies are used to evaluate and monitor students’ numeracy-related knowledge.
- Students’ capacity to interpret, apply and justify their numeracy-related knowledge relevant to context is valued and assessed.
- Students are actively encouraged to reflect on their learning and those reflections are used to inform subsequent teaching.
‘Rich’ assessment tasks and scoring rubrics are developed to assess numeracy performance on a regular basis.

Individual progress of each student is monitored using learning plans, tracking sheets and/or individual interviews to probe students understanding where necessary and identify ‘where students are at’.

Specific audits of key ideas and/or strategies are conducted across Years 5 to 9 as appropriate.

**Intervention and special assistance**

- A range of effective and efficient monitoring strategies are used to ensure students with special learning needs are identified and supported.
- There are strategies and/or structures to support students who are performing either well above or well below the level that might be expected.
- Special assistance is provided to students from non-English speaking backgrounds.
- The link between numeracy and literacy is recognised and teaching strategies that support students to read, write, interpret and critique everyday texts, including those that require some aspects of quantitative, spatial or proportional reasoning are adopted.

**Standards and targets**

- The school community has an agreed understanding of where they want their students to be, and sets realistically high targets for all students based on a thorough understanding of where students are at the present time, that is, where students need to start learning.
- The importance of communication skills in relation to mathematics and numeracy are recognised and include standards and goals related to reading, interpreting, presenting, explaining and justifying mathematical ideas and strategies in context.

**Home, school and community partnerships**

- Parents are informed about school and/or classroom practices related to mathematics and/or numeracy through information sessions, newsletters, exhibitions of student work.
- Parents are involved in aspects of students’ mathematics learning and problem solving.
- Opportunities are provided for shared mathematics where parents work with students on mathematical problems and/or rich assessment tasks at home or at school.
- Other schools are approached to provide transition programs, share resources, support remote or isolated teachers, manage cross-age tutoring;
- Student achievement is celebrated publicly.

The Action Plans of those schools who either made a substantial difference to student numeracy performance or were already achieving relatively high levels of student numeracy performance reveal a fundamental commitment to excellence in mathematics teaching and learning. While building on school mathematics is a logical starting point and consistent with what is known about learning, the literature suggests that that further gains in numeracy performance may also be achieved if:

- starting points for teaching were more aggressively determined by learner’s needs (rather than assumed levels of the curriculum) where the focus would be on the ‘big ideas’ and the scaffolding needed to move students to the next level of understanding;
• technology was explored more specifically in relation to numeracy teaching and learning;
• greater consideration was given to the use of numeracy-related tasks that involve the manipulation of concrete materials, particularly in Years 7 and 8;
• it was recognised that differential teaching is likely to be more effective than linear, lock-step approaches or differentiated curriculum (separate programs or streamed classes), particularly for those students who ‘fall behind’;
• greater attention was given to the metacognitive aspects of learning, that is, what is known, how it is known, and what strategies are useful in learning and applying what is known;
• students in the middle years of schooling were given a real say in what they learnt and when and how they learnt it.
• a conscientious effort was made to heighten student and teacher awareness of the possibilities for developing numeracy-related knowledge, skills and dispositions through an examination of problems and issues in other Key Learning Areas.

What can we learn from the experience of Trial School teachers in relation to improved numeracy performance?

The main findings in relation to this question are as follows.

• Teachers’ reflections on their practice add weight to the view that ‘good’ mathematics teaching, which focuses on ensuring that all students have the opportunity to learn, is a necessary first step towards improved student numeracy performance.
• In recognising that ‘good’ mathematics teaching is the starting point, some consideration needs to be given to what teachers see as impediments to more effective practice and thereby improvements in numeracy.
• Dealing with difference is a major issue for middle school teachers suggesting further work and professional development is needed in this area.
• A key factor in dealing with difference is the capacity to efficiently and accurately identify the specific learning needs of individuals and optimal starting points for teaching.
• Access to more appropriate resources is high on the list of what teachers identify is needed to improve numeracy outcomes.
• The sheer size and form of what is perceived to be expected of school mathematics is weighing heavily on practice in the middle years.
• There is an overwhelming perception that there is insufficient time to “do everything that needs to be done”.
• How teachers’ perceive their role would appear to be quite critical to the task of improving numeracy outcomes.
• While a range of non-text based approaches to teaching and learning mathematics, specifically, open-ended questions, problem solving, extended investigations and a greater emphasis on practical, hands-on activities, were found to be useful in engaging students in the middle years of schooling, simply engaging students will not ensure learning occurs.
• Teachers and students recognise and value the important role of discourse in building understanding and confidence.
• Teaching approaches which value and build on each student’s contribution, ensure all students have an opportunity to learn and actively support those who need it most are more likely to lead to improved student numeracy outcomes.
• Teachers clearly value and acknowledge the need for targeted professional development.
On the basis of the evidence derived from this project, what advice can be offered to schools and systems which will lead to the development of a coordinated and strategic plan for numeracy improvement?

This question deals with the major aim of the project. The advice derived from the work of the project will be reported in the form of recommendations below.

Recommendations including implications for future research

Understanding and Assessing Numeracy in the Middle Years of Schooling:

A critical starting point for improving numeracy outcomes is shared beliefs and understandings about the nature of numeracy and numeracy education in the middle years of schooling. As assessment provides an immediate and practical image of what is valued, numeracy-specific assessment has an important role to play in helping build these shared beliefs and understandings. It is also essential in identifying where to start.

1. Although this study has offered, what the researchers believe to be a fairly comprehensive view of numeracy in the middle years of schooling, it is recognised that further work is needed to translate this into practice. Ideally, this would take two forms.

   a. A review of the literature in 12-20 months time to ascertain how this view resonates with related international work in progress, for example, the Programme for International Student Assessment (PISA) and the work at the Freudenthal Centre in The Netherlands.

   b. A systematic exploration of numeracy at this level through the lens of professional development which involves teachers trialing exemplary activities, reflecting on their experiences and articulating what numeracy means for them and their students.

2. The usefulness of the Student Numeracy Performance tasks and the Scoring Rubrics suggests that they need to be expanded and published in a user-friendly form. Systematic trialing of new tasks is recommended to establish the reliability and validity of the SNP instruments over time and to elaborate and refine the Emergent Numeracy Profile.

3. Given that what is assessed and how it is assessed conveys important messages about what is valued, it is recommended that systems consider setting appropriate standards and targets in relation to the communicative aspects of numeracy which demand a wider range of assessment strategies including performance-based rich assessment tasks of the type modelled in this study.

4. The Diagnostic Interview developed for this study provides a useful starting point for the identification of numeracy-related learning needs. Given that one-on-one interviews have significant resource implications, parts of this interview could be used to probe specific areas of student learning. Further research is needed to extend the possible uses of this instrument.

5. Research and develop more reliable, ‘user-friendly’ class-based protocols for determining ‘where students are at’, that is, what they know and how they know it. Recognise that teacher knowledge and beliefs are crucial and that these are most powerfully influenced by reliable data about student learning.

Planning for Numeracy:
It is evident that improvements in numeracy will not be achieved without a significant amount of planned effort. The following recommendations address the issues of process, professional development and leadership and coordination.

6. Given that the Design Element approach to whole school improvement used to frame the school-based action planning process was a significant factor in the success of the Trial schools it is recommended that this approach be adopted by schools embarking on a structured and deliberate attempt to improve numeracy outcomes in the middle years of schooling within a school-wide policy context that supports and values the efforts of staff and students.

7. It is suggested that the Action Planning process used to guide the work of Trial Schools and the Blueprint for Action (10.1.9) be published as a kit including the Student Numeracy Performance tasks, Scoring Rubrics and the Diagnostic Interview and used in the context of a structured professional development program to begin the work of improving numeracy outcomes in the middle years.

8. The observed differences in student numeracy performance between same year level classes at the same school in relation to the student numeracy performance underlines the crucial importance of teachers to students’ numeracy learning. Schools need to ensure that teachers assigned to teach mathematics and/or numeracy in the middle years of schooling are appropriately supported through the provision of targeted professional development, a team-based approach to numeracy, suitable teaching resources and/or access to mentors as needed.

9. Serious consideration needs to be given to how mathematics and/or numeracy teaching is resourced in the middle years of schooling. In particular, to the amount of time provided in the timetable for mathematics and numeracy-related teaching, the amount of support provided to professional teams to enable them to meet and share their practice and the physical resources provided in terms of rooms, teaching materials and relevant technology and access to relevant professional development.

10. The cycle of lack of understanding is exacerbated by the dislocation and disruption to established relationships that inevitably occurs in the transition from primary to secondary school. This is a difficult issue to resolve but it would seem to be addressed in part by access to high quality, accurate information. This amplifies the need for improved assessment instruments and targeted professional development. It also suggests that more time is needed to engage more closely with individuals. This could come from increased time in the school timetable, either for mathematics or in a more integrated and focused way through the application of relevant mathematical ideas and strategies in other Key Learning Areas. Alternatively, and probably more desirably and practically, a redefinition of the school mathematics curriculum in terms of a very much smaller number of ‘big ideas’ (see below).

Re-shaping the Expectations:

Improvements in numeracy outcomes were largely achieved as a consequence of a concerted focus on recognised ‘best practice’ in the teaching and learning of mathematics. A major impediment to more effective practice is the sheer amount of perceived content. How school mathematics is represented and positioned within the context of teaching and learning in the middle years more generally is needed to improve and sustain improvements in numeracy.

11. The ‘transition dip’ between Years 6 and 7 suggests that serious and urgent consideration needs to be given to what mathematics is taught and how it is taught at this level. Traditional secondary approaches based on linear sequences of topics supported by the use of textbooks may not be the most effective way to engage young learners, many of whom need additional and special assistance.
12. While speaking and listening are key ingredients in building shared meaning for mathematical ideas and texts, quality speaking and listening can only occur where there is sufficient trust, knowledge and confidence to share and work at what is known and how it is known. Above all, where there is sufficient time to focus on meaning as opposed to just ‘doing’. This has important implications for the design and delivery of school mathematics programs. It would appear that for too many students and teachers there is simply too much to do and not enough time to do it. While many students will be able to learn from the experience of doing, this depends on having access to a network of related ideas which inform and are shaped by the doing. Without the linking, connecting ideas and the means to access and elaborate those ideas, the doing becomes a boring, repetitive and unproductive exercise. Teachers and students need time to elaborate and explore ideas. This does not mean a reduction in expectations but a shift in expectations and targets from a large range of relatively disconnected ideas to a very much smaller, far more connected set of ‘big ideas’ supported by descriptions of the sort of conversations that teachers might be expected to have with students if they understood those ideas.

13. Key growth points in major areas of mathematics learning, and the scaffolding needed to help students move from one growth point to the next, need to be identified and elaborated as a matter of priority. The Early Years Numeracy Research Project is making substantial progress in this direction but further research is needed to extend this approach into the middle years of schooling.

Teaching Strategies:

Specific recommendations to support ‘best practice’ in the teaching and learning of mathematics follow.

14. Clearly, for the students who ‘fall behind’ to feel comfortable with the areas identified as ‘hard’, it is essential that teachers of mathematics in the middle years focus more directly on identifying and scaffolding student’s ideas. Given that these key areas are loosely connected to the same ‘big ideas’, specifically, place-value and multiplicative thinking, a logical starting point would appear to be to build on students’ ideas about addition and whole number using applications in measurement to justify and extend students’ thinking. Teaching approaches should also recognise what students are identifying as a key element in helping them to understand; that is, effective teacher communication which goes beyond providing ‘more of the same’ and examples on the board or in the text. While this may sound simple, it requires extensive professional development to ensure teachers’ own knowledge and confidence goes beyond the text to an appreciation of what lies beneath and the likely sources of student confusion.

15. In planning teaching and learning for numeracy, teachers should focus on opportunities to engage with the ‘big ideas’ in a purposeful way, determine student progress and instruction on the basis of research-based, learning trajectories and differentiating the teaching and support provided NOT the curriculum. That is, offer choices within programs not between and be prepared to provide different levels of support to those who need it. Teachers need to be supported to change classroom norms to value communication and pursue the ‘big ideas’ to greater depth through the provision of challenging problems and investigative, open-ended tasks and to involve more capable students as responsible others in a committed learning community.

16. Teachers should be supported to recognise and respond to how students learn. Poor learning behaviours need to be identified and replaced by more effective learning strategies. One way of doing this is to recognise what students value and attend to in relation to the teaching and learning of mathematics. Focussing on higher order
cognitive skills, problem solving strategies and open-ended tasks can lead to a shift in student’s learning style/approach, in particular, their capacity to attend to and monitor both their understanding of the situation and their cognitive actions or problem solving behaviour (Siemon, 1993). Improvements in numeracy performance will require shifts in both the content knowledge (what students know and how they know it) and strategic or process knowledge (how to interpret, represent, communicate mathematical knowledge). Given that this requires increased attention to the metacognitive aspects of learning and using mathematical ideas and processes, that is, monitoring, regulating, and evaluating one’s thinking and actions, the recent trend towards the Thinking Curriculum (see Middle Years Research and Development website) is to be commended.

**Dealing with Difference:**

A major concern of teachers in the middle years of schooling is the issue of catering for the vastly different learning needs of individuals. This issue needs to be addressed on a number of fronts.

17. One of the clear implications that can be drawn from the student numeracy performance data and the student interviews is that early diagnosis and intervention is critical. Given that it is generally accepted that all children are able to learn given sufficient time and support, it is unacceptable that such large differences in student performance are tolerated when so much more is known about how young children learn mathematics than 30 years ago. Targeted professional development is needed to support teachers identify numeracy-related learning needs and provide the scaffolding needed to support students’ learning. While existing research in mathematics education can be used to support some of this, further research is needed to identify and elaborate the scaffolding needed to support numeracy-specific ideas and strategies.

18. The relative lack of stability in student numeracy performance over the course of the middle years of schooling and the suggestion that students are ‘back on track’ by Year 9 suggests that formally differentiating the curriculum before students achieve some sense of responsibility for their own learning can only exacerbate and amplify these differences. While further work is needed on more appropriate organisations for learning in the middle years, it would appear that the use of flexible grouping within mixed ability classrooms supported by specialist one-on-one intervention is a more appropriate option in dealing with difference in relation to school mathematics and/or numeracy.

19. Further work is needed to explore the efficacy of vertical and/or cross-curriculum or integrated curriculum arrangements in relation to improved numeracy performance.

**Engagement:**

Student interest and engagement in learning mathematics and/or numeracy is also a major issue for teachers and schools in the middle years.

20. As a sense of ‘cultural connectedness’ appears more likely to encourage constructive, risk-taking, explorative behaviour than feelings of alienation or uncertainty, it is recommended that serious consideration be given to the ways in which relevant social support systems might be provided in within the culture of the classroom and the organisation of schooling. The work of the Victorian *Middle Years Research and Development Project* (MYRAD) may be able to provide further advice in relation to this issue.
21. Although students ‘at risk’ clearly value the use of a broader range of more inclusive practices, their responses to the interview questions suggest that disengagement may have as much to do with their perceptions of how they are treated by their teachers as the particular nature of the teaching practices used. In particular, it appears that the extent to which efforts are made (and seen to be made) to communicate respectfully with students in a way which recognises and accepts ‘where they are at’ is a key factor in whether or not middle year students are prepared to engage in the task of learning mathematics and problem-solving. The critical importance of social interaction in the construction of meaning (eg, Bauersfeld and Cobb, 1995) is widely recognised but for this to be effective the nature of this communication needs to go well beyond ‘show and tell’. This can only occur where teachers have:

a. access to accurate information about what the student knows (requires high-quality, reliable tools to assess student’s mathematical knowledge and capacity to use that knowledge),
b. a grounded knowledge of the particular learning trajectories involved (that is, the major ‘growth points’ in the development of key ideas and how to scaffold these with students);
c. an expanded repertoire of teaching approaches which accommodate and nurture discourse, help uncover and explore student’s ideas in a constructive way and ensure all students can participate and contribute to the enterprise;
d. sufficient time with students to develop trust and supportive relationships; and the
e. flexibility to spend time with the students who most need their time.

It is clear from the work undertaken in relation to this project that there is an urgent need to identify, describe and resource more effective ways of supporting teaching and learning in the middle years of schooling. The work of the Middle Years Numeracy Research Project and the Middle Years Research and Development project more generally are clearly important here but further work is needed to help break down the curriculum ghettos which inhibit more effective structures and organisations for learning at this level. Structured professional development programs to support and enhance the work of teaching school mathematics at this level are a logical first step in improving numeracy outcomes. However, sustained and on-going improvement will also require a serious review of how school mathematics is represented and positioned within the context of teaching and learning at this level.
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