SUCCESSFUL INTERVENTIONS
NUMERACY RESEARCH PROJECT

THE MIDDLE YEARS NUMERACY RESEARCH PROJECT: 5-9

This project was commissioned by the
Department of Education, Employment and Training, Victoria
Catholic Education Commission of Victoria
Association of Independent Schools of Victoria

The research project was undertaken by

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FINAL REPORT

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CONTENTS:

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Associate Professor Dianne Siemon
Director MYNRP
May, 2001.

1. Executive Summary

The *Numeracy Research Project*: 5-8+ (Stage 2), or the *Middle Years Numeracy Research Project* (MYNRP) as it later came to be known, was commissioned by the Victorian Department of Education, Employment and Training (DEET), the Catholic Education Commission of Victoria (CECV) and the Association of Independent Schools of Victoria (AISV) to provide advice which will lead to the development of a co-ordinated and strategic plan for improving the teaching and learning of numeracy in Years 5 to 9.

This project commenced in September 1999 and was completed by the end of 2000.

The MYNRP involved the collection of base-line numeracy performance data in November 1999 from a structured sample of year 5 to 9 students from 27 primary schools and 20 secondary schools across Victoria. 'Rich assessment tasks' and an extended classroom activity were used to assess both the student's knowledge of key, underpinning mathematical ideas and their capacity to apply and communicate this knowledge in context. The *National Numeracy Benchmarks* at Years 5 and 7 were used to select and/or design items. Scoring rubrics were provided to assist teachers evaluate student responses. Data on related school-wide policy initiatives was also collected at this time.

On the basis of this initial data collection, 20 Trial Schools were selected to explore what works in relation to improving numeracy outcomes. School Action plans were developed in terms of the key design elements described in the *General Design for a Whole-School approach to School Improvement* developed by Hill and Crévola (1997). 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.

Trial Schools were visited by Project personnel and supported through the provision of a small school grant. At the end of 2000, the Action Plans were evaluated by means of a school-wide survey, teacher questionnaires, teacher journals and a repeat administration of a parallel form of the student numeracy performance tasks. Individual interviews were also conducted with a small sample of students identified as 'at risk' by their school.

The results and outcomes of the research support the following general conclusions.

- It is possible to measure a complex construct such as numeracy using rich assessment tasks incorporating performance measures of content knowledge and process (general thinking skills and strategies) and teachers-as-assessors at this level.

- The quality of the item analysis supported the development of an Emergent Numeracy Profile that maps student numeracy performance against a continuum of rich descriptors that can be used to inform subsequent instruction. This is a significant outcome with the potential to make a major contribution to how numeracy is viewed and assessed in the middle years of schooling.

- There is as much difference in student numeracy performance within year levels as there is between Years 5 and 9 students overall. That is, in most Year 5 to 9 classes teachers can and should expect a range of up to 7 school years in numeracy-related performance. Dealing with difference in mainstream classes is a significant issue for teachers and schools in the middle years of schooling. Further work is needed to explore more effective ways for dealing with difference in the middle years. Reframing curriculum expectations to ensure efforts to improve student numeracy performance are appropriately targeted is an important first step.

- There is a significant 'dip' in student numeracy performance from Year 6 to Year 7 which students do not appear to recover from until they reach Year 9. This supports the work of the MYRAD project and confirms the need for a quite radical reappraisal of how the transition from primary to secondary school is managed and how learning is organised in the middle years of schooling.

- Teachers and targeted programs make a difference to numeracy outcomes in the middle years of schooling, particularly where they share a common set of beliefs and understandings and are supported by a whole-school approach to planning. Effective professional leadership/coordination at the local level is essential.

- The action planning process based on the design elements of the Hill and Crévola (1997) model for school improvement was effective in supporting Trial Schools improve numeracy outcomes in the middle years of schooling. A Blueprint for Action was prepared on the basis of advice derived from the experience and Action Plans of those schools who made the greatest improvement is student numeracy performance.

- It appears that there is at least as much difference between classes at the same school as there is between schools which suggests that teachers make a difference in another way. That is, *opportunity to learn* is as much a factor in explaining differences in performance as so-called *ability*. Providing relevant professional support and differentiating teaching to ensure all students have relatively equal opportunity to learn would appear to offer a better chance of maximising success for all.

- All Trial Schools demonstrated an improvement in student numeracy performance. For 18 of the 20 Trial Schools this difference was statistically significant. In view of this, it is recommended that the action planning process and the materials that support it be published and disseminated in the form of a structured professional development program. This ‘kit’ would include the assessment protocols developed for the study and the Blueprint for Action.

- 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. However, while ‘good’ mathematics teaching is necessary to numeracy improvement, it is not sufficient. Consideration also needs to be given to how learning is organised and supported in the middle years of schooling and how what is expected of schools and students in terms of numeracy-related learning outcomes is represented.

- A significant number of students in Years 5 to 9 appear to be experiencing difficulty in relation to some aspects of numeracy ranging from key underpinning mathematical concepts, skills and strategies to issues of engagement and communication. Fractions, decimals, multiplicative thinking and the capacity to interpret, apply and communicate what was known in context were among the most common sources of student difficulty.

- One of the clear implications of the research is that early diagnosis and intervention are critical. To support this, key numeracy-related growth points 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. Teachers also need to be supported to work with these ‘big ideas’, identify poor learning behaviours early on and replace these with more effective learning strategies.

- Success is a major component in student preparedness to engage with mathematics in the middle years. Teaching approaches and strategies for dealing with difference which maximise opportunity to learn and provide students with the means to access and connect new learning to their prior learning are needed to support more effective practice. While flexible group work within mixed ability classes appears to be a useful approach, further work is needed to identify and elaborate how this might be supported more effectively and efficiently in practice.

- 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 on 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 construction of school mathematics curriculum at this level. It would appear that for too many students and teachers in the middle years 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.

- Attempting to meet unrealistic curriculum expectations places teachers and students at odds with each other. The 'crowded curriculum' syndrome provides little space for connecting, generalising and conjecturing, and the primary focus on 'doing', as opposed to inquiry tends to generate passive learning and poor learning habits. A strong implication of this research is that serious consideration needs to be given both to the nature and degree of content specificity that is provided in mathematics curriculum framework documents. A focus on the 'big ideas' and the scaffolding needed to acquire and use those ideas with confidence is needed as a matter of urgency. Consideration also needs to be given to how the curriculum in general is framed at this level with a particular focus on the relationships and possibilities for learning that exist in cross-curriculum approaches to teaching and learning.

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 Research and Development* project is 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.

2. Context and Purposes of the Study (including revised literature review and background to the study)

2.1 Background

A project which focuses on numeracy development in the middle years of schooling (5-8+) is both timely and strategic. It is timely because relatively little is known about numeracy at this level compared with what is known about literacy (AAMT, 1997). Furthermore, while there are a number of initiatives in relation to numeracy education in the early years there is a growing body of evidence to suggest that well-designed support in the middle years may have a greater impact on the child's future educational development than previously thought (Pogrow, 1998). It is strategic because quality data about what children can and might be expected to do in relation to numeracy is absolutely vital in a climate of National Numeracy Benchmarks and public statements that "every child commencing school from 1998 will achieve a minimum acceptable literacy and numeracy standard within four years" (MCEETYA, 1997). That is, data of the type likely to be generated by the *Numeracy Research Project 5-8+* is needed to inform the on-going development and evaluation of numeracy standards and targets.

The *Numeracy Research Project 5-8+* was planned as the second stage of a proposed three stage project which will take place over four years and build on the findings of the *Early Literacy Research Project (ELRP).* This stage of the project will directly relate to, and build on, the work of the *Early Numeracy Research Project (ENRP).* The first stage of the proposed three-stage project was completed in 1998. It constituted an environmental scan to determine the intervention practices currently being used to address the needs of Years 5 to 8 students in Victorian schools. A *Strategic Partnerships with Industry – Research and Training Scheme* grant was submitted by the project team and industry partners to support the third stage of the proposed project.

Given the relatively short time frame for the *Numeracy Research Project 5-8+* (originally planned for 11 months), it was felt that the most efficient, cost-effective way to collect the sort of data that will inform "the development of a strategic and coordinated approach and advice for schools about the teaching and learning of numeracy for students in years 5-8+" (Project Brief, p.1) is to gather reasonably large-scale sample data on numeracy performance at this level and compare this on a school by school basis to survey-type data which provides an indication of current school-wide policies and practices. Such an approach would provide an objective basis for determining what appears to be working and not working in numeracy-education at the present time and for examining the extent to which school policies and practices, particularly those associated with the design elements of the Hill & Crevola (1997) model, contribute to numeracy performance. Further information on the research approach adopted for the study is contained in Section 3 of this report.

As indicated above, a project which focuses on numeracy education in the middle years of schooling (5-8+) is both timely and strategic. It is timely because while there is much that can be learned from current initiatives in relation to the early years, it is clear that the definition of numeracy widens in the middle years of schooling. In the early years, the focus is strongly on the development of counting and number; especially the development of place-value understanding. In the middle years, while extension of number into decimals constitutes a major step forward, numeracy also takes on wider dimensions involving extensions of mathematical knowledge into measurement, space and chance and data. At this stage, cross curriculum links and cross curriculum learning becomes critical in developing strong foundations in numeracy, important not only for mathematics but also for providing a firm foundation for further studies in school. This implies that there is a need to examine more closely what numeracy involves at this level and how it might best be promoted and achieved. One of the advantages of working at this level is that, unlike the early years, it is possible to identify extreme differences in student numeracy performance. While this situation suggests that there is a need for differential numeracy programs at this level, it also provides a powerful means of identifying the factors effecting numeracy achievement.

The proposed project is strategic because refining and expanding the targets and programs is needed to ensure students do not fall through the net at this critical level of schooling. Appropriate levels of literacy and numeracy are needed to ensure all students have access to further study and viable career pathways. Numeracy, like literacy, is essential for full and effective participation in one's own society and for responsible global citizenship.

Numeracy-specific activity and context to date:

- Background work, eg, *Being numerate – What counts?* (Willis, 1990) and *Numerate Students - Numerate Adults*, Tasmanian Education Department, 1995).
- *National Literacy and Numeracy Plan (DEETYA, 1997)*, State and Territory governments commit to improving numeracy outcomes and the development and implementation of National Numeracy Benchmarks at Years, 3, 5 and 7.
- Considerable policy work at State and Federal level involving the Australian Association of Mathematics Teachers (AAMT) and others, eg, *Numeracy Education Strategy Development Conference* (Perth, 1998), the *Draft Numeracy Monograph* (1998-9), the *AAMT Policy on Numeracy Education in Schools* (1997), the *Numeracy Forum* (Adelaide, November, 1998), and a project aimed at improving indigenous students' numeracy (*ISAN*, AAMT, 1998).
- Current work at State and Territory level on outcomes and intervention strategies, eg, the *Early Years Numeracy Research Project* (ENRP, Vic, 1999-2001), *Key Intended Numeracy Outcomes* (Tasmanian Department of Education), *First Steps* (WA), *Count Me in Too* (NSW), and *Maths Recovery* (NSW). However, most of this work is focussed on the early years of schooling and the contribution that school mathematics makes to numeracy development.
- An environmental scan of numeracy programs at the 5 to 8 level was commissioned by the industry partners and carried out by the Mathematical Association of Victoria (MAV) on behalf of the Doe, CECV and AISV (November, 1998). The scan revealed that there were very few, well-coordinated intervention programs at the school level; and very few common features across school programs.

Project-related activity and context:

- The *Early Years Literacy Project* (ELRP) and the *Victorian Quality Schooling Project* have indicated the effectiveness of the design elements described in the general model of school improvement (eg, Hill & Crevola, 1997) in improving student literacy;
- The *Middle Years Research and Development* Project (MYRAD, 1998-9) has confirmed that the nature and scope of the problems facing schools in Years 5 to 9 are substantial. In particular, that there is a growing gap between high and low achievers, evidence of under-achievement and dissatisfaction (especially among boys), evidence of substantial between class variations and significant numbers of students failing to meet minimum standards in core learning areas.

While the work from all these projects will shape and inform the *Numeracy Research Project 5-8+*, further work is needed to elaborate what this might mean in the context of numeracy teaching and learning in the middle years of schooling.

Although an expected outcome of the *Numeracy Research Project 5-8+* will be the identification of an expanded literature base to underpin what is known about numeracy and numeracy education at this level, the following provides a brief indication of the literature and experience which has informed the work of the project team to date. This has been organised in terms of numeracy, classroom strategies and organisations, professional development, and parent/teacher partnerships.

2.2 Numeracy in the Middle Years of Schooling

The concept of *numeracy* and the term itself is relatively recent. According to Willis (1990) it was first used in the Crowther Report in 1959 to "represent the mirror image of literacy" (quoted in Cockcroft, 1982, para 36). However its use by Crowther, implied a fairly sophisticated level of understanding which now appears to have been replaced by a more functional view (Cockcroft, 1982).

To many, particularly in California, the increased use of the term, numeracy, has heralded a return to the "Back to Basics" movement (stark evidence of which can be viewed on the web, eg, *Maths Wars* debate). In Australia, the move to National Numeracy Benchmarks has provided a number of forums for interested stakeholders to discuss key ideas and issues associated with numeracy. For example, the *Numeracy Education Strategy Development Conference* (Perth, 1997) jointly organised by the WA Department of Education and the Australian Association of Mathematics Teachers brought together the key systems people together with the acknowledged 'experts' in this area (two of whom are directly involved in the Project Team). The recognised 'experts' were invited to attend a special two-day pre-session of the Conference with a view to working on a definition of numeracy. As many of the group were also involved as advisors to the National Numeracy Benchmarks Taskforce, it is not surprising that a consensus view began to emerge.

The booklet, *Numeracy = Everyone's Business* (AAMT, 1997) was published as a result of this Conference. It cites the following definitions of numeracy.

> "To be numerate is to have and be able to use appropriate mathematical knowledge, understanding, skills, intuition and experience whenever they are needed in everyday life. Numeracy is more than just being able to manipulate numbers. The content of numeracy is derived from five strands of the mathematics curriculum - space, number, measurement, chance and data, and (pattern and) algebra - as described in the National Statement and Profiles."
> *Numerate Students, Numerate Adults*,
> Education Department of Tasmania, 1995

> "Numeracy involves abilities which include interpreting, applying and communicating mathematical information in commonly encountered situations to enable full, critical and effective participation in a wide range of life roles."
> *Literacy and Numeracy Strategy 1994-8*,
> Department of Education Queensland, 1994

> "Numeracy is 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 … the National Numeracy Benchmarks will refer to the contribution that school mathematics and other areas of learning make to the development of students' numeracy. They will incorporate the development of students' understanding and competence with number and quantity (i.e., measurement), shape and location and the handling and interpretation of quantitative data.
> *National Benchmarking Taskforce, 1997*

As a summary of the views expressed at the conference, AAMT suggested that numeracy can be viewed as 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" (Morony, 1997).

What these definitions suggest is that "numeracy involves using some mathematics to achieve some purpose in a particular context" (AAMT, 1998). What they all have in common is the recognition that numeracy involves a much broader range of knowledge skills and attributes than can be simply characterised as "basic number facts and skills". They also all acknowledge the critical importance of interpreting, applying and communicating the mathematics that is known to achieve some purpose related to one's everyday existence. This requires confidence built on understanding which derives from meaningful experiences and the "ability and inclination to use this understanding in flexible ways to make mathematical judgements and to develop useful and efficient strategies for managing numerical situations" (McIntosh, 1977). In support of this, numeracy has been referred to elsewhere as "critical numeracy" or "quantitative literacy" (Tate, 1996).

From this perspective, it can be seen that there is indeed some overlap with literacy, but that numeracy is both distinct from literacy and complimentary to it. Where there is overlap, it makes sense to draw on the relevant literacy literature. For example, David Pimm (1987) makes the case for using the metaphor 'mathematics as a language' where "being fluent in a language involves being able to tap into the resources implicit within it and use these potentialities for one's own ends" (Pimm, 1987). This acknowledges the importance of knowing how and when to communicate in mathematics. Another significant and relevant outcome from the literacy area is the recognition of the role of the key design elements identified in the General Model for School Improvement proposed by Hill and Crevola (1997).

For the purposes of the *Numeracy Research Project 5-8+*, the view of numeracy adopted by the National Benchmarks 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.

Although, it was expected that models of numeracy teaching would principally be found in mathematics classrooms, the team was anxious to explore the contributions made by other curriculum areas and, to the extent possible, the students' 'out-of-school' experience at this level. Some general guidelines on what this might mean in practice were gleaned from the Middle Years Research and Development project (MYRAD), specifically, the need to have far fewer teachers at years 7 to 9, the importance of uninterrupted, significant periods of time to engage in meaningful learning experiences, and the need to provide a curriculum that is relevant, negotiated and integrated (see Hill & Russell, 1999; Venville et al, 1998; Cumming, 1996).

The view of numeracy adopted for the purposes of the project and stated above embodies the three aspects of numeracy identified by Willis (1997), that is, mathematical knowledge, contextual knowledge and strategic knowledge. It suggests that the development of numeracy is likely to involve a consideration of each of these aspects in different ways and proportions at different ages and stages of schooling. While this is relatively straightforward in the early years where the focus is primarily on the development of the key mathematical ideas, skills and strategies that underpin numeracy, it is arguably more problematic in the middle and upper years of schooling where prior knowledge and experience, issues of identity, and a range of complex social, emotional and physical factors impact student's capacity to learn. For more general background information see the work of the *Middle Years Research and Development* project at www.sofweb.vic.gov.au/mys

The particular challenges confronting the teaching and learning of numeracy in the middle years of schooling include the following.

- The enormous range in student ability and motivation, and the significant number of students whose experience of failure or sense of disconnectedness make them reluctant learners.
- The perceived demands of 'the curriculum' – too much, too soon for too many (often compounded by the physical size and weight of 'the textbook').
- Limited time, resources and availability of qualified mathematics teachers particularly in Years 7 to 9.
- Relatively sterile, transitory learning environments which do not facilitate the display of artefacts to celebrate and record prior learning in junior secondary classes.
- Procedural, 'surface' based approaches to learning mathematics, where there is little inclination to search for meaning and the primary focus is on 'getting the answer'.
- Little or no culture of communication which values explanations, justification and the elaboration of student reasoning and strategies (Siemon & Griffin, 2000).

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.

Attempts to improve numeracy in the middle years will need to consider not only the contribution that school mathematics might make (that is, essential underpinnings and new knowledge, skills and strategies), but also how to impact entrenched classroom cultures, scaffold discourse elements, and engage learners more effectively in their own learning.

2.3 Classroom Strategies and Organisational Structures

Research on classroom strategies and organisational structures impacting upon the teaching and learning of mathematics is considerable and cannot be done justice here. However, much of this evidence supports the view that classroom organisational structures and the cultures that derive from them are key elements in the construction and use of mathematical knowledge (eg, Cobb & Bauersfeld, 1995; Siemon, 1993; Zevenbergen, 1995).

Siemon (1987, 1989) identified the critical importance of system valuing in change management. Where teachers were left to their own resources to "try it and see if it works", the change initiative invariably foundered after some honeymoon period. Where school principals overtly valued or gently mandated the change, there appeared to be a far greater chance of the change initiative being adopted.

While classroom research in the West has come along way in the last three decades, the one thing that has been learnt above all else and arguably across all research perspectives and paradigms is that the classroom is a very complex phenomena which variously shapes and is shaped by those who participate in it. It is no longer appropriate to delineate 'variables' that might be seen to impact classroom culture but rather to see all these as emergent and reflexive (Cobb & Yackel, 1995). Such a view supports the notion of whole school development in general and whole class discussion to negotiate classroom norms and values in particular, eg, "from an emergent perspective, learning is a constructive process that occurs while participating in and contributing to the practices of the local community" (Cobb & Yackel, 1995, p.19).

Another area of considerable overlap with the literacy work is the research related to discourse patterns in relation to structured activity in mathematics classrooms (eg, see Krummheuer and Voigt in Cobb & Bauersfeld, 1995) which builds on the earlier work of socio-linguists such as Greene (1983) and Morine-Dersheimer (1985) and the seminal work of Cazden (1986). This work is critical in helping researchers understand the complex social dynamics that serve to shape the teaching and learning experience.

2.4 Professional Development

> "Successful change, that is, successful implementation, is none other than learning but it is the adults in the system who are learning along with or more so than the students. Thus anything we know about how adults learn and under what conditions they are unlikely to learn is useful for carrying out strategies for implementation" (Fullan, 1987).

The current, widely accepted social constructivist view of learning sees the learner as a very active processor of information who brings to the learning situation a vast amount of prior knowledge and experience, particularly beliefs and attitudes and ways of processing information. This view of learning has some immediate implications for how change might occur in this setting. The proposed change must make sense to, and be valued by, the implementers of the change. It must be meaningful and seem necessary and the process of change must recognise implementers as active learners in a complex setting (Siemon, 1987, p. 14).

Fullan (1987) has identified and described factors known to facilitate the implementation of change. These he has classified in terms of the characteristics of the process of change and characteristics of the change project:

Characteristics of the process of change
- Ongoing in-service and assistance
- School- level (principal) leadership
- Local direction, commitment and support
- Clear process of implementation and institutionalisation (all levels)
- Monitoring and problem solving
- Community support
- Environmental stability

Characteristics of the change project
- Clarity/ complexity of the change
- Consensus/ conflict about the need

- Quality/ practicality of the change.

Many of the aspects of Fullan's successful change management model were included in the design of the *Maths in Schools Project* (Siemon, 1993). The success of which was attributed to

- the capacity of individual schools to define the project they wished to work on within a given framework;
- a whole school or team approach (the agreement and support of the school principal and the school council was required); and
- the involvement of a University facilitator whose role was largely determined by the school *Maths in Schools* team (Montgomery, 1996).

It is interesting to note the similarity of these characteristics and attributes to the design elements described by Hill and Crevola (1997).

Successful attempts to improve the knowledge bases, alter beliefs and improve attitudes of practicing teachers in mathematics education have been widely documented. Most significant in the literature are studies conducted in the United States, like those of Fosnot, Simon, and Schifter; and Cobb, Yackel and Wood (reported in Cobb & Bauersfeld, 1995) and a number of studies involving the *Cognitively Guided Instruction* model (as cited in Fennema et al. 1996, p. 405) which reported considerable success in the development of knowledge of mathematical ideas and significant shifts in attitudes and beliefs of practising teachers. These studies illustrate that successful teacher development in mathematics education requires the combination of three factors. Firstly the programs involved teachers who were motivated to change their mathematics teaching practices, and secondly the programs were based in the teachers' classrooms and provided them with opportunities to try out new ideas and approaches. The third factor was regular and ongoing discussion of their experiences with other teachers in the presence of a facilitator/mentor who had an understanding of the teachers' current stage of development and a vision for the teachers' mathematical and affective development (Carroll, 1997).

2.5 Parent/ teacher partnerships; school and community numeracies

McGilp and Michael (1994) highlight the benefits of a 'learning connection' between home and school where home and school work together, listen to each other, and make good use of a variety of learning experiences available in the school, home and community. When home school and the community understand the contributions that each other can make to children's learning and use this all parties stand to benefit from the outcome. It can lead to a shared sense of responsibility and shared commitment to children and their education. The information from the collaborative assessment process can be used to improve teaching and learning and it can provide a joint understanding of realistic and attainable goals for individuals.

Collaborative assessment provides the opportunity for strong positive relationships to be developed between staff, children and the community. The process of collaboration is valuable as well as having positive outcomes for all those involved. The input of the community as well as the parents can make a difference to the cultural and individual relevance of the program and curriculum offered to young children. Gestwicki, (1992) suggests that teachers and parents can make community connections to use natural, people and material resources.

The term 'partnerships' between home and school suggests an equal although different contribution by both parties. For along time in Australia schools have relied on 'parent involvement' which often places parents in a 'helper' role rather than being involved in any real decision making for their children. Collaborative assessment provides opportunities for parents to be active collaborators in their own children's learning and development. Parents can make a valuable contribution because they have a unique experience of their child and this can be used to modify and enrich the insights of the teacher.

The Australian Parents' Council Inc (1996) have recognised the potential of this type of partnership:

> "Assessment and reporting are critical activities through which this partnership around learning can be constructed and maintained. They can be dynamic interactions when the arrangements and contexts allow all participants to learn about students' performance in order to improve what students learn, think, make and do" (p.3).

Newman (1995) emphasises the importance of mutual understanding, respect and trust to be the basis of a solid collaborative connection between teachers and parents. Parents' roles in school settings are rarely discussed, making their responsibilities unclear and making it likely that they will only be called upon when their child is having a problem (Rosenthal & Young Sawyers, 1996, 195). Parr, McNaughton, Timperley & Robinson (1993) found that teachers and principals valued receiving information from parents. However, parents did not see ‘giving information’ as one of their roles. Rosenthal & Young Sawyers, (1996) stress the importance of moving toward a system that encourages inclusion, participation and collaboration as the ultimate goal.

Given this brief analysis, it is clear that improving numeracy performance is a non-trivial, complex issue which will require time and a multi-faceted research methodology to address.

2.6 Aims and Expected outcomes of the Project

As outlined in the Project Brief (p.1), the aims of the *Numeracy Research Project 5-8+* are to

- inform the development of a strategic and coordinated approach and advice for schools about the teaching and learning of numeracy for students in years 5-8+;
- trial and evaluate the proposed approaches in selected Victorian schools; and to
- identify and document what works and does not work in numeracy teaching including those students who fall behind.

In addressing these aims, the research project will build upon and relate to the work of the projects described above, that is, the *ENRP*, the *ELRP*, the *MYRAD* project, and embody the design *Elements of the General Model of School Improvement* (Hill & Crevola, 1997).

The expected outcomes of the *Numeracy Research Project 5-8+* include the following.

- Papers and publications which document the nature of numeracy in the middle years of schooling.
- Advice to support the development of a coordinated and strategic plan to achieve numeracy improvements in the middle years of schooling. In particular, advice concerning, the nature of structured mainstream classroom programs, the nature and extent of additional assistance for students who are failing to make satisfactory progress, the role of parents, mentors and peer support, and the nature and role of professional development of teachers, coordinators, principals and regional personnel.
- Papers and reports which document the ‘big’ principles of effective numeracy education at this level, in particular, their relationship to the design elements of the *General Model of School Improvement* (Hill & Crevola, 1997), the *National Numeracy Benchmarks* (DETYA, 1999) and the current work on middle schooling (*MYRAD*, 1998-9).
- A network of aware, knowledgeable practitioners who will be able to advocate and assist with the transfer of the Strategy to other schools.
- A document which reports on and evaluates the role of the Hill and Crevola (1997) design elements in relation to improving numeracy performance, that is, leadership and coordination, school and classroom organisation, structured classroom teaching programs, standards and targets, monitoring and assessment, intervention and special assistance, home, school and community partnerships, and professional learning teams.
- A final Project Report.

A more detailed description of the particular outcomes from each phase in the research methodology is given in Section 3 below.

3. The Research Approach

3.1 Design

Given that the environmental scan conducted prior to the study revealed very little in the way of existing school-based numeracy initiatives compared to the range of school-based interventions identified in relation to literacy, the current study was commissioned to explore what was possible and to provide advice about what might be effective in relation to improving numeracy outcomes at this level. An ‘experimental/control’ or trial/reference school design was deemed to be inappropriate as the purpose of the study was to determine what might work, not to evaluate the effectiveness of a particular, pre-determined approach across all trial schools.

In view of the 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 gather baseline data on student numeracy and some insights into what appeared likely to enhance (or inhibit) numeracy performance at this level. A smaller, structured sub-sample was selected to participate in a trial phase aimed at finding ways to improve numeracy performance. This sample was selected on the basis of the 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.

An action research methodology was used in the trial schools consistent with a socio-constructivist view of learning (see for example, Lerman, 1998; Crawford & Adler, 1996) and the experience of the *Maths in Schools* project (Siemon & Ferguson, 1993; Montgomery, 1996) which suggest that success will be greatest where teachers and schools are supported to work on what they believe to be the most appropriate strategy for their situation (Siemon, 1989). This approach was selected as the research could not know in advance what numeracy-specific strategies would work most effectively in what settings at this level.

Although the project was originally planned to be completed by April 2000, this was extended to December 2000 to allow schools a greater opportunity to explore what might work in relation to numeracy improvements. The extension was also a consequence of the unavoidable delays incurred as a result of a change of government in late 1999.

3.2 Methodology

To achieve he aims and expected outcomes described above the research plan was designed in terms of four broad phases involving the collection of quantitative and qualitative data. While these are separated for elaboration and clarification below, there was considerable overlap in practice.

Phase 1: Benchmarking

The aim of this phase was to build on the environmental scan conducted as Stage 1 of the *Successful Interventions* Project (DoE, CECV, AISV, 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 current numeracy-related policies and projects, particularly, the *Early Years Numeracy Research Project* (ENRP) and *the Middle Years Research and Development* Project (MYRAD), and a detailed review of the relevant literature.

The large-scale assessment instruments were developed on the basis of the National Numeracy Benchmarks for Years 5 and 7 (Curriculum Corporation, 2000) and recognised 'best-practice' in this area (eg, Clarke et al, 1997, 1999). Teachers evaluated student performance using prepared scoring rubrics and computer-readable mark sheets. These were returned to the research team together with student work samples for aggregation and analysis (see Section 5 for further details). As soon as this was completed, feedback on the data collection was given to project schools. This took the form of individual student reports, class reports and a report of school cohort performance relative to the Phase 1 population.

Data related to the design elements described in Hill & Crevola (1997) was gathered via an auditing process, that is, schools were asked to complete a questionnaire and then meet with project team members who could ask to sight evidence in support of the claims made in the questionnaire. Schools were invited to submit a portfolio of relevant policies and programs if they wished. This data was gathered to provide additional base-line data about current numeracy-related policy and practices (see Section 4 for further details).

This phase of the methodology was designed to address the following research questions:

1. What is already known about numeracy and numeracy education at this level?
2. To what extent can numeracy be assessed by the use of structured, rich assessment tasks involving teachers as assessors?
3. What does this data indicate about current student numeracy performance?
4. What aspects of current practice appear to be associated with successful and unsuccessful numeracy performance at this level?

The following outcomes were anticipated as a result of Phase 1:

- A clearer picture of the nature of numeracy and numeracy education at this level derived from relevant literature, current policies and projects and an indication derived from current practice of what is working/not working in relation to numeracy performance.

- A set of trialed assessment instruments that relate to the National Numeracy Benchmarks at this level.
- Benchmark data concerning student numeracy performance at this level.
- A school auditing process to obtain design element data concerning numeracy-related school-wide policies and practices (Hill & Crevola, 1997).
- Identification of 'design-element-rich' (DER) and design-element-poor' (DEP) schools for participation in the Phase 3 trial.
- Identification of case-study/interview sample (students identified as "typically weak" or "at risk") for Phase 3.

Phase 2: Selection of Sub-sample and Preparation of Draft Advice

The aim of this phase was to select Trial schools and prepare a document on the basis of the knowledge and data obtained from Phase 1 that would assist the Trial Schools in the action research planning process.

The structured sub-sample of 20 schools was selected on the basis of evidence in relation to the categories of 'design-element-rich' (DER), 'design-element-poor' (DEP), 'high overall numeracy performance' (HNP) and 'low overall numeracy performance' (LNP) (see Section 4.3 for further details).

Research questions addressed by this Phase included the following.

5. To what extent can the Design Elements be used to frame the initial advice to Trial Schools and support the action planning process?
6. What aspects of the design elements under consideration, that is, structured classroom programs, special assistance, parent participation, and professional development for teachers, appear to be associated with successful and not so successful numeracy performance?

Expected outcomes of Phase 2 were:

- Draft advice based on the data derived from Phase 1 to support the formulation of Trial School Action Plans.
- Trial Schools identified and informed.
- Research papers concerning the nature of numeracy and numeracy education at this level.

Phase 3: Implementation of Trial School Action Plans

The aim of this phase was to evaluate the effectiveness of the Trial School Action Plans in relation to student numeracy performance. This was done by collecting data from Trial School students in Years 5 to 9 in November 2000 using parallel forms of the assessment materials used in November 1999 (Phase 1). Benchmark data was obtained from the 'missing cohort', that is, new Year 5 and 7 students in March 2000. As soon as possible after each data collection, copies of data reports were sent to Trial Schools.

Two professional development days were held to support and celebrate the work of Trial Schools. The first in February 2000 followed up on the training session provided to all Phase 1 Schools in October 1999 on the use of scoring rubrics and rich assessment tasks. It also provided feedback on data obtained from Phase 1 assessment of student numeracy performance, preliminary advice as to what factors appeared to be associated with higher levels of numeracy performance, and specific information related to the action research planning process. The second day was held in October 2000 to celebrate and share the work of Trial Schools over the course of the year. On this occasion, an opportunity was provided to reflect on the experience of being involved in the project, particularly in relation to the four design elements under consideration, that is, intervention and special assistance, classroom practice, professional learning teams and home, school and community partnerships.

School visits, teacher journals, and an end-of-year teacher survey were used to obtain insights into the school-based experience of those associated with the implementation of Trial School Action Plans (see Section 8). A small number of individual interviews involving students identified as 'at risk' were also conducted during Phase 3 with a view to identifying specific factors that impact numeracy performance (see Section 7).

Towards the end of 2000 Trial Schools were asked to prepare a Final Report on the implementation of their Action Plan and to complete an extended version of the initial School Survey (see Section 8). The second survey provided schools with the opportunity to provide additional information on relevant school-wide policies and feedback on the conduct of the project particularly in relation to factors that may have impeded their capacity to undertake the project as planned.

The following research questions were addressed during this Phase.

7. To what extent have Trial Schools succeeded in improving student numeracy outcomes?
8. 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?
9. 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?
10. What can we learn from the experience of Trial School teachers in relation to improved numeracy performance?

The expected outcomes of Phase 3 were:

- Quality data to inform the preparation of advice in relation to improving numeracy outcomes in the middle years of schooling.
- Clearer picture of student numeracy and numeracy education at this level.
- A greater understanding of the nature and extent to which the design elements contribute to achieving improvements in numeracy performance.

Phase 4: Preparation of Advice

The aim of this phase was to analyse the data obtained from Phase 3 in relation to student numeracy performance, identify aspects of Trial School Action plans that appear to be associated with improved numeracy performance, and prepare the necessary advice for the systems as commissioned. The research question considered by this Phase is listed below.

11. 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 co-ordinated and strategic plan for numeracy improvement?

The outcomes of Phase 4 will include:

- Advice concerning a co-ordinated and strategic plan to achieve numeracy improvements in the middle years of schooling. In particular, advice concerning, the nature of structured mainstream classroom programs, the nature and extent of additional assistance for students who are failing to make satisfactory progress, the role of parents, mentors and peer support, and the role of professional development of teachers.
- A description of the principles of best practice in the development and implementation of numeracy programs within school mathematics, across the curriculum and in the context of a whole school approach.
- Research papers on the factors contributing to enhanced numeracy outcomes and the nature of numeracy at this level.
- A Final Project Report.

4. The Project Schools and Students

4.1 Initial School Sample

Schools were selected on the basis of an Expression of Interest that required some evidence of the school's commitment to engage in an action research project aimed at improving numeracy outcomes in Years 5 to 9. Schools were selected in accordance with the selection criteria to reflect a range of settings and needs in relation to middle years numeracy. They also demonstrated a whole-school commitment to the MYNRP, a preparedness to be involved in subsequent phases of the project if required and a capacity to substantially contribute to project outcomes by virtue of their particular circumstances and/or experience.

As the success of the research methodology depended upon a genuine range of schools participating in the project, a concerted attempt was made to select schools from different regions and systems with different levels of success and/or experience in achieving numeracy outcomes. In all, 47 schools (27 Primary and 20 Secondary) were selected to participate in the first phase of the project. School numbers were taken into account when selecting the number of schools from each region.

Two State primary-secondary clusters were included in the sample (a Secondary College and 2 feeder Primary Schools from a regional area and a large outer metropolitan Secondary college with 3 feeder Primary schools). Five P-12 schools were included in the sample, 3 from the independent sector and 2 from the State sector. All 47 schools were co-educational. This selection is broadly summarised by region and sector in the Table below.

	BSW	**WMR**	**LCM**	**CHW**	**NMR**	**GNE**	**EMR**	**SMR**	**GIP**	**Total**
DEET	3	4	4	3	4	3	6	6	2	35
CECV	1	0	0	0	1	0	1	3	2	8
AISV	1	0	0	1	0	0	2	0	0	4

BSW - Barwon-South Western Region
WMR - Western Metropolitan Region
LCM - Loddon-Campaspe-Mallee Region
CHW - Central Highlands Wimmera Region
NMR - Northern Metropolitan Region
GNE - Goulbourn North-Eastern Region
EMR - Eastern Metropolitan Region
SMR - Southern Metropolitan Region
GIP – Gippsland Region

4.2 Descriptive Features of the Initial Sample

The following information was obtained from the Phase 1 School Surveys (see Appendix C) and the follow up interview with School Principals. Complete Surveys were obtained from 45 schools.

Funding Levels

- 69% received funding for students with Special Learning Needs
- 36% of schools had 20% or fewer students who received the Educational Maintenance Allowance
- 64% of schools had more than 21% of students receiving the Educational Maintenance Allowance

Gender

40.2% of the Phase 1 Years 5 to 9 students were female, 46.5% were male (13.3% did not report gender and it was not possible to identify by name).

Distribution by Year Level

Complete data sets were obtained from 6860 Year 5 to 9 students. These were distributed by Year level as follows.

	Year 5	Year 6	Year 7	Year 8	Year 9
Numbers	1315	1318	1467	1484	1276
% of sample	19.2%	19.2%	21.4%	21.6%	18.6%

Language background other than English

% Language background other than English	none	1-5%	6-10%	11-20%	21-40%	41+%
% of schools in this category	16.3	44.2	7	14	0	18.5

Only 1 school reported students with a Koorie background. 60.3% of project schools reported having 5% or fewer students from language backgrounds other than English.

Average class size

Project schools generally reported class sizes close to the average in each year level. However, there were a few outliers. The smallest reported primary class was 22 at a regional independent school. The largest was 33 at an outer metropolitan State school. The smallest reported secondary class was 14 at a rural State Secondary College. The largest was 32 at a regional Catholic College.

Year 5	Year 6	Year 7	Year 8	Year 9
27	27	25	25	25

Structural arrangements

There was considerable variety in the structural organisations reported by project schools.

- 5 secondary schools reported some form of vertical arrangement in Years 7 to 9.
- 3 secondary schools offered single sex mathematics classes.
- 8 schools (including 2 primary schools and the 4 P-12 schools) blocked same-year mathematics classes at the same time. In some cases, students were organised into flexible, like-ability groups across the cohort, in other cases, students at either end of the performance spectrum were grouped to facilitate the provision of special support.
- 7 schools (including 4 primary schools) reported that they provided some sort of intervention to support students identified as ‘at risk’. In most cases, this referred to literacy support, although one school indicated that individual learning plans were used for students with special learning needs.
- 15 primary schools and 2 of the P-12 schools reported composite grades at Years 5 and 6.
- 8 schools (including 5 primary schools) indicated straight grades with a home-room focus,
- 2 secondary colleges and 1 P-12 reported a policy of ‘fewer’ teachers at Years 7 to 9. In these cases, home-room teachers taught across at least 4 Key Learning Areas (mostly English, Maths, Science and SOSE).

Provision for teaching and learning of Mathematics

- 6 primary and 2 of the P-12 schools indicated that they were using an integrated curriculum approach at Years 5 and 6.
- 1 primary school reported using a multi-intelligences approach to curriculum planning
- Average time for maths (minutes/week) and an indication of the type of resources used are given by the following table.

Yr 5 mins/wk	Yr 6 mins/wk	Yr 7 mins/wk	Yr 8 mins/wk	Yr 9 mins/wk	Set text	Set text +	Texts +	no text range
261	261	219	213	222	17.5%	20%	45%	17.5%

- Secondary schools were much more likely to report set texts supported by a range of other resources, most generally other texts, calculators and some software. Primary schools by comparison were much more likely to report a range of texts or no texts and a variety of teacher resource material.

4.3 Trial School Sample

A structured sub-sample of 20 schools was selected from the Phase 1 sample on the basis of data obtained from the initial School Survey, the follow-up interview with Principals and the Phase 1 Student Numeracy Profile data. This sample was selected on the basis of evidence in relation to the categories of 'design-element-rich', 'design-element-poor', high overall numeracy performance and 'low overall numeracy performance' with some consideration given to region and sector.

Fewer schools were chosen to represent the *Design Element Rich-High Numeracy* category on the basis that there were considerably fewer schools in this category and their School Surveys already provided considerable information about what was likely to be associated with higher than average numeracy performance. This information was used to inform the advice to Trial Schools (see Section 8). Another reason for not selecting as many schools in this category was that the primary purpose of the research was to provide advice about what worked in relation to improving numeracy outcomes. Selecting schools that already evidenced relatively high levels of numeracy performance would be less likely to demonstrate significant improvement. The number of schools selected in each category are shown below.

	Low (L) Numeracy	High (H) Numeracy
Design Element Rich (R)	**LR** 5 schools	**HR** 3 schools
Design Element Poor (P)	**LP** 7 schools	**HP** 5 schools

This Trial School sample was also chosen to represent a range of settings and situations with respect to numeracy in the middle years of schooling on the basis that any advice generated needed to be generalisable to a wider population of schools.

4.4 Descriptive Features of Trial Schools

The following information was obtained from the SNP data, the initial School Survey and the final Trial School Survey completed at the end of the project. Complete data sets were obtained from 2899 students in Years 5 to 9 from Trial Schools.

Funding Levels

- 75% received funding for students with Special Learning Needs
- 20% of schools had 20% or fewer students who received the Educational Maintenance Allowance
- 80% of schools had more than 21% of students receiving the Educational Maintenance Allowance

Gender

50.8% of the trial school students in Years 5 to 9 were female, 47.2% were male (2 % did not report gender and it was not possible to identify by name).

Distribution by Year Level

	Year 5	Year 6	Year 7	Year 8	Year 9
Numbers	540	513	690	603	553
% of sample	18.6	17.7	23.8	20.8	19.1

Language background other than English

% Language background other than English	none	1-5%	6-10%	11-20%	21-40%	41+%
% of schools in this category	15	50	10	0	10	15

25% of the Trial School sample reported more than 21% of students with language backgrounds other than English.

Average class size

Trial schools generally reported class sizes close to the average in each year level. However, there were a few outliers. The smallest reported primary class was 17 at a rural P-12 school. The largest was 32 at an outer metropolitan State school. The smallest reported secondary class was 15 at a rural State Secondary College. The largest was 30 at a regional Catholic College.

Year 5	Year 6	Year 7	Year 8	Year 9
26	26	24	24	23

Structural arrangements

There was considerable variety in the structural organisations reported by Trial schools.
- 1 P-12 school reported some form of vertical arrangement in Years 7 to 8.
- 4 schools (2 primary, 1 secondary and 1 P-12 school) blocked same-year mathematics classes at the same time. In some cases, students were organised into flexible, like-ability groups across the cohort, in other cases, students at either end of the performance spectrum were grouped to facilitate the provision of special support.
- 5 schools (including 3 primary schools) reported that they provided some sort of intervention to support students identified as ‘at risk’. In most cases this included an additional teacher for some time during the week to facilitate smaller class sizes, withdrawal of individual students or the provision of additional assistance within the classroom. One school indicated that individual learning plans were used for students with special learning needs.
- 10 primary schools and both of the P-12 schools reported composite grades at Years 5 and 6.
- 2 secondary and 1 P-12 school reported ‘home-group’ based teaching at Years 7 and 8 for core subjects. The P-12 school reported that the Year 7 Home Group teacher teaches the core subjects.
- 2 primary schools conducted the structured individual interview with all Year 5 and 6 students.
- 3 secondary schools reported multi-campus organisations.
- 1 primary school reported a 5-7 week intensive ‘computerised classroom’ experience for students in Years 5 and 6.
- Of the 81 classes reported on by Trial School teachers, 23 classes had at least one integration student. In one class there were 5 integration students.

Provision for teaching and learning of Mathematics

Yr 5 mins/wk	Yr 6 mins/wk	Yr 7 mins/wk	Yr 8 mins/wk	Yr 9 mins/wk	Set text	Set text +	Texts +	no text range
293	292	208	213	213	16.7%	22.2%	33.3%	27.8%

- Although secondary schools were still more likely to report set texts supported by a range of other resources than primary schools, this difference was less marked than in the initial sample.

Assessing Student Numeracy Performance

5.1 Assessing Numeracy

One of the major issues that sets this report apart from comparable work in literacy is the lack of recognised instruments for assessing student numeracy at this level. As a consequence, an early challenge for the research team was to consider the ways in which numeracy would be assessed. Given a view of numeracy as something more than school mathematics (see Section 2 above) meant that, in addition to assessing key mathematical ideas and skills, it was also necessary to evaluate students’ capacity to critically apply what was known in particular contexts to achieve some purpose, and communicate and justify their thinking in relation to every day problems and events.

In addressing this issue for a population of Year 9 students in Tasmania, Callingham & Griffin (1999) used a small range of extended classroom tasks to evaluate higher order cognitive thinking and problem solving skills in contexts which required the application of relevant mathematical knowledge and skills. These materials were developed for the INISSS Project - Improving Numeracy for Indigenous Students in Secondary Schools (Tasmanian Department of Education, 1998)

Key features of the Tasmanian tasks included the following:

- they allowed all students to make a start on the problem while also challenging those students with more sophisticated mathematical knowledge and skills;
- classroom teachers were able to engage with students as they worked on the tasks, to ensure that literacy issues were not preventing students from making a start;
- students were allowed to work in pairs, although each student had to complete an individual response sheet;
- the tasks were authentic, in that they related to some realistic use of mathematics to achieve some purpose;
- teachers were provided with scoring rubrics to evaluate student responses.

It was decided to use one of these tasks, *Street Party*, as part of the instrumentation to assess student numeracy in the MYNRP as this would provide a referenced data set to evaluate the validity of the additional tasks. The remaining tasks were developed on the basis of recognised ‘best-practice’ models of assessment, that is, ‘rich assessment tasks’ (eg, Clarke et al, 1996) and performance-based assessment (Callingham, 1999; Griffin, 1998) as it was felt that this would offer the best and most practical means of assessing student numeracy performance in relation to the timeline and funding levels of the project.

A concerted attempt was made to source items and tasks from across the three strands of the *National Numeracy Benchmarks for Years 5 and 7*, that is, Number Sense, Measurement and Data Sense and Space Sense, and the tasks were chosen or adapted to ensure they provided an opportunity to demonstrate both content and process outcomes (Board of Studies, 1998). Items were also chosen to reflect Levels 4 and 5 of the Victorian Curriculum and Standards Framework II.

The *Student Numeracy Performance Profile* (SNP) as it became known, comprises two parallel versions of an open-ended, five-item written test at each of Level 4 (used for Year 5 and 6 students) and Level 5 (used for Year 7 to 9 students), together with the extended classroom task, *Street Party*. To support item analysis and the assessment of numeracy performance across Years 5 to 9, common items appeared on both parallel and vertical versions of the instrument.

The short assessment tasks were largely derived from *Effective Assessment in Mathematics Levels 4 to 6* (Beesey et al, 1998) to meet the following criteria.

- The tasks assessed numeracy performance of students in Years 5 to 9 (that is, mathematical, contextual and strategic knowledge (see Willis, 1998).
- The tasks were broadly representative of the three aspects of numeracy, i.e., number sense, measurement and data sense and space sense 9 (the *National Numeracy Benchmarks for Years 5 and 7* were used as a guideline).
- Opportunities were provided for students to demonstrate what numeracy-related mathematics they did know or could do (referenced to *Levels 3 to 6, Victorian Curriculum & Standards Framework*).
- Content as well as process outcomes were assessed, that is, conceptual as well as procedural knowledge and strategy usage.
- The tasks modelled best practice (see Clarke et al, 1996) and facilitated performance assessment, that is, the use of scoring rubrics which evaluated student’s performance including the capacity to choose, use and apply relevant knowledge, skills and strategies in context.
- They were relatively straightforward and cost-efficient to administer.
- The tasks could be locally assessed with some confidence and globally assessed using computer-readable score sheets.

The Extended Classroom Task and the short tasks were administered over two 40 to 50 minute sessions and assessed by the teachers concerned using previously trialed scoring rubrics and pre-printed scannable score sheets. Teachers could read items and/or provide more time if they felt it was needed. Two practice examples were provided on each version of the short tasks. Attention was drawn to the fact that explanations were often required and what these might look like in practice. Students were encouraged to use as much mathematics as they could in explaining their response. As this is a major outcome of the study the assessment tasks and procedures will be described in some detail below.

5.2 The initial assessment items

The Street Party Extended Classroom Task assessed students' capacity to:

- recognise patterns in pictures and diagrams and continue these accurately;
- solve simple problems involving direct relationships only;
- describe straightforward relationships in words and relate these to real situations
- solve problems involving direct relationships where the numbers involved are too large to allow just a continuation of the pattern;
- describe straightforward concrete relationships in words or symbols and manipulate these effectively;
- solve problems involving direct and inverse relationships.

The short tasks variously assessed students' numeracy. The table below summarises the capacities assessed by the tasks and indicates their source (EAM refers to the publication, *Effective Assessment in Mathematics*, Beesey et al, 1999). The Levels indicated refer to the Victorian CSF II. It should be noted that items do not represent a comprehensive assessment of CSF levels.

Title	Assessing students capacity to	Source
Without a Calculator Level 4-Number	• solve problems involving one/more of the four processes using written and/or mental strategies	EAM, p.23
Filling the Buses Level 4-Number	• solve problems involving one/more of the four processes using written and/or mental strategies	EAM, p.28
Trip Metre Level 4-Measurement	• read scales to tenths, round to nearest whole number • use place-value knowledge to solve an everyday problem	EAM, p,55
Travel Time Level 4-Measurement	• interpret simple timetables • read and interpret data presented in a variety of ways (tables)	EAM, p.69
Draw the Spinner Level 5 – Chance & Data	• recognise simple equivalent fractions • recognise the relative likelihood of events occurring on the basis of simple quantitative data • partition different measurements - length, area, volume, capacity - into simple fractional parts (area)	EAM. p.86
How Far to Walk Level 4-Number	• solve problems involving one/more of the four operations using written or mental strategies • read and interpret numbers involving tenths • identify and describe locations and routes using a sign	EAM, p.29
What day is it? Level 4-Measurement	• interpret simple timetables and calendars to find information • count forwards and backwards	EAM, p.70
Fraction Boxes Level 4-Number	• recognise simple common fractions in equivalent forms • represent fractions in different forms	EAM, p.8
Soccer Tournament Level 5-Chance & Data	• determine the event space and/or map all possible outcomes of a simple experiment or graph	EAM, p.88
CD Sales Level 5-Chance & Data	• read and interpret data presented in a variety of ways (graph) • recognise and use ratio ideas to solve problems	Trial Item
Bird's Eye View Level 4 - Space	• locate, place an object on a simple map or plan • describe simple movements of 2D/3D shapes	Trial Item
Medicine Doses Level 6 - Algebra	• recognises and uses inverse relationships, simple ratios • deals with different division formats • solves practical problems in familiar context	EAM, p. 169

As indicated above two parallel versions of the Numeracy Tasks were developed for Years 5 to 6 (Versions 4.1 and 4.2) and two more for Years 7-9 (Versions 5.1 and 5.2). The following table indicates where common items were included across versions to facilitate whole cohort analysis.

SNP 4.1	SNP 4.2	SNP 5.1	SNP 5.2
Without a Calculator	How Far to Walk	CD Sales	Bird's Eye View
Filling the Buses	Filling the Buses	Trip Metre	Trip Metre
Trip Metre	Trip Metre	Fractions in Boxes	Medicine Doses
Travel Time	Do You Know What Day It Is?	Draw the Spinner	CD Sales
Draw the Spinner	Fractions in Boxes	Dr Maths Soccer Tournament	Dr Maths Soccer Tournament

5.3 The Scoring Rubrics

The development of Scoring Rubrics has been a significant outcome of the MYNRP. The prototypes of the short assessment tasks included a detailed description of what might be expected from an accomplished performance, but specific Scoring Rubrics were not included. In any event, it was necessary to develop scoring rubrics for each item that reflected key components of numeracy. The Scoring Rubrics for the MYNRP were developed with several key purposes in mind:

- to provide teachers with a readily accessible and consistent means of assessing student numeracy performance;
- to draw the attention of teachers to crucial aspects of numeracy performance, in particular to emphasise and value the use of mathematical knowledge and skills relative to context;
- to provide the Research Team with a basis for consistent task analysis and of comparing performances across year levels both within and between schools.

For example, the Scoring Rubric for the *Filling the Buses* indicated to teachers that merely providing the result of a computation was insufficient to score a 2. Students needed to recognise that an additional bus would be needed to accommodate remaining pupils. The Scoring Rubric to the task *CD Sales* recognises that students are likely to develop increasingly sophisticated explanations as they extend their understanding to include percentage increase and ratio. The Scoring Rubric for this task allows students at different stages of schooling to achieve the maximum score using knowledge appropriate to their stage of schooling.

The following examples illustrate the numeracy values implicit in the scoring rubrics. The first emphasises the importance of solution methods appropriate to context.

WITHOUT A CALCULATOR:		
1.	No explanation or irrelevant answer	0
	Records relevant information, but does not recognise what operation is required, eg, records distances only	1
	Correct (about 200 km or 202 km), but recording shows method of calculation does not take account of situation, eg, assumes access to pen and paper or calculator in car	2
	Correct (about 200 km or 202 km), explanation shows that method of calculation is appropriate to the situation, eg, uses appropriate mental strategy	3

The second illustrates the importance given to reading and interpreting quantitative information relevant to context. For *Travel Time* students needed to coordinate the information from bus and train timetables and they were expected to make allowances for the possibility of trains being slightly late and the time required to walk from the bus stop to the train platform.

TRAVEL TIME:

4a.	Incorrect or no response	0
	Correct (8:27 am)	1
4b.	Incorrect or no response	0
	Correct (9:30 am)	1
4c.	Incorrect or no response	0
	Ideally correct (9:37 am), no allowance made for possible lateness of train, explanation relies on times alone	1
	Correct (9:12 am), explanation reveals more realistic interpretation of situation	2

In the Scoring Rubric for *Medicine Doses*, students were expected to see that the fraction 1/3 is far easier to use to change an adult measure to a child's measure than the corresponding fraction 6/18.

MEDICINE DOSES:		
3a.	No response or incorrect	0
	Information from formula used but incorrect or incomplete calculation	1
	Correct (5 mL), appropriate use of formula or recognition of proportion	2
3b.	Incorrect or no response	0
	Fraction component identified but incomplete, eg, recorded as 6 divided by 6+12	1
	Fraction correct (6/18) but not interpreted appropriate to context	2
	Fraction given as 1/3	3
3c.	No response or incorrect	0
	Information from formula used but incorrect or incomplete calculation	1
	Correct (20 ml, appropriate use of formula	2

The following rubric illustrates the value placed on being able to justify a response using appropriate mathematical ideas.

CD SALES:		
4.	No response or "yes" or "no" without an explanation	0
	Reasoning based on numbers alone, no recognition that "big" is relative	1
	Reasoning shows some recognition that "big" is relative to total sales, but unsupported conclusion, little or no explanation, eg, "it depends…"	2
	Reasoning concludes that increase is not "big" relative to total sales, some attempt to relate this to notion of proportion, eg, "15 out of 725 is not very big"	3
	Correct conclusion (not "big"), %, fractions, ratio used correctly to support detailed explanation	4

Some items evaluated students' capacity to use mathematical representations to communicate their thinking, For example,

DR MATHS SOCCER TOURNAMENT:		
5.	No attempt or incorrect response (8 x 8 or 8)	0
	Incorrect solution, but some appropriate representation, eg, diagram leading to incorrect solution, calculation leading to incorrect solution, eg, "Each team plays 7 other teams, 8 teams altogether so 56 games"	1
	Correct (28 games) but explanation incomplete, representation not clear	2
	Correct (28 games), detailed explanation, representation clear and unambiguous, eg, appropriate tables or diagrams used systematically	3

Scoring Rubrics were provided for the *Street Party* Extended Classroom Task (Callingham & Griffin, 1999).

5.4 Trial Phase Items

As a consequence of the statistical item analysis (see Section 6), the *How Far to Walk* item was identified as not performing as well as the remaining items. This was subsequently modified to make the intention of the item clearer.

Although all remaining items performed well, an analysis of a student work samples, suggested that *Medicine Doses* and *Bird's Eye View* could be usefully modified to further probe student understanding. In the case of *Medicine Doses*, an additional question was inserted to determine the extent to which students were able to use a 'rule of thumb' (the child's dose is about 1 third of the adult dose). For the *Bird's Eye View* task, an additional option was inserted as the two existing options gave students a 50% chance of being correct.

6. Benchmarking Numeracy in the Middle Years

6.1 Analysis of the data

The data was analysed using SPSS and Quest, a Rasch modelling tool developed by Adams & Khoo (1993). The following figure shows the Quest analysis of item estimates, or thresholds (p = 0.5), for all students across all items (each X represent 26 students) for the initial data collection (Phase 1, November 1999). The coded items on the right refer to a particular part of each task (**sp2** for instance refers to question 2 of the *Street Party* task, possible score 0 or 1). The location of the coded item indicates the point at which students scoring at this level (indicated by the X's immediately to the left) have a 50% chance of satisfying the scoring criterion indicated by the number following the full stop. For example, **spna.1**, indicates part (a) of the *Draw a Spinner* short task. Its location indicates that those students whose total score relative to the whole population is represented by the X's on the left have a 50% chance of achieving a score of 1 on this part of the task (possible scores 0, 1 or 2).

```
------------------------------------------------------------------------
                                  |    cd  .4
                                  |
  3.0                             |
                         X        |
                         X        |
                         X        |
                         X        |
                        XX        |    spnb.2 frcc.2
  2.0                   XX        |
                      XXXX        |    sp8b.2
                     XXXXX        |    trvc.2 docm.3
                    XXXXXX             sp10.2 wlka.2 frca.2 frcc.1 cd.3 medb2
                   XXXXXXX        |    frcb.2
                XXXXXXXXXX        |    sp4.3 sp9    docm.2
  1.0           XXXXXXXXXX        |    sp8a   wlka.1
           XXXXXXXXXXXXXXX        |    sp8b.1 dayb.2 cd.2 bird.2 medb.1
            XXXXXXXXXXXXXX        |    trpb.2 sp4.2 sp10.1 frcb.1
       XXXXXXXXXXXXXXXXXXX        |    busb.2 trvb   spna.2 meda.2
      XXXXXXXXXXXXXXXXXXXX        |    trvc.1 frca.1
           XXXXXXXXXXXXXXX        |    trpa.2 sp5b.2 sp6 .2 wlkb.2 daya
   .0  XXXXXXXXXXXXXXXXXXX        |    calc.3 docm.1 meda.1
          XXXXXXXXXXXXXXXX        |    busa.2 trpa.1 spnb.1
           XXXXXXXXXXXXXXX        |    busb.1 sp6 .1 wlkb.1
          XXXXXXXXXXXXXXXX        |    calc.2 sp5b.1 dayb.1
                XXXXXXXXXX        |
               XXXXXXXXXXX        |    trpb.1 sp5a   sp7
                  XXXXXXXX        |    calc.1 bird.1
 -1.0                XXXXX        |    trva
                   XXXXXXX        |
                     XXXXX        |    sp4 .1 cd  .1
                       XXX        |    busa.1
                       XXX        |    sp3c
                        XX        |    spna.1
 -2.0                  XXX        |    sp3b
                         X        |    sp3a
                                  |
                        XX        |
                                  |
                                  |    sp2
 -3.0                    X        |
                                  |
                                  |
                         X        |    sp1
                                  |
 Each X represents 26 students 22 cases perfect scores, 26 cases 0 scores
------------------------------------------------------------------------
```

Figure 1. Quest Analysis of Item Estimates (Thresholds), all-on-all (N=6861, p=0.5)

A similar variable map was generated for Phase 2 data (November 2000). Both maps show the ordering and spread of item difficulty, the range of student performance and the likelihood of success on particular items given student scores. The Phase 2 map shows that there is an upward shift in the spread of student performance.

This data will be reported more fully below.

Of all the items used in the SNP Profile, 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 incorporating performance measures of content knowledge and process (general thinking skills and strategies). Although further trialing is recommended to establish the reliability and validity of the SNP instruments over time. Another encouraging feature of the overall item analysis as it is presented in the figure below is that the degree of difficulty of the SNP appears to be appropriate for the cohort tested. This is indicated by the normal distribution of scores around 0 on the left hand side.

The most promising result however, is that the scaling indicated by the location of the items in Figure 1 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. 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. Callingham (1999) has reported a similar developmental pattern for the *Street Party* task which she has described using the SOLO taxonomy. As the development of the Emergent Numeracy Profile is a major outcome of the project, it too will be described in some detail below.

6.2 The Emergent Numeracy Profile

On the basis of the Rasch item analysis of the Phase 1 data, it was possible to identify patterns in students' responses. For example, for students performing at the highest level (greater than 2 on the variable map above), the analysis indicates that they have a 50% chance of scoring a 4 on the *CD Sales* task, a 2 on part (b) of the *Draw a Spinner* task and a 2 on part (c) of the *Fractions in Boxes* task. Listing what these different levels of performance meant in terms of the scoring rubrics led to eight, relatively discrete, hierarchical clusters. The first attempt at this clustering is indicated in the table below. The bold type descriptors refer to the *Street Party* task scoring rubrics.

cd.4		Full explanation based on fractions, %, ratio
spnb.2		Full explanation, including reference to fractions, % or ratio and significance of 60 spins
frcc.2	**H**	Complete explanation involving fraction equivalence
[medb.2]		[Complete solution involving algebra]
sp8b.2		**Understands relationship between variables**
trvc.2		Reads timetables 'backwards', interprets appropriate to context
docm3		Complete representation and explanation
sp10.2		**Describes relationship for chosen tables in words or symbols**
wlka.2	**G**	Correctly interprets sign, calculates distance
frca.2		12 fractions correct, can consistently rename fractions
frcc.1		fraction equivalence partially explained
cd.3		"not big" conclusion related to fractions and/or proportion
medb.2		Complete solution to multiple step problem
frcb.2		All cells completed correctly for chosen fraction
sp4.3		**Represents seating pattern using table or relationship**
sp9		**Determines correct number of chosen tables needed to seat 200**
docm2		Correct (28 games), incomplete representation

sp8a		**Draws appropriate diagram to show how 'big' table grows**
wlka.1		Recognises 5 km and 1.3 km relevant (involves difference)
sp8b.1		**Recording indicates an understanding of linear growth pattern**
dayb.2		Appropriate 10 week period indicated
cd.2		"Big" is relative, little/no explanation
bird2		Explanation provided
medb.1		'Indirect' relationship, numbers identified but not dealt with successfully
trpb.2		Correctly deals with relationship (10L/100km)
sp4.2	**F**	**Represents seating pattern using diagram or description**
sp10.1		**Recognises and describes general pattern for chosen tables**
frcb.1		Appropriate fraction chosen, less than 4 correct
busb2		Bus plan appropriate to situation
trvb		Reads 2 timetables (forwards)
spna.2		Data represented appropriately
meda.2		Correct manipulation 'direct' relationship involving 3 steps
trvc.1		Reads timetables correctly, not interpreted in context
frca.1		Renames and models simple fractions, decimals, %
trpa.2		Rounds to nearest km
sp5b.2		**Explanation based on relationship**
sp6.2		**Explanation based on generalised relationship**
wlkb.2		Interprets signpost, accommodates opposing direction in calculation
daya	**E**	Reads, interprets calendar, works with ordinal numbers
calc3		Chooses strategy appropriate to context, mentally calculates
docm.1		Multiplies without relating to context [7 x 8 games]
meda.1		Recognises relevant numbers, unable to complete multiple-step problem
busa.2		Calculates appropriate to context, recognises significance of remainder
trpa.1		Reads ones, tenths
spnb.1		Partial explanation of spinner
busb.1		Plan provided but not interpreted in context
sp6.1		**Explanation based on pattern recognition**
wlkb.1	**D**	Adds 1.3 and 0.8, little/no explanation (involves +)
calc2		Recognises mathematical operation required, written calculation
sp5b.1		**Describe pattern, eg, "goes up by 2"**
dayb.1		10 week period identified, no justification
trpb.1		Recognises relevant information (eg, 713 km)
sp5a		**Apply pattern to 99 tables**
sp7		**Identify and draw non-square table**
calc1	**C**	Recognises relevant information
bird1		Correct floor plan, no justification
trva		Reads simple timetable
sp4.1		**Represent pattern in one way only**
cd.1	**B**	Read graph without regard for meaning/significance of axis (i.e., considers one dimension only)
busa.1		Estimates, calculates without regard for situation

sp3c spna.1 **sp3b** **sp3a** **sp2** **sp1**	**A**	**Extend model, count, check [20 people]** Three parts shown, incorrect representation **Make a simple model, check [12 people]** **Make a simple model, check [8 people]** **Read, make a simple model, count [4 tables]** **Read, make a simple model, count [2 tables]**

Analysis of randomly selected student work samples, led to a further refinement of the profile in terms of the mathematical knowledge, skills and strategies that could be inferred from the nature of the students' responses. It was very clear that student's understanding of and capacity to apply rational number ideas was a major discriminating factor in students' numeracy performance. It was equally evident from the nature of student explanations that higher levels of performance were associated with a more focussed attention to both conceptual and procedural knowledge. In the developed profile this is described in terms of *monitoring cognitive goals* (indicative of conceptual understanding of the situation/task) and *monitoring cognitive actions* (indicative of procedural management of the solution attempt). This is consistent with earlier work of Siemon (1993) which examined the role of metacognition in children's mathematical problem solving. The third major discriminating factor is the extent to which students were able to deal with patterns – at lower levels of performance this was restricted to recognising and describing a pattern

H	Generalises, manipulates, applies relationships to solve problems Recognises that sums, differences, products and quotients or some combination of these can be treated as objects in their own right (eg, Medicine Doses) Uses rational number knowledge in an appropriate form (fraction, decimal, percent, ratio) to justify solutions to problems (eg, CD Sales) **Well established in the use of fraction/ratio knowledge** **Able to generalise and apply number relationships to solve problems** **Monitors cognitive actions and goals (that is, almost always evaluates what they are doing for meaning and relevance to problem solution**
G	Describes number pattern or relationship in general terms, words Uses a generalisation to solve a problem Interprets complex timetables, charts, and location signs appropriate to context Renames fractions in all forms Recognises scale and relative size as relevant factors in reading a graph Represents and solves multiple-step problems (eg, Dr Maths Soccer Tournament and Medicine Doses **Established in using/interpreting data and information appropriate to context, fraction representations, describing patterns and relationships** **Able to explain solutions to problems**

F	Recognises, describes and represents a number pattern in a variety of ways. Uses pattern or given relationship, eg, 10L/100km to solve a problem Represents experimental data appropriately (eg, Design a Spinner) Uses a calendar to locate a given period appropriate to context Reads and interprets signpost difference (same direction, subtracts) correctly, understands 'big' is relative little or no explanation offered Recognises and explains 2D representation of objects in 3D space Solves multiple step problems not requiring transposition/manipulation **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 (that is, evaluates what they are doing for meaningfulness and relevance to problem conditions)**
E	Explanation based on relationships (formulated as actions) Interprets signpost difference (opposing direction, adds) Mentally calculates 3-digit difference Reads timetables correctly but without regard to context Renames, models simple fractions and %s Recognises relevant problem information, unable to complete multiple step problem (eg, Dr Maths Soccer problem) **Consolidating fraction/% 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)**
D	Explanation based on pattern recognition, described locally, eg, "goes up by 2". Describes simple patterns, Solves division problem involving 2-digit divisor, interprets remainder relative to context Interprets signpost sum (opposing direction, adds), identifies appropriate period on calendar, little/no justification Uses a calculator or written method to solve 3-digit difference problem **Beginning to understand and represent simple fraction situations** **Generally solves one-step problems involving 3-digit whole numbers, ones and tenths.** **Describes simple patterns**.
C	Able to apply pattern to 99 tables [Street Party], identify and draw a non-square table Reads simple timetables and 3D representations of 2D shapes Recognises relevant information **Able to use a number pattern to solve a problem** **Monitors cognitive actions and/or goals some of the time, eg, recognises relevant information but unable to use it effectively**
B	Recognises pattern, represents in one way Reads graph [eg, CD Sales] without regard for scale **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, eg, estimates or calculates without regard for meaning or applicability**
A	Solves simple one-step problems using concrete materials Represents first few terms of a number pattern using materials and diagrams **Uses make-all, count-all strategies to solve a simple number pattern problem**

In developing the student data reports the Numeracy Profile was abbreviated to the following. It was referred to as the Emergent Numeracy Profile to indicate that it is regarded as work in progress. More work is needed to tease out and enrich the levels. The reference to CSFII Levels is indicative only.

The Emergent Numeracy Profile:

H CSFII 6	*Well established in the use of fractions/ratio. Able to generalise and apply number relationships to solve problems. Monitors cognitive actions and goals (i.e., almost always evaluates what they are doing for meaning and relevance to problem solution).*
G CSFII 5+	*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.*
F CSFII 5	*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).*
E CSFII 4+	*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).*
D CSFII 4	*Beginning to understand and represent simple fraction situations. Generally solves one-step problems involving 3-digit whole numbers, ones and tenths. Describes simple patterns.*
C CSFII 3+	*Able to use a number pattern to solve a problem. Monitors cognitive actions and/or goals some of the time (eg, recognises relevant information but unable to use it effectively).*
B CSFII 3	*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, eg, estimates or calculates without regard for meaning or applicability.*
A CSFII 2+	*Uses make-all, count-all strategies to solve a simple number pattern problem*

6.3 Observations from the Phase 1 (November 1999) data collection

Complete data sets were obtained from 6860 Year 5 to 9 students from a representative sample of 27 primary and 20 secondary schools across Victoria.

Individual school data will not be reported here as the purpose of the exercise was to gather baseline data on numeracy performance to help select and inform Trial Schools. Particular areas where students demonstrated some consistent difficulty were identified from the analysis of items and overall student performance. These came to be referred to as 'hotspots' and were used to inform the development of the draft numeracy advice to Trial Schools.

'Hotspots' identified by the initial data collection, indicate 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.

Overall cohort data is reported below by various population variables. Given that the Rasch analysis indicated it was possible to identify student numeracy performance along a single dimension, scores are comparable across Year levels. Means are given in bold type. Standard Deviations for each population are shown in italics. The maximum score possible was 95.

Performance by Year Level:

All differences between consecutive Year levels are significant. That is, there were significant differences between Years 5 and 6, Years 6 and 7 and Years 7 and 8 (p<.001) and Years 8 and 9 (p<.02). The maximum score possible was 95.

Total Phase 1	Year 5	Year 6	Year 7	Year 8	Year 9
Mean Score: **51.2** (53.9%)	**47.8** (50.3%)	**52.9** (55.7%)	**50.1** (52.7%)	**52.0** (54.7%)	**53.1** (55.9%)
Std. Dev. 11.2	*10.5*	*11.0*	*10.9*	*11.1*	*11.8*
N = 6859	1314	1318	1467	1484	1276

Given that this 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 mean score of 53.9%. To some extent it is an artefact of the analysis that distributes scores against items on the basis of observed probabilities. Nonetheless, given that the majority of mathematical content was representative of CSFII Levels 2 to 4 for a Year 5 to 9 sample that might be expected to be operating at CSFII Levels 3 to 6, the overall performance must be viewed as disappointing.

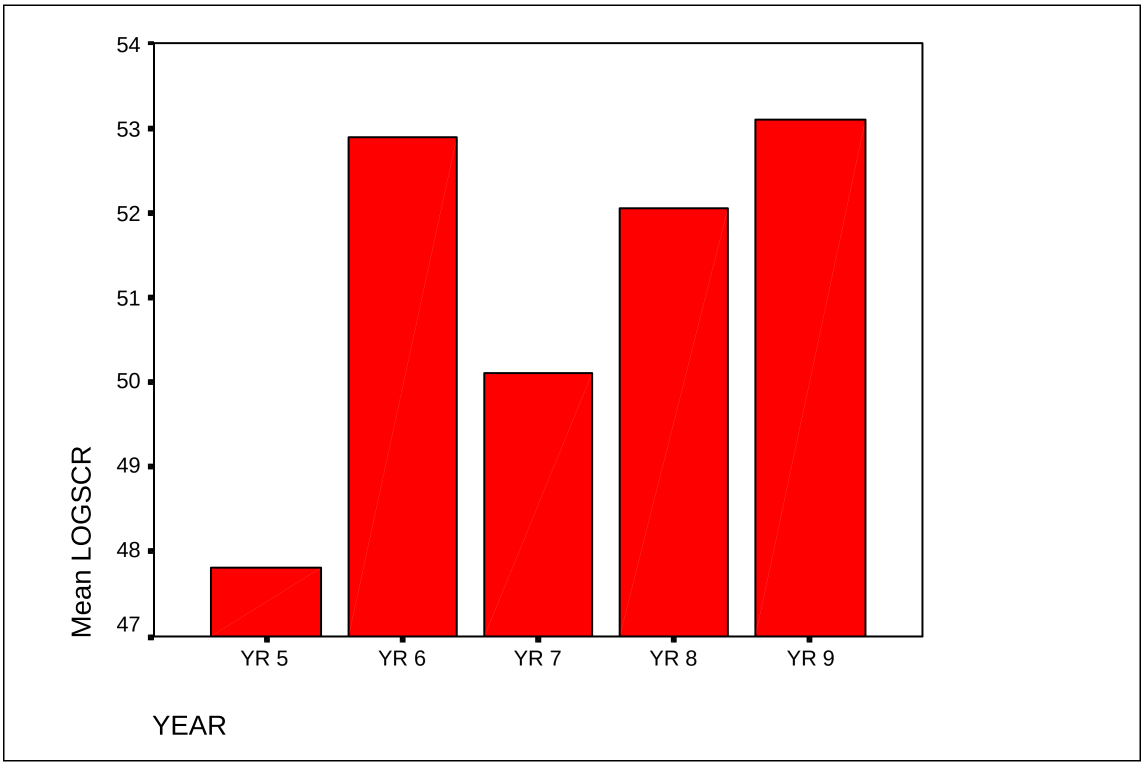
This level of performance is even more disappointing given the emphasis on mathematical problem solving and the use of mathematical tools and procedures in Victorian curriculum framework documents and policies over the last ten to fifteen years. Of course, what this level of performance could mean is that students are unfamiliar with the mode of assessment, particularly the requirement to interpret tasks relevant to context and explain and justify one's thinking and/or actions. However, this is exactly what the tasks were specifically designed to do in order to assess key aspects of numeracy. To the extent that these aspects are not assessed in school mathematics at the current time, it is inappropriate to compare these levels of numeracy performance to performance on more familiar assessments of school mathematics. 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.

The data reveals a significant 'dip' in numeracy performance between Years 6 and 7 which is illustrated in the graph below. This is consistent with similar data reported in relation to literacy performance in the middle years of schooling (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, at least some of the variance would appear to be due to a decline in the expectations of Year 7 students. For instance, a cursory look at most of the commonly used texts suggests that much of the material that is presumably 'covered' in Years 5 and 6 is repeated in Year 7. This is consistent with a study reported by Flanders (1986) of relative content of major mathematics textbooks in the United States. This issue may well be exacerbated by the way in which this repeated content (mostly number related) is handled. More often than not in Years 7 and 8 this content is dealt with in a very different way to how it is approached in the upper levels of primary schooling. Where this is done through innovative problems and tasks, it may well contribute to student understanding. Where it is dealt with in a traditional, rule-based manner it is unlikely to have much effect on student learning. 'More of the same' for students who did not understand it in the first place is unlikely to lead to an improvement in student learning.

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, in particular *Fractions in Boxes*, *Draw a Spinner*, *Trip Metre*, *CD Sales* and *Medicine Doses.*

Given the importance of this area to the development of numeracy and in the interests of discouraging 'more of the same' approaches, the following resources are highly recommended as exemplars of more appropriate teaching and learning materials. The first two are produced by the Curriculum Corporation and have been developed from effective classroom practice. The third resource was developed for the adult numeracy area, but it has been used successfully in Years 6 to 8. All three resources address key aspects relevant to numeracy.

- Fraction Estimation activities from *Maths Project 300*,
- The *Replacement Unit on Computation for Years 7 and 8* (Curriculum Corporation, 1998-2000), and
- *Measuring Up* (Marr & Tout, 1998)



Mean Logit Score for Phase 1 Overall Cohort

Performance by Class:

It appears that there are significant differences between classes in the same Year level at the same school and that these differences might in fact be as great as the differences between schools. It is beyond the scope of the study to explore this in more detail for Phase 1 schools as insufficient data was available to isolate the variables that might be contributing to the differences, for example, the allocation of students to classes on the basis of ability. This issue is examined further in relation to Trial School data.

Performance by Gender:

Total Male	Year 5	Year 6	Year 7	Year 8	Year 9
Mean: 51.3	**48.8**	**52.8**	**50.1**	**52.2**	**53.0**
Std. Dev. 11.2	*10.3*	*11.3*	*10.9*	*11.3*	*11.6*
N = 3191	593	628	713	714	543

Total Female	Year 5	Year 6	Year 7	Year 8	Year 9
Mean: 51.3	**47.2**	**52.9**	**50.8**	**52.4**	**53.7**
Std. Dev. 11.1	*10.6*	*11.3*	*10.9*	*11.3*	*11.6*
N = 2757	571	528	587	572	499

There were no significant gender differences in student numeracy performance as measured by the instruments described above.

Performance by Sector:

The following data should be read with some care. Given the smaller number of Catholic and Independent schools included in the sample, it is possible that they are less representative of the full range of schools in those sectors than the State schools. It is also possible that there is 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 when considering the data as is the fact that, strictly speaking, the sampling unit in this case is the school not the individual students.

Total DEET	Year 5	Year 6	Year 7	Year 8	Year 9
Mean: 49.9	**46.7**	**52.0**	**48.2**	**50.6**	**52.0**
Std. Dev. 11.3	*10.3*	*10.4*	*11.4*	*11.6*	*12.0*
N = 4686	902	946	981	1009	850

Total CECV	Year 5	Year 6	Year 7	Year 8	Year 9
Mean: 52.6	**48.9**	**53.0**	**52.7**	**54.4**	**52.7**
Std. Dev. 10.4	*10.9*	*13.5*	*8.7*	*8.1*	*11.8*
N = 946	133	103	259	550	231

Total AISV	Year 5	Year 6	Year 7	Year 8	Year 9
Mean: 54.9	**51.0**	**55.8**	**55.3**	**55.6**	**58.1**
Std. Dev. 10.4	*10.4*	*11.4*	*9.0*	*10.4*	*9.1*
No. Students	279	269	227	1012	801

To the extent that the data above represents a valid comparison, it is interesting to note that it appears that there is very little difference in the Year 6 and Year 7 performance of students in Catholic and Independent schools compared to those in state schools. There are a number of possible explanations for this which may, when taken into account, wash out this apparent difference between the private and public sectors, but this is beyond the scope of the present data set to examine with any confidence.

Performance by Location:

On the basis of the following data, it appears that the ‘dip’ between Year 6 and 7 performance is 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. That is, it is plausible that where students progress from Year 6 to Year 7 within a fairly well-defined, familiar ‘community’, where they feel comfortable with the vast majority of those around them, either because they came from the same feeder school or because of the strength of their social ties, they are socially supported in ways that enable them to perform at a higher level than their urban peers faced with very significant changes in their social and cultural experience.

Total Rural/ Regional	Year 5	Year 6	Year 7	Year 8	Year 9
Mean: 52.4	**47.2**	**51.6**	**53.7**	**54.3**	**56.1**
Std. Dev. 10.7	*10.0*	*11.0*	*9.1*	*9.4*	*11.5*
N = 2556	558	577	474	472	475

Total Metropolitan	Year 5	Year 6	Year 7	Year 8	Year 9
Mean: 50.5	**48.3**	**53.9**	**48.4**	**51.0**	**51.3**
Std. Dev. 11.6	*10.9*	*10.9*	*11.3*	*11.7*	*11.6*
N = 4303	736	741	993	1012	801

The notion of ‘cultural connectedness’ is related to the notion of social support systems evaluated by Marks

(2000) as a major factor in student engagement. It would appear that both notions are far more likely to encourage constructive, risk-taking, explorative behaviour than feelings of alienation or uncertainty.

Performance by Year Level and Emergent Numeracy Profile

The following table shows the percentage of Phase 1 students at each level of the Emergent Numeracy Profile. Level A is the lowest level, indicative of Level 2 of the Victorian CSFII (around Year 2) and H is the highest level, indicative of Level 5+ to 6 of CSFII (around Year 9/10) which was the highest level assessed. The distribution of students across 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 '7 year gap' in mathematics performance of students in the middle years of schooling. That is, that in any one, 'mixed-ability' class 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.

Phase 1 Total (N=6860)	Year 5 (N=1315)	Year 6 (N=1318)	Year 7 (N=1467)	Year 8 (N= 1484)	Year 9 (N=1276)
Level A: 4.8%	6.2%	3.3%	6.1%	4.2%	4.3%
Level B: 5.2%	8.1%	3.9%	5.5%	4.5%	3.8%
Level C: 12.2%	17.1%	10.6%	13.0%	10.5%	9.9%
Level D: 16.0%	23.3%	15.7%	16.5%	13.6%	11.3%
Level E: 20.9%	18.3%	18.1%	22.5%	22.8%	22.6%
Level F: 23.9%	18.7%	27.1%	23.7%	25.3%	24.5%
Level G: 13.5%	7.1%	16.9%	10.2%	15.6%	18.0%
Level H: 3.4 %	1.3%	4.3%	2.6%	3.4%	5.6%

One of the clear implications that can be drawn from the data above 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.

Key growth points in 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.

Poor learning behaviours (elaborated in the PEEL Project, see Baird & Mitchell, 2000) also need to be identified and actively worked on to replace them with 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. Focusing 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.

6.4 Trial School Data (comparison of November 1999 and November 2000 data)

For the purposes of anonymity, Trial Schools were numbered from 1 to 20 (see Sections 4 and 9 for further details). Complete data sets were obtained from 2899 Year 5 to 9 students from the Trial Schools. This data is reported below

Performance of Trial Schools by Year Level:

The following tables give the mean logit scores for Phase 1 and 2 by year level for Trial School students. For the 'missing cohort', that is Year 5 and Year 7 students in 2000 who were not assessed in November 1999, the Phase

1 data was collected in March 2000. For all other year levels, the Phase 1 data was collected in November 1999.

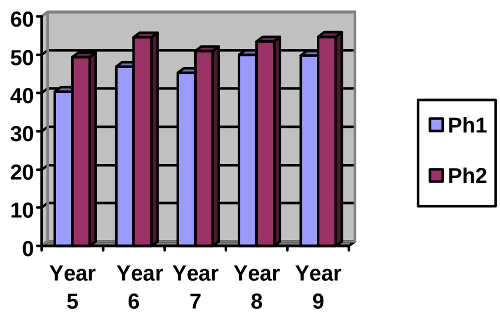
As for Phase 1, there were significant differences between Years 5 and 6, Years 6 and 7, and Years 7 and 8 in the Phase 2 data (p<. 001). In contrast to Phase 1, there was no significant difference between Year 8 and Year 9.

All of the increases in each year level between Phase 1 and Phase 2 data are significant (p<. 05). That is, the data points to significant improvements in numeracy outcomes as measured by the instruments used in the study. However, it would appear that the 'transition dip' has 'deepened' (see graph below).

Trial Phase 1	Year 5	Year 6	Year 7	Year 8	Year 9
Mean Score: 46.5 (48.9%)	**40.4** (42.5%)	**46.9** (49.4%)	**45.3** (47.7%)	**50.0** (52.6%)	**49.8** (52.4%)
Std. Dev. 12.9	*12.98*	*11.4*	*12.2*	*11.8*	*13.7*
N = 2899	540	513	690	603	553

Trial Phase 2	Year 5	Year 6	Year 7	Year 8	Year 9
Mean Score: 52.6 (55.3%)	**49.4** (52%)	**54.6** (57.4%)	**51.0** (53.7%)	**53.5** (56.3%)	**54.7** (57.6%)
Std. Dev. 11.8	*10.0*	*10.7*	*11.3*	*13.5*	*13.5*
N = 2899	540	513	690	603	553

The significant improvement from Phase 1 to Phase 2 is shown in the graph below.



Mean Phase 1 & Phase 2 Logit Scores for Trial School Sample

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. For example, *Travel Time* (connecting timetables), *Draw a Spinner* (interpreting data tables), *Trip Metre* (reading decimal fractions in context, odometres) and *Do You Know What Day It Is?* (using a calendar, ordinal number). There was also considerable improvement on tasks that required students to monitor and regulate their cognitive behaviour such as *Dr Maths Soccer Tournament, Travel Time* and *How Far to Walk*. The ability to represent fractions and decimals in a variety of forms (*Fractions in Boxes*), interpret data relevant to context (*Filling the Buses*), perform mental calculations (*Without a Calculator*) and recognise, describe and use patterns (*Street Party*) were also areas where student numeracy performance improved.

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. For instance, it is possible that the form of assessment used provided sufficient stimulus in its own right to alert teachers to a broader range of expectations in relation to teaching and learning. And that this alone prompted teachers to value and attend to those aspects in a more conscious and focussed way.

However, there is sufficient difference between Trial Schools to suggest that something more was responsible for the improved performance. While a detailed description of Trial School Action Plans is presented in Section 8, student numeracy performance by school is detailed below.

Performance Between Trial Schools:

The following table lists schools by initial sample status and mean student numeracy scores for Phase 1 and 2. Schools have been ordered according to the mean difference shown on the right. Significant differences are indicated by * (p<. 05).

SCHOOL NUMBER	SCHOOL TYPE	MEAN PHASE 1	MEAN PHASE 2	MEAN DIFERENCE	SAMPLE STATUS (Based on Ph1 data)
10	Prim	53.46	54.97	1.52	HNP
16	P-12	54.19	55.85	1.66	HNR
17	Prim	55.2	57.05	1.86*	HNP
6	Sec	50.04	53.36	3.32*	HNP
5	Sec	43.08	46.40	3.32*	LNR
3	Sec	49.76	53.42	3.66*	HNP
12	Prim	40.39	45.73	5.34*	LNR
1	P-12	54.53	60.05	5.52*	HNR
20	Sec	44.24	49.83	5.59*	LNP
2	Sec	43.93	50.29	6.36*	LNP
18	Prim	50.62	57.20	6.59*	HNR
7	Sec	52.11	58.88	6.77*	HNP
15	Prim	45.16	51.98	6.82*	LNP
11	Prim	43.70	51.20	7.50*	LNP
8	Prim	42.23	51.62	9.39*	LNP
9	Prim	40.78	50.76	9.98*	LNP
19	Prim	39.50	51.05	11.55*	LNP
4	Prim	43.24	56.03	12.79*	LNR
14	Prim	39.32	52.54	13.22*	LNR
13	Prim	34.83	49.01	14.18*	LNR
Overall		**46.50**	**52.57**	**6.08***	

The observations drawn from this data have been grouped according to the two sampling criteria. That is, level of student numeracy performance (high/low) 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). See Section 4 for further details. The initial sample status of each school is given in the table above where LNR refers to Low Numeracy/Design Element Rich and HNP refers to High Numeracy/Design Element Poor.

With respect to pre-existing levels of *student numeracy* as measured by the assessment tasks used in this study, the following observations can be made from the data presented in the table above.

- Students in those schools with the 'furtherest to go', that is, with lower Phase 1 student numeracy performance scores, generally made the greatest improvements. For example, Schools 13, 14 and 19 had the three lowest mean scores on the Phase 1 assessment of student numeracy performance but were in the top 4 schools who made the greatest improvement on Phase 2. As might be expected primary schools were more likely to be represented in this group.

- 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'.

- Both P-12 schools were classified as High Numeracy-Design Element Rich at the outset. It is not clear why one appears to have been able to make more improvement than the other, although changes in school management that occurred during the Trial period may be related to this.

With respect to the extent that schools had a range of *school-wide policies and practices* in place at the outset, the following observations can be made from the data presented in the table above.

- 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 (see graph below).

- 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).

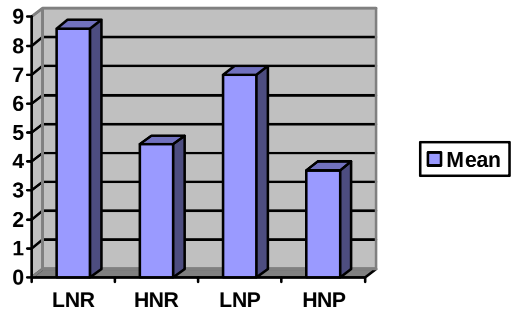
- With the exception of one school, High Numeracy/Design Element Poor schools (identified as HNP above) were among the schools who demonstrated the least improvement in student numeracy performance. This is possibly due to the 'ceiling' effect described above, but it is more likely due to the particular socio-cultural 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.

Performance within Trial Schools



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). Further more, 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.

Performance by Gender:

In the Phase 1 testing there was no significant difference between sexes (p=.225), but there was a significant gender difference in Phase 2 (p=.011) in favour of the females (Mean Logit 53.21 compared to 52.08 for the boys). This could simply be an artefact of the sampling and/or the fact that 2% of the population were excluded from the analysis on the basis that their gender could not be determined from the information supplied. 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 and featured in a number of Trial School Action Plans.

Performance of Trial Schools by Emergent Profile Levels

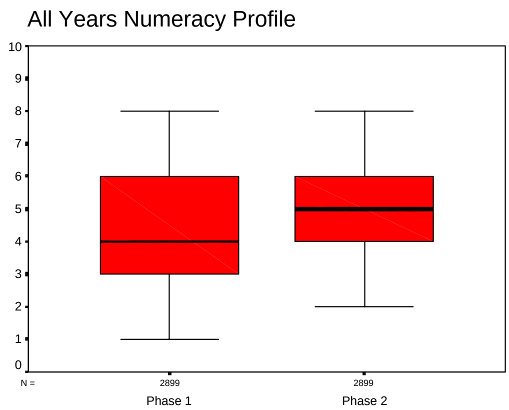
Not surprisingly, given the overall increase in student numeracy performance, there has been a significant shift in the proportions of students at each level of the Emergent Numeracy Profile.

Total	A	B	C	D	E	F	G	H
Ph1 Trial N=2899	10.6%	10.3%	17.7%	15.9%	18.1%	16.7%	8.7%	2.0%
Ph2 Trial N=2899	3.7%	5.9%	10.5%	15.8%	20.0%	22.3%	15.2%	6.6%

In November 1999, just over 61% of the students in Years 5 to 9 of the Trial schools were performing at or above level D (Table 1). In November 2000, that proportion had risen to just under 80%. While schools adopted a variety of approaches, systematic attention to the key areas identified by the Phase 1 data collection, for example, problem solving and the capacity to explain and justify one's mathematical thinking, have clearly yielded results.

The mean overall shift was 1.52 Profile levels with the highest shifts being demonstrated by Years 5, 7 and 8 (mean 1.7 Profile levels) and the lowest shift by Year 9 (mean 1.0 Profile levels).

The following box-plots shows the shift in levels (1=A (lowest); 8=H (highest)) along the Numeracy Profile from one phase to the next as well as the range of student numeracy performance. The shaded area represents 50% of the population, the line indicates the median (the thickness of the line is indicative of the relative number of students at the median.



6.5 Implications of Student Numeracy Performance Data for Improving Numeracy Outcomes

Planning for Numeracy

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-of-school approach to numeracy improvement is a key element in achieving success. Summary descriptions of the particular programs and approaches associated with significant improvements in student numeracy are presented in Section 8.

Organising for Numeracy

The measurable dip in performance in Years 7 and 8 relative to Years 6 and 9, suggests that it is unwise to categorise students into differentiated curriculum courses on the basis of their Year 7 performance. A more sensible approach would appear to be to focus on improving and extending all students knowledge, particularly as they appear to be getting ‘back on track’ by the end of Year 9. The ‘transition dip’ also suggests that serious and urgent consideration needs to be given to what mathematics is taught and how it is taught at this level. Traditional approaches based on linear sequences of topics may not be the most effective way to engage young learners, many of whom need additional and special assistance.

Given that the MYNRP data also indicates that there is at least as much difference between classes at the same school as there is between schools (irrespective of streaming), suggests that teachers make a difference in another way. That is, it needs to be kept in mind that *opportunity to learn* is as much a factor in explaining differences in performance as so-called *ability*. It seems somewhat inequitable to assign students to socially stratified groups on the basis of missed opportunities that were beyond their control. Differentiating the teaching to ensure all students have relatively equal opportunity to learn would appear to offer a better chance of maximising success for all.

7. The Student Interviews

“maths…not easy, not hard, I want to learn, just need to get taught” (Brendan, Year 9)

The student interviews were undertaken to ascertain students’ views about their experiences in relation to numeracy, what motivated their learning and what prompted them to disengage with the teaching and learning of school mathematics. The particular sample was selected to shed light on the specific teaching and learning implications for students ‘who fall behind’ (Project Brief, 1999).

7.1 Student Selection

Trial Schools were invited to nominate 2 to 4 students (depending on size) from Years 5 to 9 as appropriate to be interviewed by the Project Team. Nominated students were expected to satisfy the following criteria. That is, they were

- fairly typical of “lower performing” students generally;
- performing at one or two CSF Levels below where they might be expected to be;
- prepared to talk to project team members about their mathematics/numeracy-related experience;
- regarded as ‘under-achieving’ in relation to mathematics.

Schools were advised that the Project Team was not looking for the very weakest students or students with severe learning problems as we were trying to understand what it was that hindered mainstream numeracy performance. The students who were nominated for interviews were largely representative of the larger school population in terms of social and language background.

42 students from Years 5 to 9 were interviewed. 23 were females, 19 were males.
The breakdown by Year Level is given in the Table below. At least 2 students from each Trial School were interviewed in July and August of 2000.

	Year 5	Year 6	Year 7	Year 8	Year 9
Male	6	4	4	3	6
Female	6	4	4	1	4

7.2 The Interview

The interview comprised a brief introduction aimed at putting the student at ease and exploring his/her beliefs about mathematics. A short Likert survey was used to document student's beliefs about themselves in relation to school mathematics. The second part of the interview involved asking students to reflect on their experience of doing the assessment tasks for the project. In some instances, this meant showing the student the relevant Student Numeracy Performance Tasks. Students were asked to nominate those items that they found relatively easy and those they found 'hard' or 'harder'. They were then asked to choose one or two tasks to solve. The interviewer asked further questions to elicit students reasoning and understanding depending on the student's response. Where students showed some reluctance to proceed, the interviewer reverted to a set list of questions designed to elicit students understanding of key areas identified by the Phase 1 data (the Diagnostic Interview).

Interviews were generally arranged during class time but not necessarily when mathematics was scheduled. They were conducted in an Interview Room or a small room away from the classroom and varied in length from 40 minutes to an hour. A selection of the interviews were videotaped, all other interviews were audio-taped. Student work samples were collected where generated.

7.3 Summative Analysis of Student's Responses

Attitude Survey:

Responses to the statements, "maths is hard", "maths is my best subject" and "most of my friends are better at maths than me", suggest that the nominated students generally satisfied the sampling criteria.

Statement	Agree/Strongly Agree	Disagree/Strongly Disagree
7. Maths is hard	68.3%	17.1%
8. Maths is my best subject	14.6%	82.9%
5. Most of my friends are better at maths than me	58.4%	24.4%

However, this raised some interesting questions that remain unanswered, for example, 'Why is it that 17% or so of these students believe that maths is "not hard?' A comment from one student when probed about this suggests that it may have something to do with the way maths is "done". The implication being that it wouldn't be hard if it was done another way, that is, "not textbooks and stuff like that where you have to work on your own" … "if the teacher explained it to me better".

Given that the sample was made up of students who had a relatively long history of failure in relation to school mathematics, it is perhaps surprising that a significant majority regarded mathematics as "important".

Statement	Agree/Strongly Agree	Disagree/Strongly Disagree
3. Mathematics is not as important as some people think	17.1%	75.6%
4. If I could get out of doing one subject it would be maths	34.1%	58.5%
11. People who have a calculator or a computer don't need to learn as much maths	12.2%	85.4%
12. We learn a lot of things in maths classes that we'll never use outside of school	36.6%	53.7%
20. If I don't understand what the teacher has explained I just forget about it	19.5%	73.2%

While 34% would elect not to do mathematics if they could avoid it, the data above suggests that a significant number of 'at risk' or 'weaker' students are motivated to pursue mathematics despite their classroom experiences and perceptions that most of their friends are better than they are at mathematics. Also, while close to 37% believe that they have to learn a lot of things that they'll never use, the fact that the remaining students are either unsure about this statement (roughly 9%) or disagree with it (close to 54%) suggests that the majority of these students believe that mathematics is not only important but relevant to their future lives.

It is also interesting to note that although only 39% reported that it was "fun to do maths problems", more students reported liking mathematics classes than not (48.8% compared to 34%), and the sample was evenly split on the question of whether or not "maths is boring" (Agree/Strongly Agree 41.5%, Disagree/Strongly Disagree 41.5%). While this situation may be regarded as less than desirable, it conflicts with the rhetoric that has almost become a mantra among secondary teachers of mathematics. That is, that school mathematics is universally perceived as 'boring' and 'irrelevant' and that this is the major reason why students disengage. In actuality, it is probably no more 'boring' than any other school subject at this level and given its perceived status as 'important', it is arguable that students may in fact believe it to be more relevant and are therefore more inclined to engage with mathematics than some other subjects. This suggests that the reasons for the reported disengagement of students in school mathematics in the middle years are more complex and may need to be found elsewhere.

Although success at school mathematics is seen to be associated with a knowledge of 'rules', knowing what and how 'to do it', and being able to explain what was done, success is not generally seen in terms of passive dependence on the teacher and rote-learnt techniques.

Statement	Agree/Strongly Agree	Disagree/Strongly Disagree
10. Mathematics is easy if you know the rules	56.1%	31.7%
14. Sometimes I just know the answer but I don't know how to do it	68.3%	26.8%
13. I can do maths but find it hard to explain what I've done	63.4%	26.8%
9. To be good at maths you just need to do what the teacher tells you to do	39%	51.2%

In fact, the level of agreement with statements 13 and 14 above and the following statements, suggest that engagement may be related to the extent to which students can access the communicative aspects of mathematics, that is, the ability to read, write and 'speak' mathematically. It also suggests that opportunity to understand, provided by one-on-one conversations with the teacher and/or more learned peers, may be a factor in engagement.

Statement	Agree/Strongly Agree	Disagree/Strongly Disagree
15. Maths is good when the teacher goes slowly	87.8%	7.3%
17. I like it when the teacher explains things to me by myself	85.4 %	12.2%
18. If I don't understand what the teacher has explained I ask for it to be repeated.	75.6%	22%
19. If I don't understand what the teacher has explained I ask a friend to help me.	78%	7.3%

These are hardly the views of students who do not want to learn mathematics. That they are prepared to accept some of the responsibility for this themselves is evidenced by their commitment to engage more knowledgeable others in the enterprise and their more equivocal response to the statement, 'If I don't know how to do a maths problem I ask the teacher straight away' (Agree/Strongly Agree 56%, Disagree/Strongly disagree 39%). Again, the weighting given to 'going slowly' and 'explaining' suggests that a major reason these students appear to be disengaged is that they are unable to participate in the text and conversation of mathematics. They literally do not understand and cannot translate the symbols, processes, diagrams, and models used to explicate mathematics, partly because they do not have access to many of the key underpinning ideas and partly because teachers of mathematics have tended to assume that the texts of mathematics are self-evident. As a result, many students are isolated from the means to understand and have little option but to resort to a range of self-protective behaviours. The following analysis of the interview questions amplifies the importance of understanding from the student's perspective.

Interview Questions:

It is inappropriate to compare Year level responses as the numbers are too small. However, it is appropriate to compare primary and secondary students' responses and to discuss the group as a whole as their student numeracy performance data tended to be fairly similar. In the following, students' names have been changed to preserve their anonymity.

When was the last time you enjoyed doing some maths either in school or outside of school?

Cooking, football scores and part-time work were generally nominated as the sources of enjoying maths outside of school although 2 students included homework in this category.

> "Mum buys maths books that we can fill in if we are sick. I just liked it… addition and subtraction sums: (Tom, Year 5)
> "homework the other night…one-step linear equations, it was fairly easy" (Carl, Year 9)

In terms of when students last enjoyed doing maths in schools, four main categories of responses were identified. These described situations and events which involved

- some form of activity maths, mostly maths games but also extended investigative projects and work with shapes;
- personal experience of success;
- problem solving; and
- a supportive relationship with a teacher.

Some examples of students' responses follow. The relative recency of the responses in the first three categories is heartening. However, the fact that all of the references to a supportive relationship were to primary and not secondary teachers is a matter of some concern.

Activities:

Angie, Year 5:	"doing M&M maths with MrsX , fractions"
Eric, Year 5:	"with Mrs X in maths groups, we do this house thing with 3D things, had to design a house from bird's eye view, put all the angles in, good, drawings and things"
Jim, Year 5:	"in class, we did 'Earn & Learn' I applied and got to be a loan manager. It was set up like a little city".
Susie, Year 5:	"in school, played a game with fractions, you had to make up two fractions to make up five … like hangman".
David, Year 6:	"Last Friday-maths activities out of bags, sometimes science & IT as well not just out of the book"
Samantha, Year 6:	"a couple of days ago in class we had maths games"
Breanna, Year 7:	"architectural maths, floor plan last year in primary school, real architect person, I could draw, could really join in"
Jason, Year 7:	"never really have enjoyed it, this year we made some shapes, that was good"
Warren, Year 7:	"a couple of weeks ago, we played a maths game, did something on the board, wrote down the numbers" [backtracking]
Erin, Year 8:	"a couple of weeks ago, pattern cutting out, we made nets of shapes in class"
Marie, Year 9:	"a week ago we did an activity, we had to create new shapes from old shapes, you were told a shape to make"
Vincent, Year 9:	"today, doing some graph type things, tally graphs, drawing them"

Experience of Success:

Sarah, Year 5:	"the maths test on Tuesday, some questions were hard but some were good and I could understand them"
Natasha, Year 5:	"at school, fractions, adding and taking away, taught me new things I didn't know"
Matt, Year 6:	"in class recently doing fractions, changing fractions to decimals, it was good because I actually understood it and I felt better"
Elise, Year 6:	"at school, times tables, I know them"
Peter, Year 7:	"when we did the Westpac competition in June/July, cause I knew most of the answers and I got sent off to compete for my school"
Brendan, Year 9:	"could do year 8 easy – struggle with Year 9, once I learn it OK".
Billie, Year 9:	"Indices, just recently…it was fun 'cause I understand how to do it"

Problem Solving:

Sophie, Year 6:	"last time we did problem solving in class, it was a chance and data thing"
Lydia, Year 7:	"in class just recently, the 'locker bay' problem"
Liam, Year 7:	"last maths lesson, solving different problems out of book, challenge encourages you to learn more, if you don't know how to do maths problems, you have less chance of getting a job"
Tim, Year 8:	"last maths class, problem solving in pairs, you had to pick cards and solve the problem asked"

Supportive relationship:

Amanda, Year 7:	"primary school- teacher was really nice and helped me and it was easier, my teacher made us learn our times tables and I knew them, but now I've forgotten them"
Rebecca, Year 9:	"grade 3, it was my favourite subject. It was easy, then it got hard. Teacher really knew me, I had her in grade 1 as well"
Francis, Year 5:	"last year in Mr X group maths games, good"
Simon, Year 9:	"grade 4, doing fractions, finally got it, teacher finally explained enough and it clicked, hands on and bookwork. Teacher went to every student individually, explained it, extra help for those who needed it"

Students were shown a copy of the relevant Student Numeracy Performance Tasks and asked what they remembered doing well and what they experienced some difficulty with.

While there appears to be little relationship between what students reported "doing well" and their actual performance, it is interesting to note some of the reasons given for believing they had done the task reasonably well. In most cases, the reasons given related to the presence of visual images, usually in the form of a graph (*CD Sales*) or a picture (*Bird's Eye View*), for example,

> "the bird one wasn't bad and the CD one - it had a graph, the answer's there, it shows you" (Erin, Year 8).

Other reasons seemed to relate to the type of response required. For instance, while they were not well done, *Draw a Spinner* and some parts of the *Fractions in Boxes* tasks may have appeared 'easier' as they required students to draw even though a correct drawing or representation generally relied on some form of calculation.

By far the most commonly reported task in relation to the question, "What do you remember having problems with and why?" was *Trip Metre* (nominated by 45% of the interview sample). This is perhaps not surprising as it involved the ability to read and interpret decimal fractions. Most reported that they "just couldn't work it out", some nominated "tenths" as the problem.

The next most frequently nominated task was *Filling the Buses*. This is surprising as it involves a fairly straightforward application of division and a sensible interpretation of a remainder. Perhaps it is because these students did not have the flexibility to see that this task was most easily solved by estimating and multiplying rather than by literally dividing by a 2-digit number, for example,

> "bus problem – had to do heaps of working out, didn't know it basically" (Ian, Year 6)

The *Fractions in Boxes* task was nominated by 23% of the students as a 'harder' task. This is consistent with the overall data which identified fractions and decimals as the most problematic for students in the middle years.

> "some easy, some hard" (Sophie, Year 6)
> "didn't understand changing fractions into decimals and stuff" (Marie, Year 9)
> "can't read symbols" (Breanna, Year 7)

Doctor Maths and *Medicine Doses* were also nominated as more difficult. But as the first of these required some capacity to represent and solve unfamiliar problems and the second a capacity to manipulate formulae or, at the very least, calculate and keep track of at least three steps, this is not surprising.

Some difficulties appeared to be due to lack of familiarity with timetables (*Travel Time*).

> "no idea how to read" (Madeleine, Year 6)
> "hard, didn't know how to read grid" (Sarah, Year 5)
> "couldn't work it out, the times, not experienced time tables before" (Susie, Year 5)

Other tasks (*Draw a Spinner* and *How Far to Walk*) were nominated on the basis that students could not make sense of what they were being asked to do.

> "spinner was hard because I don't really understand the question" (Billie, Year 9)
> "couldn't figure out how to draw spinner, not that good at multiplication had to go through it a lot" (Gerard, Year 5)
> "walk [task] …didn't really understand what the question was saying" (Sophie, Year 6)
> "walk one - don't understand what it's all about, don't get the maths in it, it's just like common sense-you just see it" (Matt, Year 6)

What makes maths easier or better for you?

Six categories of responses were identified in relation to what was perceived to make mathematics 'easier' or 'better'. By far the most frequently given responses concerned explanations appropriate to level of understanding and individual assistance.

- Use of calculators, materials, diagrams, pictures and/or games, for example, “diagrams and pictures” (Breanna, Year 7), “If I had a calculator” (Rebecca, Year 9) and “When it’s not just a sum, when it’s a problem” (Jim, Year 5).
- Supportive culture, for example, “When everyone’s nice and people aren’t talking and you can do your work” (Amanda, Year 7), “the teacher uses examples, demonstrates, repeats if needed” (Carl, Year 9), and “groups, it’s more fun like that” (Tim, Year 8).
- Pace that supports understanding, for example,

  “When the teacher teaches slow, at the pace I can work at” (Marie, Year 9)
  “If the teacher explains it slowly and does lots of examples on the board, and then asks if you understand it” (Erin, Year 8)
  “If I understand it … if the teacher goes slowly”(Carl, Year 9)

- Individual assistance, for example,

  “When Mr X helps me out, when he explains it to me” (Sarah, Year 5),
  “When I’ve got someone to help me, show me what to do, what I’m doing” (Natasha, Year 5), “Working with a friend” (Madeleine, Year 6)
  “When the teacher is there to ask” (Warren, Year 7),
  “helping individually” (Jodie, Year 9),

- Explanations appropriate to level of understanding, for example,

  “When someone explains it properly, they talk to you about it” (Susie, Year 5),
  “When I know it better, when it’s explained well” (Eric, Year 5)
  “If I could understand everything, if I could understand the explanation quickly” (Matt, Year 6),
  “If I know exactly what I have to do, if it’s explained so I know” (Lydia, Year 7),
  “If the teacher ‘explains it better’, tells you how to do it, tells you differently” (Jason, Year 7),
  “When I know what to do, when the teacher explains it like they’re supposed to” (Edward, Year 8)
  “The way the teacher explains it” (Olivia, Year 9)

- Knowing tables and practice, for example, “Practice it a fair bit, trying to get times tables, if I knew my division” (Gerard, Year 5), “knowing my tables” (Madeleine, Year 6).

What makes maths hard for you?

Although most of the responses to this question could be classified in terms of ‘not knowing what it means or what to do’, there is an interesting split around responses that attribute difficulty to external factors, such as perceived lack of support, the way that maths is taught and poor learning behaviours, and those that attribute difficulty to internal factors such as knowledge and ability. What is of interest is the number of responses that refer to teacher explanations. This is consistent with the importance given to teacher explanations in what makes maths ‘easier’ (see above).

Perceived lack of support:

Sarah, Year 5:	“When I don’t understand it and he says work it out and I can’t and he’ll help me [but he doesn’t]”
Samantha, Year 5:	“When it’s not explained very well”
Susie, Year 5:	“When I can’t work it out and I can’t get help”
Rick, Year 6:	“Someone not explaining it”
Warren, Year 7:	“It’s hard when I’ve got problems that I don’t know, like on a test, I can’t ask the teacher”
Peter, Year 7:	“When the teacher doesn’t explain it properly, the teacher just tells us what to do and then just says do it”
Amanda, Year 7:	“When you don’t know the questions and the teacher is with someone else and your friends are too busy talking and you don’t know what you’re doing”
Patrick, Year 9:	“When no one explains it and you just have to do it”
Olivia, Year 9:	“Something that I don’t understand, it makes it hard if the teacher explains it once and expects us to understand it, I’d like him to explain it to me personally”

The way maths is taught:

Deanna, Year 5:	"When it's just on a piece of paper and nobody explains it"
Angie, Year 5:	"Writing it down, not sure, copying a problem"
Like, Year 5:	"Pieces of paper with sums"
Natasha, Year 5:	"Tables"
Ian, Year 6:	"When the teacher doesn't tell you what to do"
Breanna, Year 7:	"Textbooks, copying stuff off the board "
Erin, Year 8:	"If the teacher just says do this set and we don't understand it"
Marie, Year 9:	"Moving on to different topics too fast and I forget"
Brenden, Year 9:	"Just being given a sheet without explanation"

Poor learning behaviours:

Sophie, Year 6:	"If they're just going on about something and you don't pay attention"
Edward, Year 8:	"When it's hard to think, it's hard to make sense of [it]"
Matt, Year 6:	"I don't listen and it's like yr12 work, when I do listen it's like yr 1 work
Madeleine, Year 6:	"Not listening, I don't understand, don't know times tables"
Tom, Year 5:	"When everybody talking, can't concentrate"
David, Year 6:	"Shouldn't read too quickly, think you know what to do"

Lack of understanding:

Eric, Year 5:	"When I don't know the answer… sometimes what they are talking about"
Jessica, Year 5:	"Not understanding it – what it means"
Elise, Year 6:	"Sometimes its hard to understand, then I get to know, remember what teacher said"
Jason , Year 7:	"If you don't know how to do it, makes you angry that you can't do it, then I skip it or ask teacher or friend or just guess it"
Lydia, Year 7:	"If I don't know what to do it's hard"
Liam, Year 7:	"When I don't understand, some of the texts … too much writing"
Annie, Year 7:	"Questions you don't understand"
Tim, Year 8:	"The questions, the way they're set out I can't understand them"
Leigh, Year 8:	"Sometimes you don't understand what it is"
Billie, Year 9:	"When it's confusing, everything everywhere"
Carl, Year 9:	"Teacher not explaining, not using method that is recognised, confusing"
Vincent, Year 9:	"If I don't understand what the teacher is talking about"
Simeon, Year 9:	"Not having a calculator, general knowledge"
Gerard, Year 5:	"My times tables and division"

How would you prefer maths to be?

While this question was included to provide students with the opportunity to suggest more effective ways of teaching and learning mathematics, it was also included to test students' strength of opinion in relation to what makes maths easier/harder. As a consequence, it is not surprising that many of the same categories emerged.

Activity-based learning, the way maths is taught:

Angie, Year 5:	"Fun, hands on, no writing, no paper, adding stuff up but with objects, teacher showing examples, kids trying it out"
Jim, Year 5:	"Like 'Earn and Learn'"
Tom, Year 5:	"Quiet"
Sophie, Year 6:	"Fun and learning at the same time "
Samantha, Year 6:	"More games"
Breanna, Year 7:	"Going outside, measuring, drawing, practical"
Annie, Year 7:	"materials"
Liam, Year 7:	"More games, everyone enjoying the lesson"
Tim, Year 8:	"Like it is now with groups"
Edward, Year 8:	"Enjoyable, not boring, not just sitting at a desk, activities"
Erin, Year 8:	"If it was fun, practical work, something with our hands, work it out that way"
Marie, Year 9:	"Make it more fun, more activities, instead of just board work [chalk and talk]

Carl, Year 9: "Not so much stuff from texts, boring too hard to concentrate, more talking, explaining, questions that help us understand"
Patrick, Year 9: "Do stuff you don't know, learning how to do things you don't know, need a challenge, need a reason.

At a level I can understand:

Sarah, Year 5: "Some hard and some where I understand"
Gerard, Year 5: "Medium not too hard not too easy"
Eric, Year 5: "Easy- they'd know it a lot better, do easier things"
Susie, Year 5: "Not as hard "
Deanna, Year 5: "No maths, …adding like 1 plus 2..stuff like that, kids telling teacher what the answer is – she would write it on the blackboard"
David, Year 6: "Make division easier"
Sophie, Year 6: "not above your level"
Warren, Year 7: "Prefer it to be not too hard"
Amanda, Year 7: "Make the sums easier even though they're hard you think they're easy"
Annie, Year 7: "questions bit easier"
Simon, Year 9: "Just addition and subtraction, doing what I know"
Brendan, Year 9: "Not easy, not hard, I want to learn, just need to get taught"

Relevance, what mathematics is taught:

Jim, Year 5: "Like 'Earn and Learn'"
Natasha, Year 5: "Knowing my tables, facts"
Leigh, Year 8: "Doing maths you actually need to use"

Explanation, individual assistance:

Natasha, Year 5: "Having friend to help"
Francis, Year 5: "helping us and stuff instead of getting angry"
Peter, Year 7: "If the teacher explains the rules to me, just explains it"
Amanda, Year 7: "If the teacher explains it so it's easier for you"
Annie, Year 7: "Help a bit more"
Liam, Year 7: "teacher would be helping those who don't understand"
Billie, Year 9: "Put the easiest way possible, explained clearly"
Vincent, Year 9: "Everything to be plus sums. Change the way it's explained, they need to think about how you understand not how they explain"
Olivia, Year 9: "Less students in a class, could help students individually, and a patient teacher"
Rebecca, Year 9: "That each person had their own maths tutor"

What areas do you find easy / hard?

This question was asked to determine likely starting points for teaching, that is, where these particular students felt comfortable. These are listed in order of frequency nominated (students could nominate any number of topics/areas).

Easy:	*Hard:*
Addition (20)	Fractions (12)
Measurement (12)	Multiplication/tables (10)
Subtraction (11)	Division (7)
Multiplication (11)	Decimals (6)
Space (6)	Measurement (6)
Division (4)	Algebra (5)
Algebra (linear equations) (3)	Subtraction (4)
Money, "some fractions", indices (1 each)	Space, Chance and Data, square roots (2 each)
	"Long addition", percentage (1 each)

The nomination of multiplication as ‘easy’ is interesting as many of these students could not generate a multiplication story given 2 single digit numbers (Diagnostic Interview). This possibly reflects the status given to the learning of multiplication tables, rather than any sustainable and/or generalisable knowledge of multiplication, particularly as division is nominated as ‘easy’ by only 4 students.

“Easy…times, plus, take away a bit, except the really big numbers” (Eric, Year 5)
“Easy…addition, subtraction, times tables, space, measurement OK (Francis, Year 5)
“addition, subtraction, percentage, measurement, shapes” (Leigh, Year 8)
“addition and subtraction, measurement, can handle them” (Simon, Year 9)

In addition to the ‘hard’ topics listed above, students also nominated problem solving (4) and the use of brackets (2) and symbols (3) as problematic.

Deanna, Year 5:	“division fractions, times, measurement”
Jessica, Year 5:	“measurement project”
Eric, Year 5:	“Not good at measurement, division, fractions and decimals”
Angie, Year 5:	“Tables hard to learn”
Luke, Year 5:	“multiplication and take away”
Tom, Year 5:	“dividing by, measurement”
Natasha, Year 5:	“tables, subtracting are hard, don’t know facts”
Gerard, Year 5:	“space multiplication and division are hard, chance and data”
Sarah, Year 5:	“Problem solving”
Samantha, Year 6:	“problem solving”
Rick, Year 6:	“multiplication and square root is hard”
Matt, Year 6:	“Long division is hard, complicated shapes, decimals, fractions, dividing is all complicated stuff”
Ian, Year 6:	“share betweens-hard”
Elise, Year 6:	“fractions “
Peter, Year 7:	“addition and multiplication with brackets and fractions”
Warren, Year 7:	“square roots and things”
Annie, Year 7:	“fractions, decimals, times tables, measurement”
Amanda, Year 7:	“Find it hard when you have to find the answers all the time”
Tim, Year 8:	“Long problems with brackets”
Erin, Year 8:	“take away 9 is hard and algebra”
Leigh, Year 8:	“hard-volume, fractions, decimals, algebra…don’t understand letters”
Brendan, Year 9:	“fractions, decimals”
Rebecca, Year 9:	“dividing, timesing and sometimes subtraction”
Simoan, Year 9:	“only some tables, algebra-letters, what they represent”
Billie, Year 9:	“geometry”
Vincent, Year 9:	“graphing is hard, too many numbers to work with”
Carl, Year 9:	“fractions, number facts are hard, didn’t get it”
Olivia, Year 9:	“what’s hard is fractions, algebra, decimals, all the different symbols that confuse me”

Not surprisingly, the students’ recognition of the areas of mathematics they are finding difficult is consistent with the overall student numeracy performance data. That is, fractions, multiplication, division and decimals. Where students feel comfortable (most notably, with addition and measurement), they are more able to interpret, apply and communicate their thinking, that is, to demonstrate a numeracy capacity.

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.

Fractions are difficult for a lot of kids. How do you find fractions?

This question was asked in an attempt to uncover what aspects of fractions were most problematic. Unfortunately most of the responses simply confirmed that "fractions were hard". Answers to probes and the Diagnostic Interview questions suggest that the major problem is not what is meant by a fraction in a 'real-world' context, that is, half an apple, 3 quarter time at the football and so on. But rather, how fractions are represented more formally in terms of fraction diagrams, models and symbols, including decimals and percent, and how to work with fractions, for example, addition and subtraction, converting, and renaming (equivalent fractions).

Deanna, Year 5:	"Don't make sense"
Francis, Year 5:	"Pretty hard, not understanding the number, not used to seeing them"
David, Year 6:	"OK, some kids tell themselves they can't do it, conversions hard, changing them [equivalent fractions]"
Matt, Year 6:	"Some are easy…equivalent fractions, decimals are alright if I know what to do. It's easy if I know what to do"
Samantha, Year 6:	"Some are easy like halves … fractions plus another fraction, quarters are hard"
Sophie, Year 6:	"Difficult when I have to add them and subtract them"
Jason, Year 7:	"Pretty hard. Numbers everywhere, don't know where to start"
Lydia, Year 7:	"Hard…What are fractions again?"
Annie, Year 7:	"Confusing because numbers on top and lower numbers, usually bigger numbers on bottom, decimals not sure what they mean"
Amanda, Year 7:	"They're hard, really hard"
Leigh, Year 8:	"Don't make sense"
Carl, Year 9:	"Don't understand how its set out, don't like to write it down if I don't understand… idea there, but how to write it, what to do with it"
Olivia, Year 9:	"Difficult, very confusing, hard to understand"
Simon, Year 9:	"Hard, it's intimidating, the way it's set out, numbers over one another, just complicated, how you work out percentage"

What areas of maths are you really good at?

This question was included to test the strength of students' opinion about the areas of maths they regarded as 'easy'. The responses indicated that students opinions were highly consistent. That is, they confirmed that students felt most confident with addition, subtraction, multiplication (generally with reference to basic fact knowledge only) and measurement.

What areas would you like more help in?

Again, the responses to this question were highly consistent with the responses to the question, 'What areas of mathematics do you find hard?' That is, fractions, decimals and percent, division, and times tables. While a number of students referred to large numbers, no-one referred to place-value. This is understandable as it is not identified or talked about in the same way that the four processes or other major areas of the mathematics curriculum are discussed, and yet it is clearly a major underpinning idea which these students find particularly challenging. This is evidenced by students' general lack of ability to 'read' numbers, for example, to read to the tens place to recognise that there are 80 tens in 803 (Diagnostic Interview), where most students said "none" initially and when challenged, proceeded to treat this as a formal division problem.

What's the best maths lesson you can remember?

This question was included to verify student's responses to the question 'How would you prefer maths to be?' While many of the same features were nominated, for example, the use of investigative activities, concrete materials, maths games, practical measurement and space tasks, it was interesting to note that experience of success emerged as a new and important category.

Matt, Year 6:	"Year 2, dividing, I was the only one who knew what to do. Graphic nail things not long ago, I knew how to do it and nobody else did"
Warren, Year 7:	"The last test I did, I got 79 out of 100 … fractions and lots of other stuff on the test"

Billie, Year 9:	"Year 7 maths competition – got a Distinction [at a different school]"
Marie, Year 9:	"When I first learnt how to do times tables"
Olivia, Year 9:	"Primary school, I'd been trying to do long multiplication for ages and I came into the class one day and I could just do it, I always remember that"

It is sad that very little of this reports recent experience and perhaps this explains why success did not feature in the responses to the question, 'How would you prefer maths to be?' This suggests that many students no longer expect to be successful. Even sadder are the following responses to this question.

> "When the teacher didn't turn up for class …nothing stands out" (Patrick, Year 9)
> "When the teacher didn't come, [we] stayed outside" (Leigh, Year 9)
> "Don't really have one" (Jessica, Year 5)

Involvement with older peers was also something new to emerge, in this case, as a consequence of the trialing.

> "my favourite are the problem solving ones we have now because we have older kids from X College helping and you're in groups" (Sophie, Year 6)

It is interesting to note that the use of textbooks and/or worksheets was not referred to at all in this context, except in the following instance.

> "Wouldn't be too sure, one that doesn't involve texts … worksheets that set it out in a way I can understand, not too many questions" (Carl, Year 9)

What's the worst maths lesson you can remember?

Although there is considerable overlap between the responses to this question and the question, 'What makes maths hard?', nominations for the 'worst maths lesson' tended to focus more on the quality of the relationships and classroom culture and, not surprisingly, issues related to assessment and failure. Other categories of responses were related to lack of understanding, fractions and repetitive, text-based work.

Classroom culture:

Jessica, Year 5:	"People talking to you when you're trying to do it"
Matt, Year 6:	"Almost everyone except the ones above [referring to the lessons he nominated as 'best lessons']…[when] Mr X gets really angry"
Jason, Year 7:	"Most are pretty bad … when the teacher is grumpy"
Lydia, Year 7:	"When I didn't understand anything, the teacher got really angry at me"
Annie, Year 7:	"When the teacher was in a bad mood, we weren't allowed to talk, had to finish, got home work … textbooks – prefer copying off board, need to talk but won't have time to do our work"
Erin, Year 8:	"When everyone's being bad and we have to do it ourselves"
Leigh, Year 8:	"When I got into trouble … Textbook-OK, answers in the back"
Edward, Year 8:	"Just sitting and writing as punishment"
Billie, Year 9:	"Every maths lesson this year except for the last week, it's hard adjusting to new school. Just started here this year"
Vincent, Year 9:	"Copped a detention for not knowing what I was doing, the teacher said I should have listened, I said you should have explained it properly, and he kicked me out"

Assessment and failure:

Sarah, Year 5:	"The first maths test we did"
Francis, Year 5:	"Problem tests, Maths Olympiads"
Ian, Year 6:	"Times tables in grade 4 when you were timed to do it.
Breanna, Year 7:	"Tests"
Warren, Year 7:	"The test before the last, I failed [problem solving]"
Peter, Year 7:	"The test that got us into our groups. It was on fractions. There's a group ahead of us and below us, I'm in one of the middle groups"
Tim, Year 8:	"Year 7 when we did 3 tests in the double period and then we had a fraction test"

Olivia, Year 9:	"When we have tests on anything, everything goes blank"
Simon, Year 9:	"Year 7 quiz and I had no idea and I got all the answers wrong"

Lack of Understanding – When it's 'hard':

Tom, Year 5:	"Teacher I didn't know – hard maths"
Luke, Year 5:	"When I don't understand the teacher"
Eric, Year 5:	"When we have to do problems with 2 dots [division] from the board"
Samantha, Year 6:	"Don't remember but don't like ones that are really hard"
Jodie, Year 9:	"Computers in maths"
Brendan, Year 9:	"Grade 5 medium hard maths class had no idea"

Fractions:

Susie, Year 5:	"Fractions"
Sophie, Year 6:	"Doing fractions one time and no one knew what he was talking about and he said, 'I taught this to my grade last year you should know this'"
Marie, Year 9:	"When we were learning fractions, no one could understand it so we just gave up"
Amanda, Year 7:	"When I came to this school and she put down fractions and I didn't know what I was doing"
Natasha, Year 5:	"Decimals"

Repetitive, Text-based Work:

Angie, Year 5:	"Paper maths…written maths"
David, Year 6:	"Doing pages from text [and] don't work with others, better to do problems"
Jim, Year 5:	"When we got this page with 200 sums"
Gerard, Year 5:	"When first had to do a whole lot of times tables"

Only one student indicated that the 'worst maths lesson' for him was

> "very boring, didn't want to do work, problems too easy… its like old stuff, you don't exactly want to do that – you want to learn something new…challenge" (Liam, Year 7)

Although these students clearly value the use of a broader range of more inclusive practices, their responses to the interview questions above suggest that disengagement may have as much to do with their perceptions of how they are treated/regarded/supported 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. Given the importance now given to social interaction in the construction of meaning (eg, Bauersfeld and Cobb, 1995), it is widely recognised that the nature of this communication needs to go beyond 'show and tell'. This can only occur where teachers have:

- 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),
- 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);
- 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;
- sufficient time with students to develop trust and supportive relationships;
- flexibility to spend time with the students who most need their time.

While such provision has enormous implications for the organisation, resourcing and conduct of mathematics classrooms, it is difficult to see how else this cycle of not understanding, leading to not engaging, leading to even less opportunity to understand can be broken. The evidence from the interviews suggests that students want to learn and are trying to listen. The problem is that they are not hearing because they do not understand what is being said, after a while they do stop listening as what is the point of trying to make sense of something you don't understand. It is like listening to people talking in a foreign language – after a while you just tune out. It is also very difficult for teachers to 'hear' what is being said. With access to sophisticated representations of mathematical ideas, it is often hard to appreciate that some students may still be talking from a 'groups of ones' model for multiplication or a notion of the number line which places decimal fractions to the left of zero (Siemon, 1997).

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 construction of mathematics curriculum. 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 just 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.

The cycle also appears to be 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. It was interesting to observe that while all students interviewed were assessed by their teachers as performing "one CSF level below where they might be expected to be", the snapshot image provided by the interview suggested that most students were in fact two CSF levels below where they might be expected to be. A small but not insignificant number appeared to be up to three CSF levels below in relation to the key ideas of place-value and common fractions. Of course, care needs to be exercised in interpreting this data as the interview could only assess a small number of key ideas and strategies. However, this simply 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' as described above.

7.4 Individual Case-Studies

The following case-studies were selected to represent a range of social, attitudinal factors that appeared to be influential in shaping the learning behaviours of these students. They were also chosen on the basis of the particular insights they offered in relation to the particular learning needs of these students and what it means to be numerate.

Vincent:
A Year 9 student at an inner metropolitan, state Secondary College. The school is situated in a lower socio-economic area of Melbourne with a relatively high proportion of recently migrated families. There is a fairly high turn-over of students at the school due to the transient nature of local employment.

Vincent's solution to the *Medicine Doses* task revealed his considerable difficulty with reading and interpreting fractions written in symbolic form, for example, the fraction

$$\frac{\text{Child's Age}}{\text{Child's Age} + 12}$$

was read and calculated as 18 (child's age was given as 6 years). Vincent recognised that the child's dose could not be 18 ml (the adult dose was given as 15 ml) but when asked to explain how he had arrived at this, he said "age plus 12". Asked, "What does this mean?" [Interviewer pointed to the line between the numerator and denominator], Vincent said "a line, separating both of them". He continued, "I just do everything, everywhere, 120 (from15 x 6) … Can't remember how to do it"

By contrast, Vincent was able to read, interpret and manipulate decimal fractions in a real-world context. For example, on the *Trip Metre* task, Vincent correctly rounded to 713kms "because tenths kilometres gone past 5 so round it upwards". On part (b) of this task, he responded, "7 litres… 70 litres, 1 litre for every 10km, 71 litres and point 3, 71.3 litres"

On the basis of his responses to the Student Numeracy Performance Tasks, Vincent was asked a number of questions from the Diagnostic Interview. As might be expected he successfully ordered the decimals, 4.5, 1.06, 0.8 and 1.60 from smallest to largest. Asked to read the fraction 10/3 and say what it meant, Vincent responded, "ten over three, ten divided by three equals three point one". His reference to "point one" presumably indicating the remainder 1 after dividing by 3. Although Vincent interpreted 10/3 in terms of division, it would appear that this interpretation was not called upon to inform his ordering of fractions from smallest to largest as 1/6, 2 1/4, ¾, 10/3. Asked why he did this, Vincent replied, "because of the top number and the second number, starts with 2. That is, he seems to have reverted to another strategy, that of reading the numerators (or whole numbers) only without reference to the denominator or its impact.

Vincent was able to demonstrate a range of effective strategies to support mental computation, specifically for addition and subtraction. He seemed more reluctant to engage with mental computation involving multiplication or division

Vincent's reading was hesitant. He said he had been in Australia for 10 years. He skipped Prep to Grade 2 when he came here from overseas, then a grade 4 teacher apparently said he "didn't know how to speak proper English", so he "stayed in grade 4 again". Vincent appeared quite confident, almost cocky, to the point where "you would believe he was probably quite bright" [teacher's comment]. However throughout the interview, it was apparent that there were significant gaps in his learning. Most of which he attributed to other people's fault. Vincent reported an incident where he stood up for himself when he didn't know something and the teacher said he should have been listening. Apparently he told the teacher he should have explained it properly. He was promptly asked to leave the room and received a detention for his trouble. Commenting on "How would you prefer maths to be?" Vincent offered the following, "Everything to be plus sums!" but then he said, "Change the way it's explained, they need to think about how you understand, not how they explain".

Vincent's difficulties cannot be described as 'fractions in general'. There are clearly some things he does understand, however, they are not particularly robust nor are they applied consistently. Faced with a task that he does not believe he can do immediately, he tends to resort to inappropriate strategies. Addressing Vincent's problems is a difficult challenge for the classroom teacher. While Vincent clearly believes it is the teacher's role to 'explain it more clearly', it would be very difficult for the busy classroom teacher to ascertain exactly where to start without a detailed understanding of Vincent's thinking. One suggestion, on the basis of this interview, would be to explore his understanding of decimals with a view to using those ideas to enhance his ability to read and interpret common fractions.

Carl:
A Year 9 student at a rural, state Secondary College. The school is relatively remote with a very stable teacher and student population. There are very few opportunities for students to study elsewhere, so most students move from the local primary schools to the one Secondary College. There are very few students from non-English speaking backgrounds.

Carl's solution to the *Medicine Doses* task (Phase 1 version) indicated that while he had difficulty simplifying fractions, transposing and recording his solution in a systematic way, he did have a good understanding of what was actually involved. For instance, giving up on his attempts to record, he used the fraction 2/5, simplified from 8/(8 + 12), to simply and correctly reason that "2/5 (of the adult dose) is 6 ml (child's dose), 1/5 is 3 ml, so 5/5 must be 15 ml (the adult dose)". This type of response is an excellent example of what it means to be numerate in this situation. However, it raises two very interesting questions. To what extent are we devaluing, possibly inhibiting, the emergence and use of this type of oral reasoning by preferentially valuing formal, written mathematical texts? Conversely, to what extent are we ultimately inhibiting students from becoming numerate citizens by not ensuring that they have access to the means to more formally communicate their mathematical thinking?

In relation to the *Trip Metre* task, Carl uses his informal proportional reasoning skills to determine that approximately 70 L of fuel will be used (on the basis of 10 L per 100 km, so 70 L for 700 km). He also relies on this capacity to determine that the increase in sales is not big in the *CD Sales* task by recognising the relative magnitude of each month's sales in relation to total sales. However, Carl was unable to go beyond this to formulate a reasoned argument that makes use of written fractions or percentages.

This suggests that teachers should maintain a sensible balance between oral explanations and written argument - modelling, expecting and valuing both in the interests of promoting quality reasoning and communication - both key aspects of numeracy. Although it is difficult to recognise in the context of the 'traditional' classroom, reasoning based on the informal and the intuitive can be revealed and valued in the context of regular classroom discussion. Once recognised, this can be used to establish meaning and build a case for the use of more formal written arguments.

Carl appears to lack confidence in himself as a learner. He doesn't think he knows much and does not realise that what he does know is worth knowing. Carl has an understanding of fractions and proportion at a hands-on level. He needs the scaffolding to link what he knows to the new things he is being taught because he can't see it or 'do it' for himself. He would like teachers to explain more, spend a lot more time talking and showing rather than giving students work to do "on their own". At the same time, he indicated that he doesn't mind doing work if he knows what to do and he doesn't mind doing tests because it makes him do some work. According to his teachers, Carl is in a difficult class but he is one of the better behaved.

David:
A Year 6 student at a regional, state primary school. The school is located in a major regional centre. It is generally regarded as a progressive school with a fairly uniform, stable population. David was nominated by the school as an 'interesting' student who appeared to be under-achieving.

David completed the *Filling the Buses* task quickly using short division and a double digit divisor to obtain 11, remainder 8 which, when prompted, he correctly interpreted as indicating that 12 buses would be needed. For the *Trip Metre* task, David was able to read the odometer correctly, interpreting fact that it showed between 6 tenths and 7 tenths as 650m. However, for *Travel Time*, David selected the earliest train but was unable to connect this to the bus time-table. For the *Draw a Spinner* task, he also appeared to read or attend to only part of the problem and was unable to complete the task as required.

David was able to read 10/3 and rename it as 3 and 1/3. In fact, he seemed quite confident and able when the task demand was very straightforward, but as soon as the comprehension demand of the task increased to require the recognition and management of multiple steps or an interpretation relative to an unfamiliar context, David experienced considerably more difficulty. Probed about this, David said "if you're quick at reading you get sums done quick". David seems to think the quicker he is the better he is! He didn't always appear to read the whole question, but as soon as he thought he could work something out he proceeded without stopping to check or reconsider the meaningfulness of what he was doing. David's story is included here as an example of how beliefs such as "you have to get the maths done" and "maths is about doing sums quickly to get answers", often get in the way of more reasoned, reflective approaches which might help students like David achieve far more success.

Edward:
A Year 8 student at a rural, state secondary college reasonably close to a major regional centre. The school has a fairly diverse population and a relatively high number of students on educational maintenance (EMA). Edward was nominated by the school as an under-achiever who had a tendency to provoke those around him.

On the *CD Sales* task, Edward said that there was "not a big increase, because they have only sold 20 more, they've already sold 710 so that's not much more". However, he did not attempt to support his argument more formally, for example by using fractions, proportion or percentages. For *Trip Metre*, Edward was able to read the odometer and said the fuel consumption "was around 70.1 L" but was unable to say how he had arrived at this amount. On the *Fractions in Boxes* task, Edward was able to represent halves, fifths and tenths in all forms (that is, as a diagram, number line, common fraction, decimal fraction and percentage) but left the rest. For *Doctor Maths*, Edward drew a diagram representing a knock out competition, he began to work out how many games would be played and realised it was not going to be enough, he then said "40 or 50 matches, maybe". Asked why he thought this, Edward shrugged his shoulders and replied "I'm lazy".

Apparently Edward was awarded a 'distinction' in the Tournament of Minds. His teacher said he has the ability but doesn't achieve, he "will cover up what he can do, by being messy … he's a bright kid". His coordinator reported there was a family break up about 5 years ago and his mother has remarried. Apparently he sees his father but does not relate well to his step-father … "he's very angry". According to the coordinator, he gets into a bit of strife but low level, he puts teachers off side, he appears to know how much trouble to get himself into and seems to be a fringe dweller with the 'bad' kids. He was voted class captain by his peers but lost the privilege because he misbehaved. He was on a warning and told he would lose his position if he didn't come up to scratch, he didn't! His coordinator said he was great for the first couple of months while he was class captain.

Edward's case illustrates the importance of social factors in the lives of students in the middle years of schooling. This is consistent with the results of a study on engagement conducted in the United States by Marks (2000) which reported that while social class did not contribute to the engagement of elementary or high school students it was a factor affecting the engagement of middle school students. However, authentic work and systems of social support were found to mitigate against personal background effects on engagement.

Breanna:
A Year 7 student at an outer metropolitan, state Secondary college. The school is in an area of relatively high unemployment and has a significant number of single-parent families.

For *CD Sales*, Breanna said [the increase] "was half as big, so it was a reasonable increase". Breanna appeared not to notice the numbers on the axis using the relative heights of the histogram columns only to make her judgement. For *Trip Metre*, Breanna added 10 to each digit to get "17, 11, 12, 16". Apparently in response to the problem stem which referred to the odometer as a record of "kilometres and tenths of kilometres". When asked how many kilometres had been travelled to the nearest kilometre Breanna said 16. Asked how she arrived at this, she said she had added all the digits, that is, 7 and 1 and 2 and 6. Breanna had very little idea about fractions, saying, they "are a bit like a foreign language". She tried to connect 25% to a clock-face but became confused and was unable to proceed or explain what she had been attempting to do. For the *Draw a Spinner* task, Breanna drew spinner based on the first 20 spins, when asked about the other 40 spins she said she thought it wouldn't change much. Her diagram showed proportions relative to the first data set.

Her response to the Diagnostic Interview questions indicated that she relied on make-all-count all models for addition and multiplication. For example, in response to the following problem, Breanna added 7 and 8 (to get 15), then 7 and 3 (to get 10) and 1 more, 11.

A farmer planted 7 rows of strawberry plants.	1 38
There were 38 plants in each row. How many	x 7
strawberry plants were there altogether?	115

Asked how she would prefer maths to be, she wrote "2 x 4" … "sums like that, but it'd be better like this" and drew 4 rabbits with 2 ears each. Breanna was able to physically share 42 objects among 7 but was not able to deal with this when it was recorded as a division equation. Breanna was unable to determine how many tens in 803.

At the start of the interview, Breanna said she was an "art type person", she "wants to see what she is doing all the time". Clearly, Breanna has some very significant gaps in her mathematical knowledge, most notably with the foundation ideas underpinning the notion of number and operations. She would appear to be a very visual, concrete learner who is still reliant on count-all models. This presents a major challenge for the busy secondary teacher of mathematics who is generally not trained in the development of these early mathematical ideas. Even if the teacher was prepared to address her learning needs, the social implications of trying to meet Breanna where 'she is at' in front of her peers in the classroom may well be counter-productive. Given this, it would appear that for students like Breanna, a one-on-one withdrawal program is the only possible solution.

7.5 Observations concerning students who 'fall behind'.

Evidence from the surveys and the interview data more generally suggests that these 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. This raises the issue of student engagement, that is,

> "the attention, interest, investment, and effort students expend in the work of learning" (Marks, 2000, p. 155)

The evidence presented here suggests that 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.

1. Students believe that mathematics is important and relevant.
2. Students generally want to learn and be able to apply mathematics.
3. Mathematics is not perceived to be as 'boring' or irrelevant as is often assumed.
4. Students are prepared to accept some of the responsibility for learning
5. 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.
6. The teaching focus needs to be on identifying and scaffolding student's learning needs.
7. Accurate and reliable assessment is essential to identify where to start teaching.
8. 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.
9. 'Traditional' text-only based approaches are seen as a major impediment to engagement and successful learning.
10. 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
11. Success is crucial to engagement.
12. Students would prefer more one-on-one assistance.
13. 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.
14. 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.
15. Given that 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.

The observations reported here are supported by a recent large-scale study on student engagement conducted with a sample of schools in the United States. The study by Marks (2000) found that class subject matter was a significant factor in the engagement of elementary and high school students and that mathematics classes increased student engagement markedly for both these levels of schooling. However, mathematics was "no more likely than social studies to engage middle school students" (p.172). This suggests that the issue of engagement is considerably more complex for students in the middle years of schooling than it is for students in Years Prep to 4 or Years 10-12.

While personal background accounted for little of the variance in engagement among students, Marks reported that at all year levels,

> "positive orientation towards school, as reflected in school success, solidly predicts engagement; negative orientation, as reflected in alienation, just as solidly predicts disengagement" (p.173)

This confirms the importance of the experience of success in student engagement reported above. For 'students who fall behind' success can only come with recognition of where these students 'are at', the setting of appropriate standards and targets, and interactive teaching aimed at scaffolding their understanding to higher levels of performance.

Authentic instructional work was another factor that was found to contribute strongly to the engagement of all students. Authentic work as described by Marks

> "involves students intellectually in a process of disciplined inquiry to solve meaningful problems, problems with relevance in the world beyond the classroom and of interest to them personally " (Marks, p. 158).

This supports students' views about effective mathematics teaching and learning. That is, activities which they understand sufficiently enough to participate in and contribute to, which involve them in 'real' work and which they perceive to be relevant by being of interest *to them*. Where 'of interest to them' might be as much about accessing mainstream maths as it is about solving somebody else's 'real-world' problem.

The third factor found to be a strong predictor of student engagement was systems of social support.

> "A positive school environment is favourable to learning by being normed for respect, fairness, safety, and positive communications. Such an environment enhances the engagement of students at all grade levels. Similarly, supportive classroom environments, in which students experience high levels of expectations and receive help from teachers and peers, promote the engagement of all students" (Marks, 2000, p. 174)

This supports a range of students' views about the importance of access to more knowledgeable, approachable others, quality explanations and supportive classroom cultures where it is possible to work without fear of retribution or being made to feel a fool.

8. Trial School Action Plans

9. Draft Advice to Trial Schools

Draft advice was prepared on the basis of the literature review, the Phase 1 School Surveys from those schools identified as *Design Element Rich - High Numeracy* (see Section 3), and the Phase 1 Student Numeracy Performance data. The aim was to provide initial advice to trial schools on how they might begin to improve the numeracy performance of students in Years 5 to 9. This advice was presented in terms of the general principles outlined by Hill and Crévola (1997) followed by some key beginning strategies on how these general principles might be implemented in relation to numeracy education in the Middle Years of schooling. While Trial Schools were expected to use these ideas and strategies in formulating their Action Plans, their draft status was emphasised.

Trial schools were encouraged to consider additional strategies and/or to modify or combine strategies to suit the particular challenges of their situation. In accordance with the Project Brief, all Trial Schools were expected to implement strategies related to:

- structured classroom programs (informed by effective, school-based assessment)
- additional assistance for students identified as 'at risk'
- parent participation and
- professional development for teachers (extending the knowledge base).

As the provision of these inevitably involve some form of school leadership and coordination, it was expected that trial schools would also be explicit about strategies related to this design element as well.

Each school and/or school cluster was expected to develop an Action Plan to guide the implementation of the framework at their particular site. The effectiveness of the framework was evaluated using a range of research tools. These included:

- the use of standardised, student numeracy performance data;
- school-based assessments of numeracy and numeracy-related performance;
- teacher journals;
- student reflections on the teaching and learning process;
- case-study interviews of selected staff and students, and
- school visits by project personnel.

As indicated above, the ideas and/or strategies contained in the initial advice were presented in terms of the Design Elements of the Hill and Crévola (1997) model (italicised below). As many of the ideas and/or strategies related to more than one design element, there is inevitably some overlap in the following list. The ideas and/or strategies have not been organised in any particular order. They are included here in the interests of informing the work of other schools in this area.

1. Beliefs and Understandings

Teachers, students and all those associated with the education of Middle Years' students have a shared set of beliefs and understandings. That is, they believe or know that

- *all students can achieve high standards given sufficient time and support*
- *all teachers can teach to high standards given the right conditions and assistance*
- *high expectations and early intervention are essential*
- *teachers need to be able to articulate what they do and why they teach the way they do (that is, to be theory-based rather than trade-based).*

Ways in which these might be achieved in school (this heading was used to provide initial advice to Trial Schools and to help them formulate their Action Plans):

- Develop a numeracy policy which lists shared beliefs (why, what, how, when), establishes expectations and standards (see 5 below) and identifies the strategies needed to ensure these will be achieved
- Decide how numeracy performance will be measured and acknowledged, collect and/or build on relevant data
- Engage a consultant to work with school community to determine shared beliefs, negotiate goals and agreed targets and identify what conditions and support are needed to ensure improvements in numeracy outcomes (for example, staff planning and development time, increased time on task, access to appropriate resources, staff development)
- Focus on the development of an appropriate knowledge base to support numeracy teaching and learning (this will include mathematics content knowledge and appropriate pedagogy)
- Engage the wider school community in finding ways to provide the time, resources, conditions needed to improve numeracy outcomes.

2. Leadership and Coordination

- *Principals give first priority to their role as instructional leaders*

- *There is a consistent understanding of the priorities of the school among the leadership team and all staff members*
- *Teachers are trained for and appointed to coordination and mentoring roles, with appropriate time release*
- *School systems invest in training focused on leadership for learning and teaching.*

Way in which these might be achieved in school:

- Identify and provide some time release for a Middle Years numeracy coordinator, decide on an agreed job description and how other staff will be involved (for example., a Numeracy Committee or Working Group with cross-curriculum representation).
- Allocate resources in accordance with strategic priorities, ensure numeracy learning is adequately resourced and supported across relevant KLAs.
- Plan and resource targeted professional development of all Middle Years staff irrespective of subject area, ensure feedback mechanism exists to inform other staff.
- Provide planning time for working groups to consider their practice, plan appropriate learning opportunities, develop and/or access high quality common assessment tasks .
- Explore alternative organisational structures to maximise opportunities to learn - this might include a re-allocation of staff, different use of staff, rearrangement of timetable, or the curriculum.
- Develop a communications strategy to promote the school's commitment to improved numeracy education (for example, newsletters, policy statements, numeracy workshops involving parents, community members).

3. School and Classroom Organisation

- *Attention is given to the allocation of time, staff, resources including class size*
- *The school has policies to eliminate unnecessary interruptions*
- *Teachers work to establish classroom routines that minimise disruptions*
- *Daily use is made of within-class mixed ability groups*
- *Instructional blocks are organised according to a whole class/ small group/ whole class structure.*

Way in which these might be achieved in school:

- As part of a Middle Years numeracy policy, develop strategies to maximise time on task (that is, reduce interruptions, maximise student engagement) and identify the school and classroom organisations needed to support numeracy education in the Middle Years
- Implement an agreed structure for the delivery of numeracy education, this might involve structured mathematics lessons and/or the provision of structured time/modules in other subject areas as appropriate.
- Decide on time, location, staffing for numeracy education - identify where and when this will occur in the curriculum, what resources will be allocated.

4. Structured Classroom Teaching Program

- *Use is made of a balanced repertoire of teaching strategies*
- *There are shared understandings of core teaching strategies*
- *Teaching is focused on the learning needs of each student*
- *There is a balanced use of teacher-directed and student-centred teaching strategies.*

Way in which these might be achieved in school:

- As part of a Middle Years numeracy policy, agree on a range of teaching strategies and classroom structures, identify non-negotiable elements (for example, the use of open-questions, investigations, performance-based assessment, whole/group/whole structure, etc.)
- Ensure teachers have access to accurate data on the numeracy-related learning needs of each student
- Maximise staffing for mathematics/numeracy classes
- Include numeracy as part of an uninterrupted Literacy/Numeracy block (for example, in upper primary provide 1.5 hours of numeracy within a 4 hour daily block from 9 am to 1 pm)
- Provide additional mathematics/numeracy learning opportunities for special needs students

- Timetable mathematics/numeracy classes at the same time across year levels to support vertical integration, needs-based grouping
- Provide and appropriately use a range of 'best practice' resources (for example, task centre activities, investigations, games, communications and information technologies/software)
- Think creatively and imaginatively about the possibilities for numeracy education across the curriculum (for example, via the Arts, HPE, SOSE and Science) to maximise student engagement and commitment to learning
- Develop strategies to support and extend students' capacity to explain and justify their thinking and build connections to related learning (for example, require groups to present the 'products/outcomes' of their time working together, provide time for oral rehearsal in small groups, encourage the use of information and communication technologies in presentations)
- Timetable mathematics/numeracy classes before lunch
- Integrate special assistance, intervention strategies within mainstream mathematics/numeracy classes
- Consider alternative and/or additional ways to provide numeracy learning opportunities (for example, within an integrated, thematic, problem-based curriculum, within other subject areas and/or school activities such as camps)
- Participate in activities such as Mathematics Talent Quest, Mathematics Olympiad, Tournament of Minds, Country Connection
- Ensure students are 'turned-on' to learning numeracy/mathematics (for example, warm-up session at beginning, quick quiz, review, feedback, appropriate incentive schemes for students).

5. Standards and Targets

- *A common framework of standards is a precondition for systemic improvement*
- *It is necessary to have both content standards and performance standards*
- *High expectations need to be translated into specific targets for schools and students.*

Way in which these might be achieved in school:

- Identify common framework (for example, CSF and National Numeracy Benchmarks for Years 5 and 7) and ensure curriculum provision maximally geared to achieving key elements
- Identify and publicise expectations of students and staff, elaborate in terms of specific expectations (for example, successful completion of a complex task, high levels of student satisfaction)
- Identify high but achievable targets in relation to numeracy education (include targets related to student performance, teacher effectiveness, parent/community involvement)
- Include targets and standards related to oral and written explanations.

6. Monitoring and Assessment

- *Assessment is essential at the beginning of the year to establish starting points for teaching and learning*
- *Assessment must reveal students' strengths and weaknesses*
- *Assessment must inform teaching*
- *There must be ongoing monitoring of student progress*
- *Assessment should indicate the extent to which targets have been met.*

Way in which these might be achieved in school:

- As part of a Middle Years numeracy policy develop a systematic approach to assessment and monitoring of student achievement in relation to numeracy
- Decide how numeracy performance will be measured and acknowledged, collect and/or build on relevant data
- Use rich assessment tasks and scoring rubrics to assess numeracy performance on a regular basis
- Provide adequate planning time for staff teams to develop and/or identify appropriate assessment material (for example, reliable diagnostic instruments, rich assessment tasks linked to National Numeracy Benchmarks and CSF)

- Use a range of appropriate assessment strategies, including the use of student reflection (for example, the IMPACT procedure from MCTP Assessment Kit, open questions and techniques from the Project to Enhance Effective Learning (PEEL))
- Adopt evidence-based approaches to teaching and learning (that is, use numeracy assessment and monitoring data to inform choice of content and form of presentation).

7. Intervention and Special Assistance

- *Even with the best teaching, many students need extra time and support*
- *Intervention at all year levels is essential*
- *For those students who are most at risk, one-to-one intervention is likely to be the most effective*
- *Individual learning plans for students needing ongoing support.*

Way in which these might be achieved in school:

- As part of a Middle Years numeracy policy develop a coherent set of strategies to support special needs students
- Provide additional staffing for mathematics/numeracy classes (for example, block timetable and provide for additional group, provide team-teaching opportunities, engage parents/volunteers as support tutors within mainstream classrooms)
- Develop efficient and effective monitoring strategies to ensure students in need of special assistance are identified and supported as soon as possible (for example, consider appropriate diagnostic resources, the use of open questions and learning probes, parent and/or cross-age tutors to conduct structured individual interviews)
- Develop individual learning plans for special needs students (i.e., for 'at risk' and 'accelerated' students) which include high but achievable goals and targets
- Provide flexible ability groupings within mainstream mixed-ability classes
- Work on ways to support students develop their communication skills in relation to mathematics and numeracy (for example, expect and nurture oral and written explanations, provide time for oral rehearsal in small groups)
- Provide alternative learning opportunities (for example, a lunchtime mathematics/numeracy club, after-school supported homework sessions, a Learning Support Centre, withdrawal groups).

8. Home, School and Community Partnerships

- *The school must be proactive and systematic linking with the home, the previous school, other service providers and the wider community*
- *Problems such as poor attendance can be tackled successfully*
- *Programs for parents and care givers should be based on the notion of 'partnership'*
- *Training is provided for all classroom support personnel.*

Way in which these might be achieved in school:

- As part of a Middle Years numeracy policy develop a plan to involve and support parent involvement and build community-school partnerships aimed at improving numeracy performance
- Incorporate excursions into curriculum planning (for example, supermarkets, real estate agencies, post office, sporting venues, cemetery, local landmarks/features, transport timetables etc.), invite community representatives to school to present local problems, invite students to think about how they might contribute to a solution)
- Run parent workshops, information evenings to support numeracy (for example, FAMPA, MTQ, Earn and Learn material)
- Institute program to support the involvement of parents as volunteer tutors, teaching aides
- Use Homework Diary as a communication tool
- Involve parents in school committees, home-school activity projects, structured homework program
- Survey parents to determine needs and interests, areas for possible collaboration

- Make numeracy (and literacy) a focus of transition programs, provide opportunities for teachers of Year 6 and Year 7 students to share their knowledge and understanding of student's numeracy strengths and weaknesses.

9. Professional Learning Teams

- *Teachers attend off-site professional development as a team (to provide the impetus for further thought and discussion)*
- *On-site professional development takes place daily within the context of the school*
- *A team coordinator at each school acts as a mentor and lead learner and organises school visits, demonstration teaching, classroom observation and professional learning team meetings*
- *There is a team responsibility for all students and for each other's professional growth.*

Way in which these might be achieved in school:

- As part of a Middle Years numeracy policy develop a 2 year professional development plan to ensure staff have access to relevant content and pedagogical knowledge
- Individual teachers maintain a professional practice journal in which they record and reflect on key aspects of their numeracy-related teaching experience (for example, discuss best way to teach a particular topic)
- Develop a team of mathematics/numeracy leaders who meet regularly to discuss and share their practice in a systematic and reflective way (for example, a Mathematics/Numeracy Working Group which includes teachers from other subject areas, a shared database of activities, resources, team-teaching, peer observation)
- Consider an extended support group for numeracy learning involving parents, community groups, local librarian, traders/business people
- Teams to determine curriculum, develop year, term and weekly plans, review implementation on a regular basis (for example, at least three times per term)
- Agree to work on specific issues such as how to support and extend students' capacity to explain and justify their thinking, how to engage and motivate Middle Years' students or how to make group work really effective (the Middle Years website provides some useful material to support such discussions)
- Individuals and teams actively seek relevant, targeted professional development opportunities (for example, by being members of and participating in the activities of the Mathematics Association of Victoria, attending conferences, engaging consultants).

10. Trial School Action Plans

While schools were required to implement certain key aspects of the draft framework, how these were operationalised in each setting was largely determined by the schools themselves in consultation with members of the Project team. The table below provides a summary account of the major focus adopted by each Trial School and the planned strategies for achieving this.

Most Trial Schools chose to focus on school mathematics as the domain most likely to impact student numeracy performance. This is understandable, especially given that it is ‘early days’ with respect to numeracy reform, and it is consistent with the approaches to literacy improvement which have tended to use English as a springboard to other curriculum areas.

The results of the Phase 1 assessment were used by many schools to refine their project focus, particularly in relation to

- problem solving and the use of open-ended tasks;
- students’ capacity to interpret, explain and justify their mathematical thinking,
- structured classroom lessons and/or programs, and
- performance-based assessment (rich assessment tasks).

It is interesting to note that of the 10 Trial schools that demonstrated above average improvement in student numeracy performance (that is, schools 4, 7, 8, 9, 11, 13, 14, 15, 18 and 19), problem solving was listed as a major focus by 7 schools.

SUMMARIES OF TRIAL SCHOOL ACTION PLANS

School	**Major Focus**	**Strategies**
1. Regional Independent P-12	To improve numeracy teaching in Years5 – 9	• Maximise face to face contact. Emphasis on structured learning in large and small vertical groups • Regularly test and regroup to ensure the most effective groups for learning (ability groups). • Restructure time table so first period after lunch is free, students who have not achieved outcomes go to new teacher who plans to teach unit differently – matching teaching styles with learning styles. • Involve staff in more PD, planned meetings to support numeracy • Develop a system of student reflection & monitories: or example, using tracking sheets and portfolios
2. Metropolitan State Secondary College	To improve students' ability to interpret mathematical questions, explain and justify their thinking	• Regular team based meetings. Involvement in PD activities • Communication through the College newsletter, fostering partnerships between the three campuses of the college • Introduction of a regular mathematical problem solving session in classes where students tackle task, and write about their findings in a journal. Students expected to complete one maths project per term. • Maths Mate weekly homework program. Mathematics bilingual Arabic program • Small group assistance from teacher aides in classrooms
3. Regional State Secondary College	To expand the repertoire of teaching strategies, to extend students' capacity to explain and justify their thinking and develop an understanding of numeracy in everyday life.	• Develop a range of teaching strategies to include open ended questions, investigations, performance based assessment . • Compile a booklet that includes a range of 'best practice' resources with examples of students' solutions to problems where appropriate. All tea hers to contribute to the compilation of the booklet. • Develop strategies to encourage students to explain and justify their thinking. • Include a greater variety of activities related to real life situations and use scoring rubrics to assess student performance. • Resource targeted PD for all maths staff • Cross age tutoring with Primary school Yr 5 students and Yr 8 students • Team involvement, greater interaction with Primary School
4. Regional State Primary	To improve students ability to solve problems and increase teachers repertoire in this area.	• One hour or more daily maths focus in timetable • Reduced class size for numeracy sessions by using support provided by unit leader. • Whole small whole structure, small group learning. • Family maths program, parent evening to show case students problem solving skills and for parents to work with their child on these tasks. • Transition program with secondary schools • Problem solving with real life links (Olympics), focus on literacy related aspects of problem solving, encouragement of maths dialogue in the classroom where students are encouraged to explain their maths thinking • Outside maths games used to engage boys

5. Metropolitan State Secondary College	To develop students' language skills in maths in order to improve their ability to explain and justify their thinking and work on the development of an differentiated integrated curriculum	• Attempt to have classes in the same room each time and maximize time on task by minimizing disruptions where possible. • Develop a differentiated/integrated curriculum creating modules of work • Develop own rich assessment tasks and rubrics, identify students 'at risk', provide intervention. • Engage consultants such as Charles Lovitt and develop a two year PD plan • At KLA meetings provide opportunities for teachers to share strategies • Develop stronger communication links between home and school via newsletter, homework activity sheets parents sign the completed activity. • After school maths tutoring class which students attended on their own volition or after recommendation from their teacher in consultation with parents.
6. Regional Catholic Secondary College	To implement Middle Years Numeracy Draft Strategy Lesson Format in as many lessons as possible	• Pretest students' numeracy in whole number and identify students not up to Level 4 • Keep a track of these students with further testing, provide individualised remedial program, needs-based pathways • Provide a half-day for teachers of each year level to plan & consider appropriate learning opportunities & common assessment tasks. Develop and trial an integrated unit of work • Develop strategies to support & extend students' capacity to explain & justify their thinking & build connections to related learning. • Use of warm up, introduction, teaching focus, sharing strategies and reflection lesson format • Use of teacher diaries to reflect and discuss the pros and cons of specific lessons and as a reference for improving teaching of concepts.
7. Rural State Secondary College	To develop students' skills in collaborative problem solving, change the way mathematics is presented	• PD staff on the use of small groups in the classroom to develop problem solving skills • Introduction of 'table teams' in Yr 7- Yr 9 maths classes and the extension of these into Yr 7 English classes • Develop a uniform approach in teaching strategies and classroom structures • Work on ways to support students to develop their communication skills in relation to mathematics and numeracy • Identify the links between students with literacy problems and numeracy problems • Use rich assessment tasks and scoring rubrics to assess numeracy performance on a regular basis • Introduce 'Blast Off' multiplication sheets.
8. Rural State Primary (part of cluster)	To develop strong cross school teams and consistency in curriculum and focus on engagement of students	• Adopt agreed teaching strategies through regular cluster meetings, joint PD, and regular teacher reflection on practice. • Actively seek to ensure all sessions include review and feedback for students • Adopt learning strategies that maximise engagement and allow for articulation of task solutions • Develop shared numeracy policy across cluster schools. • Plan across schools to relieve isolation and maximise resources • Utilise Secondary College facilities, develop closer links with secondary staff • Make numeracy an issue at Transition meetings • Conduct a joint curriculum day with all schools in the cluster focusing on improving classroom practice through engagement. • Develop resource sharing across schools

9. Rural State Primary	Focus on problem solving strategies, open-ended learning activities which require students to explain & justify their thinking	• Develop a school maths policy • 1-2hrs daily timetabled maths sessions before lunch • Small groups to operate to maximize student engagement • Trial "whole, intro, small, sharing, whole" model in teaching strategies • Conduct individual interviews to gain a wider perspective of the range of approaches used by children when doing maths tasks. • Use open ended questions and investigations • Identify a range of assessment tasks which could be used sequentially to articulate student achievement • Fortnightly meetings of staff and principal to review and plan learning activities
10. Rural State Primary (part of cluster)	To develop strong cross school teams and consistency in curriculum	• Adopt agreed teaching strategies through regular meetings • Actively seek to ensure all sessions include review and feedback for students • Adopt learning strategies that maximise engagement and allow for articulation of task solutions • Develop shared numeracy policy across schools • Plan across schools to relieve isolation and maximise resources • Utilise Secondary College facilities • Make numeracy an issue at Transition meetings • Forge close relationships across secondary and primary staff by providing ample opportunities for interaction • Develop a resource sharing plan
11. Rural State Primary (part of cluster)	To develop strong cross school teams and consistency in curriculum and focus on engagement of students	• Adopt agreed teaching strategies through regular meetings • Actively seek to ensure all sessions include review and feedback for students • Adopt learning strategies that maximise engagement and allow for articulation of task solutions • Develop shared numeracy policy across schools • Plan across schools to relieve isolation and maximise resources • Utilise Secondary College facilities • Make numeracy an issue at Transition meetings • Forge close relationships across secondary and primary staff by providing ample opportunities for interaction • Develop a resource sharing plan • Use of structured lesson format

12. Metropolitan State Primary School	To improve students application of mathematical knowledge in problem solving situations, identify children in need of extension/intervention, teacher PD in certain mathematics strands	• Maximise classroom time for numeracy • Develop a common structure for mathematical lessons • Provide adequate time for planning and implementation • Incorporate numeracy education in other curriculum areas • Encourage oral and written presentation of mathematical tasks • Place more emphasis on mathematical texts for Guided Reading and Writing sessions in Literacy • Provide interesting and challenging numeracy activities including the use of rich assessment tasks. • Identify children with special needs and cater for intervention, teaching focus and extension children • Develop and conduct a teacher survey for confidence/competence in numeracy • PD on Reasoning and Strategy strand • Participate in Tournament of the Minds, Maths Talent Quest
13. Metropolitan State Primary School	To be aware of and change the way numeracy is taught	• Plan PD for middle years staff • Allocate time at meetings to discuss strategies, samples, classroom structures • Allocate at least 5 hours per week in maths and reduce interruptions to classes wherever possible • Use open ended, rich assessment and investigative activities in teaching program • Use of 'brain starter activities at the beginning of lessons • Use a balance of teacher directed, student centred strategies in teaching approach • Use of rubrics as an assessment tool • Students to keep a maths journal • Include new structure in existing homework program such as 'brain buster' activities to encourage parental involvement • Develop efficient and effective monitoring strategies to ensure 'at risk' and 'bright future' students are identified
14. Rural State Primary School	To develop a maths program that encourages students to be active mathematically, (think & discuss)	• Create a maths coordinators position. • Implement 1 hour per day maths block • Implementation of a whole school professional development focus day on mathematics • Adopt information evenings for parents and community • Identify and implement mathematics best practice • Decide on lesson model, begin to develop 'ideas bank' related to courses • Class structure to allow group work and problem solving activities • Use of similar teaching approaches and styles with maths tasks in the classroom • Identify students above and below the expected CSF levels
15. Rural State Primary School	To improve students' ability to problem solve and explain and justify their thinking	• Set a minimum number hours on the timetable for maths to be strictly adhered too • Share successful teaching strategies focussing on open-ended questioning and exploration • Two mornings a week include an extra staff member to reduce group sizes and enable intervention, trial like ability grouping • Adopt a whole/group/whole structure for lessons • Use learning centre and activity based problems in classes, use of rich assessment tasks • Actively seek out PD opportunities in maths, invite regular specialists into the school to enhance teacher's knowledge • Use rotations in Health, Science, LOTE and Technology to incorporate integrated activities

16. Rural State P-12 College	To encourage Middle Years teachers to think about their classroom practice, adopt open ended tasks and problem solving strategies, move away from text books. Identify 'beliefs and understanding' for improved numeracy outcomes in the middle years	• Appoint a Middle Years Coordinator • Middle years team to develop own charter of values, mission, vision and basic beliefs and understandings • Team teaching at 5/6/7 levels to allow fluid and flexible teaching groups • Home group teachers established in year 7 – same teacher for maths, English, SOSE, and science • PD on integrated curriculum • Student Individual learning improvement plans developed for all 5&6 students in mathematics • Home school support groups established for at risk students 5-7 • Yr 7 teachers trailed extra rich assessment tasks • Use of individual diagnostic assessments
17. Metropolitan Catholic Primary School	To develop students' understanding of their own needs in mathematics, introduce numeracy block, open ended tasks and diary writing	• Development of a numeracy block • Monitor the individual progress and understandings of each child by allowing more share and reflection in maths times • Children keep a maths journal about their week in maths, what they discovered, what they would like to know more about or found difficult • Ensure maths is timetabled three times a week in the morning • Adopt a whole class introduction, small group, reflection and sharing time. • Arrange a Friday session to tackle individual problems or whole class issues that may have developed over the week • Open ended questions are an integral part of the teaching strategy • A session once a week of rotating games, activities and open ended questions for reinforcement purposes • Sample book goes home containing assessment of units taught • Plan further units and sessions using student and teacher reflections
18. Metropolitan Catholic Primary School	To develop students' independent problem solving skills through equal focus on how we learn and what we learn	• Mathematics timetabled for five one hour sessions • Two lessons on operations in context (mental computation/estimation), one lesson on – mass, one lesson building structures, one lesson on maths task centre activities • Meet once a week with staff to discuss issues and strategies • Implement the four step plan for problem solving • Set realistic benchmarks for at risk students • Use maths share cards to help make the connection between school maths and real life maths • Maths homework challenges that families work on together • Parent information evenings that has a focus on how children best learn mathematics

19. Rural State Primary School	To improve students' problem solving skills and their ability to explain and interpret data	• Block one hour of maths a day for all classes • Trial grouping of students in intra and inter class groupings • Use rich assessment tasks, problem solving activities, extension programs, earn and learn activities in teaching programs • Students have a special book to use for rich assessment /problem solving activities where they keep a personal journal, parents teachers and students make evaluation notes with each problem • Develop own assessment rubrics for tasks • Cross-age tutoring with Year 8 students from Local Secondary College in Yr5/6 maths sessions • Rich assessment tasks as part of weekly homework • Regular meetings with middle years staff for interaction and sharing of ideas • Invitation to Local SC staff to attend these sessions
20. Rural State Secondary College (part of cluster)	To develop students' numeracy to deal with everyday life problems	• Stock take of existing resources, establishment of a maths faculty computer where staff download and access each others materials • Utilise Secondary College facilities by cluster schools • Plan across schools to relieve isolation and maximise resources • Develop a resource sharing plan • Make numeracy an issue at Transition meetings • Adopt a like ability grouping structure • Adopt agreed teaching strategies through regular meetings • Actively seek to ensure all sessions include review and feedback for students • Adopt learning strategies that maximise engagement and allow for articulation of task solutions

The data to be reported below is derived from the Final Trial School Reports that required schools to report on what was actually done, major project outcomes, the role of the Hill and Crévola Design Elements in their planning, and any factors or circumstances that impeded their progress. Trial Schools were also invited to make recommendations for improving student numeracy outcomes based on their experience.

As the students' voice was amplified in the previous Section, so too, the voice of the Trial Schools' in this Section and of individual teachers in the following Section has been used quite deliberately to acknowledge and authenticate the source of the advice provided in Section 10. As in the preceding Section, the statements provided have not been edited. They have been categorised as part of the research methodology to determine the most salient features.

9. Major Outcomes Reported by Trial Schools

"From the final data we can see significant improvement in most students. This is certainly gratifying and we have seen inter and intra school outcomes such as:

- **strengthened links across schools;**
- **teachers are positive towards sharing ideas;**
- **a reassessment of the numeracy program, focusing on engagement and active learning and regular teacher reflection on practice;**
- **a commitment by staff to include review and feedback in each teaching session; and**
- **an increased profile within the school on Numeracy". (School 8)**

The quote above from the Final Project Report provided by School 8 is fairly indicative of the range of outcomes reported by Trial Schools[1]. The following illustrates the major categories of outcomes reported by Trial Schools at the end of the project. These provide an important window into the experience of the Trial Schools and evidence the value of a whole-school/whole Department approach to school improvement. In this case resulting in significant improvements in student numeracy performance. The numbers in brackets acknowledge statements provided by particular Trial Schools.

Enhanced professional team culture:

One of the most important outcomes as far as the majority of Trial Schools were concerned was the increased professional collaboration and mutual support that flowed from working in teams to achieve shared outcomes. Some of the statements from the Final Reports that refer to this are included below.

- Improved team work (1)
- [The project] involved a large number of staff across both 7-10 campuses sharing useful ideas (2)
- Team involvement –something maths staff in particular are not good at. Sharing of resources. Getting to know staff through less formal and smaller meetings such as 'mark-ins' over a bottle of red (3)
- Focussed [team meetings] on maths teaching strategies and resources (3).
- The establishment of the learning team and their regular review of what they were doing in maths (9)
- The 5/6 unit worked together for a common goal and used similar teaching approaches and styles to maths tasks in the classroom (14)
- Better organised, Better team work (20)

Development/use of middle school specific program, materials, teaching approaches:

The majority of schools reported some shift in their teaching approaches and/or programs as an outcome of the project. These included the following.

- Development of a Middle School program (1)

[1] At the time of writing the Final Reports, Trial Schools had not received their feedback on the final phase Student Numeracy Performance so would have been unaware of their overall performance.

- Some units of work have been developed incorporating recommended approaches (5)
- Individualising work to suit the needs of weaker students in the class (6)
- The introduction of table teams, and the extension of these into English at Year 7 with a team approach between the two teachers - hopefully. I would expect the rest of the trial team will be continuing with their table teams next year (7)
- Changed focus on classroom teaching – more emphasis on verbalisation, justification; increased awareness of timetable allocation. Lesson structure example was useful (11)
- We have worked on a common structure for maths lessons. Include oral and written presentations for problem solving activities (12)
- Place more emphasis on mathematical texts for Guided Reading and writing sessions in Literacy. Investigate the use of peer tutoring and parental involvement across all school levels (12)
- Teachers providing more variety and real-life maths in their programs (13)
- Teachers are far more aware of a balanced approach to Maths with activities that are based in real life situations, and are open-ended. Using the lesson break-up as suggested by the program for maths sessions [structured, whole-small-whole lesson plan] (15)
- Improving the profile of maths through diary writing and numeracy blocks (17)
- Cross-age tutoring has been given a direct purpose, which is beneficial to both school communities [primary and secondary], the decision to continue with this program next year indicates the level of commitment from the staff (19)
- Focused approach. Improved structure [class groupings and student progress plan]. Providing a consistent approach to delivery and appraisal of student work (20)

Greater range of assessment options and the use of data to inform teaching:

The use of ‘rich’ assessment tasks, particularly the valuing of explanations and interpretations relative to context, clearly stimulated a number of schools to focus on alternative approaches to assessment in their Action Plans. The following outcomes were reported in relation to this category.

- Monitoring and reporting policy (1)
- Further analysis of student achievements and knowledge of the research approach [use of scoring rubrics] (2)
- There has been a valuable gathering of data from the testing carried out as a part of the project. This will provide an important base for further policy and program development (5)
- SNP’s [referring to project ‘rich assessment tasks] were an interesting comparison to/addition to our own assessments (11)
- The use of Rubrics as an assessment tool (13)
- Using rich assessment tasks as used by MYNRP (15)

Enhanced understanding of student learning:

An important set of outcome statements were those related to the identification of individual student’s learning needs and/or preferences.

- Becoming aware of student’s individual strengths and weaknesses and how vital that is to the health of the whole class (6)
- Confirmation of the wide range of learning strategies children use when confronted with problems which don't immediately fit into their learning (9)
- Discovering the variety of different learning strategies and then attempting to provide activities that can build on these experiences and extend the children's skills. Also, the importance of concrete materials in the teaching of maths in the upper school (9)
- From the last testing I discovered my children fared rather low on the ‘Fraction boxes’, although we’d just spent a month investigating fractions. From these results I was able to set up a sequential lesson plan and retest to develop the skills in my children. Results were very encouraging (17)
- Children are generally better able to explain and justify their actions (11)
- Year 5/6 teachers have seen the benefit of incorporating open-ended problem solving activities into the maths program (12)

Resource improvement:

Quite a few schools nominated improved teaching resources as a major outcome of the project, including in a number of instances, ideas gleaned from the De-Briefing Sharing Day held at the end of the project.

- Developing a pool of resources – and in some instances examples of students' work (3)
- Resources, for example, Maths Project 300 and MCTP Activity Banks (12)
- More resources to meet the needs of the changed approach and ideas from the sharing session in Melbourne (15)
- Improved materials. Improved software for staff (20)

Recognition of the importance of appropriate staffing was formally nominated by one school as an outcome. This issue was raised in other areas of the Final Report as well by other schools.

- The involvement in the project really highlighted the staffing issues which have begun to be addressed in the staffing for next year (5)

Increased awareness of and commitment to numeracy as an issue:

Another important set of outcomes relate to the recognition of numeracy as an important issue and the commitment of a number of Trial Schools to continue the work they had begun in relation to the MYNRP.

- While these things have challenged us, the project has also encouraged us to continue the search for solutions to an important issue for our students (2)
- Raised the profile of the need to improve this aspect of the College numeracy programs and general consensus was reached (2).
- Challenged the status quo and showed that the issues are statewide and recognised by the evaluators. Identifies an important agenda for future work for mathematics teachers in the college (2)
- Highlighting the importance of numeracy at the school level through newsletter etc (3)
- The development of an increased awareness of the issues relating to numeracy in the middle years and the different approaches that are possible has been an important outcome at this school. This has led to an increased willingness to look at different approaches. However, again we have had a significant change in staffing in Maths and it will be interesting to see how the work undertaken so far is carried on and picked up by new staff. (5)
- A renewed focus of Mathematics – a better understanding of CSF2. The fact that every one agrees to continue with their focus on Middle Years issues (13)
- The profile of the 5/6 area was improved (14)

Enhanced professional knowledge:

Outcomes related to the enhancement of teachers' professional knowledge and skills were also reported by Trial Schools.

- Influenced teacher practice to varying levels, presumably changing the student experiences and outcomes. Extra PD and good teaching resources to support this goal (2)
- Being given the opportunity to share our findings at the regional level through facilitating at professional development session (3)
- Becoming aware of structure of a math's lesson (6)
- Provided and will continue to provide relevant professional development (12)
- ideas from the sharing session in Melbourne (15)
- Having a chance to reflect and discuss the pros/cons of specific lessons in the diary format [journal entry]. Diary entries are worth keeping for future reference in regard to improving teaching of concepts and will now encourage other teachers to do same (6)

Greater enjoyment, improved attitudes:

- Students have enjoyed working on problems which can stimulate them to different degrees (12)
- A very positive attitude towards maths from students and teachers. Maths is fun and challenging – teachers and students agree!!!! (13)

- Students attitudes and confidence towards maths tasks has increased (14)
- An increased level of teacher enthusiasm for Maths (15)

School organisation:

It is clear that many schools are struggling with the question of optimal organisational structures to support effective teaching and learning in the middle years of schooling. This is a major, long-term issue that is well beyond the scope of the current research project. Nonetheless, being involved in the project prompted at least one school to think about structural relationships.

> "Next year our College is operating according to 3 main teams – Early Years encompassing years P-4, Middle Years encompassing years 5-9, and Latter Years encompassing years 10-12. This structure will give much more freedom to develop and implement [our] Action Plan …. Also, fortunately the majority of the "keen" teachers involved in the MYNRP will also be in the Middle Years team in 2001. One teacher as major leader is most keen to follow this Action Plan (further developed) into fruition and has incorporated it into her Performance Plan. We are also commencing our next Triennial Review 2001. Since we now have extra data re numeracy in years 5-9, it allows us to examine this area in detail and determine what needs to be done. Our involvement in the MYNRP besides giving us this impetus re our Action Plan and providing data for examination, has led our teachers to reflect on and examine their own numeracy teaching." (School 16)

Greater interaction between primary and secondary schools:

One of the observable outcomes from the researchers point of view was the obvious benefits gained from local primary and secondary teachers talking to one another about their practice. This happened through the establishment of local network meetings and on the final De-Briefing Day.

- Greater interaction with primary schools (3)
- Increased contact with colleagues at neighbouring primary schools (11)

8.4 Trial School Reflections on the Design Elements for School Improvement

In preparing their final Report, Trial Schools were asked to rate the importance of each of the Hill and Crèvola (1999) design elements to the success of their Action Plan on a scale of 1 to 10. The three most important elements on the basis of the Trial Schools' experience were

- *Beliefs and Understandings* (Mean 6.7);
- *Professional Learning Teams* (Mean 6.7); and
- *School and Classroom Organisation* (Mean 6.4).

Although *Structured Classroom Programs* (Mean 6.2) and *Leadership and Coordination* (Mean 6.1) also featured as significant elements. As might be expected there were differences by school type. Primary schools rated *Structured Classroom Programs* as the most important element from their perspective. Secondary Schools rated shared *Beliefs and Understandings* and P-12 schools rated *Professional Learning Teams* and *Monitoring and Assessment* as the most important elements from their perspectives. Secondary and P-12 schools rated *Standards and Targets* significantly higher than Primary schools. These differences are illustrated in the table below.

Design Element:	Primary N=12	Secondary N=6	P-12 N=2	Total N=20
Beliefs and Understandings	6.4	7.7	7.0	6.7
Professional Learning Teams	6.5	6.8	7.5	6.7
School and Classroom Organisation	6.7	6.5	4.0	6.4
Structured Classroom Programs	6.9	6.0	2.0	6.2
Leadership and Coordination	6.1	6.0	6.5	6.1
Standards and Targets	5.6	6.5	6.5	6.0
Monitoring and Assessment	5.3	5.5	7.5	5.6
Intervention and Special Assistance	5.2	4.8	3.5	4.9
Home, School, community Partnerships	4.9	4.0	1.5	4.3

Although Principals were asked to complete the Final Report Form, in some cases, it was the Project Contact Person and/or Coordinator who were given the task of rating the design elements. As a consequence, it is highly likely that the role of school-based *Leadership and Coordination* was under-valued. From the perspective of the members of the research team who interacted with and visited the Trial Schools, this element was seen to be crucial to the success of the Action Plan and the delivery of improved student numeracy outcomes. Although there were a whole range of factors that hindered the implementation of Trial School Action Plans, without strong, effective and committed professional leadership, schools faced a very significant up-hill battle to engage effectively with the project.

The Project Brief required a focus on the design elements of *Professional Learning Teams*, *Special Assistance*, *Structured Classroom Programs* and *Home, School and Community Partnerships*. Trial Schools variously focussed on these and others according to their circumstances and priorities.

Special Assistance - Although a few schools nominated the identification of learners 'at risk' or those 'above and below the relevant CSF levels' as strategies in their Action Plans, in practice this proved difficult primarily because of the resourcing issues involved (time and staffing implications). A Diagnostic Interview schedule was developed and provided to all Trial Schools to support this focus if required. One school used the interview with all their Year 5 and 6 students. The experience provided them with invaluable information about their students learning needs and was undoubtedly a significant factor in their substantial improvement in student numeracy performance (School 9). Time and resources are real issues, but it is evident that the benefit to be gained from having an in-depth knowledge of individual student's learning is well worth the additional effort required.

Structured Classroom programs was a major focus of most Trial School Action Plans. Schools generally reported a "changed focus" with more emphasis on students' capacity to explain and justify their thinking, and the use of open-ended questions, problem solving and rich assessment tasks. Within classes, there was also an increased focus on the use of group work to meet individual learning needs and a structured approach to lessons.

Home, School and Community Partnerships was more of a focus for primary schools than for secondary schools. Where this was picked up as a strategy it was mostly implemented in terms of family maths sessions (primary) and parental involvement in homework (secondary).

Professional Learning Teams was one of the most critical aspects of the Trial School experience. Schools provided many anecdotal reports of how important this was to the implementation of the project and how beneficial it was to the individual teachers.

The action planning process used by the project required schools to identify their key strategies and classify these in terms of the Design Element framework. Schools were then asked to consider the remaining Design Element categories with a view to identifying the strategies that would be needed to support their primary focus. For example, if the school's key strategies related to *Structured Classroom Programs*, they were asked to identify what strategies were needed across each of the other Design Elements to maximally ensure that their key strategies were effective.

8.5 Limitations reported by Trial Schools:

Inevitably, and particularly from the Trial Schools' experience, there were a number of factors and circumstances that impeded the implementation of the school-based Action Plans. These are mentioned here briefly to acknowledge the very real difficulties encountered by a number of Trial Schools and in recognition of the professionalism demonstrated by the school teams concerned in addressing these issues.

Unfortunately, there was an unavoidable delayed start to the project in 1999 due to an unexpected change of government. This pushed back the initial assessment into November/December which was an exceedingly difficult time for schools. The fact that so many completed the data collection in the time-frame required is an enormous credit to the commitment of teachers involved. This initial delay was compounded by another unavoidable and quite significant delay in analysing the data. Although these difficulties had been overcome by the Trial Phase there was still some delay in processing the school grants due to administrative changes at RMIT.

In retrospect, more could have been done to build a shared understanding of what the project was about (and more importantly what it was not about) at the commencement of the project. Some schools were clearly expecting something similar to the *Early Years Numeracy Research Project* which had the time and resources to focus on student's mathematical development in a more sustained and professionally rewarding way. This had its limitations in managing teacher's expectations about the level of support and direction that the project could provide. The two projects were quite different and it was appropriate that they were for the reasons outlined in Section 2 of this report. The MYNRP was essentially an explication study not an implementation study as less is known about numeracy in the middle years of schooling. The project was aimed at identifying what might work to improve numeracy outcomes not to evaluate a given set of well-defined strategies and teaching approaches. As such, extensive professional development opportunities were not provided by the project team, but it was hoped that schools would use some of their project grant to commission professional development that was pertinent to the implementation of their Action Plan. Having noted this, it is fair to say that the shared practice opportunity provided at the end of the project would have been very useful at the beginning and/or middle of the project, as well as at the end.

The significant amount of work involved in the assessment and the unfortunate delay in returning the initial data was not helpful to schools planning on using the data to inform their Action Plans. However, the experience of being involved in the marking of the assessment tasks appeared to off-set this to some extent as it was clearly used to inform the majority of Action Plans. Some schools who were already well down the track in terms of initiatives to improve numeracy outcomes, did not see much value-added in the project and this is understandable as the project was designed to learn from the experience of these schools.

> "The school has been using this approach to the teaching of mathematics for several years. The emphasis placed on problem solving skills as outlined in our original action plan has been a part of our regular planning so there hasn't been much of a change from usual.
> Our problem has been the need to put replacement and emergency teachers unfamiliar with this process into our classes due to our changing circumstances." (School 18)

A major factor identified by Trial Schools was unexpected staffing changes that left teams without members and/or leaders or contact people for a variety of reasons. Related to this were perceptions that some teachers were not as motivated or as interested as others for whom maths was their first priority. This, added to a range of contextual problems, was clearly a difficulty for some schools as is illustrated by the following statement.

> "The staffing of the Maths learning area has been a concern for some time. A large number of those who teach Maths do so as a second method, consequently only teaching one or two classes and so not being fully committed to curriculum development in the area as their priorities lie with their other teaching area. Furthermore, there were several changes to Maths allotments during the year. Consequently, different staff moved in and out of the project team during the year.
> The lack of background of the students in the approaches that were being trialed led to frustration amongst both students and staff who were concerned about the apparent inability of the approaches to engage students or to promote successful outcomes. Added to this is the large number of NESB students and others with severe literacy problems that impeded the success of the approaches trialed. The lack of experience amongst the staff and their own need for more in-servicing in approaches to 'numeracy' rather than 'maths' was clearly a factor here." (School 5).

Time and lack of resources was a common thread in most Trial School comments concerning limitations. Relevant resources were identified and made available to Trial Schools (also published on the Middle Years website) but as these did not offer a comprehensive replacement to 'the textbook' they may not have been seen to offer sufficient support. Availability, access and time to manage these resources may also have been a problem for some schools, although some were more optimistic than others about this.

> "Time and confidence with what we were doing probably were the biggest factors that we found restrictive. We have slowly built up our resources and will continue to do so and just becoming familiar with what we were doing and what we wanted to achieve. What we have done is a great start and is a basis for further growth and expertise in this area." (School 14)

The feedback received from one school faced with a particularly difficult set of circumstances summarises some of the more entrenched issues that make any change initiative a challenge. It is presented here to acknowledge the reality of teachers' day-to-day existence. The statement has not been acknowledged to ensure the anonymity of those concerned.

> "Work load. There have been numerous competing demands on time
> Money. More money would have given us better resources and greater ability to use replacement staff to allow the faculty to work on those goals not fully implemented.

Age of staff. Most of the faculty are experienced teachers who have established teaching practices. They are reluctant to replace something they are confident will work with a new philosophy and outlook [and] are cynical of any new initiative (can you blame them after the total destruction of education by the previous regime) and some are just waiting to retire and have 'been there and done that'.
Lack of staff turnover. Too many staff have been at the same school too long.
Lack of team-work. A cohesive team approach was not always evident. Time and leadership, hopefully, will change that.
Cultural values. Unfortunately some parents of the weaker students have little interest in their child's education and these negative influences affect the students wish to improve. Some students here also come from poor environments and dysfunctional family structures
There is only so much a school can do. It does require the support from family and the community."

8.6 Trial School Recommendations for Improving Numeracy Performance

Trial Schools were asked to recommend strategies for improving numeracy outcomes on the basis of their experience. These are listed by category below. The numbers in brackets refer to Trial Schools.

Structured classroom programs:

- Providing structured lessons with appropriate tracking and reporting of outcomes. Improving organisation of classes to provide the best learning opportunities (1)
- Use of mathematics in other subjects using an integrated approach, eg. Olympic Travel project at year 8. Compile maths problem cards which create practice in numeracy that students can use individually (6)
- Continued practice of the basic skills is important, as is the use of written questions with a "real-life" basis. Next year I would like to see an extension of table teams and the Blast-Off type sheets (7)
- Initially to get a link between all year levels, identifying strategies children use to learn math strategies and then to be able to effectively prepare a learning program that caters for the range of learning approaches (9)
- For teachers to focus more on number facts and times tables in order to give students confidence (13)

"I found the numeracy block works really well and allows time for working with specific children and lots of discussion. Talking about their methods is really valuable.
I really believe most children struggle with problem solving (maths language). This really needs to be addressed in light of the four step plan, strategy list and integrating a range of open ended problems where children can discover a variety of solutions are correct. Then individual learning styles are appreciated. Through this approach Maths can be integrated into all areas of the curriculum, eg, solving a pattern problem by acting it out, drawing, describing or writing a sum." (17)

Leadership and Coordination:

- Making teaches more accountable (1)
- Good resources are available however it takes time to find or adapt, that is, time at the school level to work in teams to develop these (3)
- Primary and Secondary schools to work more closely to provide more relevant activities e.g. open ended as in the Australia Project (12)
- Ongoing funding, establish a coordinator, providing classroom release, develop teams of schools – covering all levels of middle years (19)

Dissemination and professional development:

- The team publish best practice ideas (1)
- Extra PD and good teaching resources to support this goal [improved numeracy]. (2)
- Relevant, local and good professional development especially for the later stages of Year 8 and Year 9. Attendance at professional development sessions on 'Engaging Students in the Middle Years' have very clearly indicated that there are many strategies, resources, kits for SOSE, English etc. Maths hardly gets a mention, or response from a facilitator is often 'That's a hard one' (3)
- Publicising the availability/ strengths of such resources and giving staff time through CRT coverage to attend workshops on how to use such resources eg 'Civics and Citizenship' Kit (3)

- There is a genuine and urgent need for teachers to receive P.D. in this area. This needs to be in a form that is inexpensive for schools (teacher release needs to be funded) and yet allows teams of teachers to attend on some sort of ongoing basis rather than just one day (5)
- The shortage of Maths teachers is also clearly an issue that needs to be addressed if numeracy in the middle years is to be addressed. Students in the middle years need to be taught by teachers who are committed to the subject and who have an approach which will engage young adolescents (5)
- Addressing the issue of teachers who do not necessarily have a math's degree being confident and able to deliver the concepts of numeracy clearly and effectively (6)
- Recognition that we still aren't doing a number of things correctly, for instance the teaching of fractions (what are the skills we use to learn these relationships) and how we actually bridge from learning number facts to actually using this knowledge in real life situations (9)
- Relevant professional development to lift the profile of maths amongst this age group of students (12)
- More PD for teachers in how to teach fractions, decimals and percentages. We understand how to do them but the results show that the majority of students are not understanding the concepts we teach! A real conscious effort by teachers to understand the link between numeracy and literacy. (13)
- Something along the lines of the Early Years Program where PD is offered to teams and a definite direction is determined to follow. What has started is great but this needs to be continued by offering teachers support with ideas, resources and appropriate PD. (15)
- In light of our unexpected year of teacher and Principal change, I feel that the importance of teaching teachers to teach mathematics effectively is the biggest challenge. We can have great facilities, modern work environments and the latest technology but the most important factor is the teacher. Therefore I would hope that this project can continue to seek the best and most effective teacher practice and use these findings to promote Professional Development for teachers in both Secondary and Primary schools.
- I think sessions where teachers from different schools can sit together and share thoughts about what is and isn't working is beneficial. (18)

Continued program of action research:

- Continue the same model for seeking improved strategies for numeracy education. Improve teacher practice. Encourage change in our approach to learning and how we evaluate the changes (2)
- I would hope that the 2001 [school-based] Middle Years team adopt a commitment to continue to develop and implement the Action Plan [aimed at] improvement in Middle Years numeracy. I remain positive and very hopeful that this will happen. (16)

Resource development:

- Further development of resources such as 'Effective Maths Assessment' and 'Curriculum at Work' CD (3)

Focus on engagement:

- Our focus on engagement and classroom practice [decreased focus on narrow number work] has generally significantly improved students' interest in Maths sessions and, by extension, their progress. The development of positive attitudes to any area is critical to success. We believe this is reinforced by the results of our Action Plan and has probably reduced the number of students in the "at risk" category (8).

Focussed Meetings:

- Teachers should always make the time to openly appraise their practise and share ideas with their colleagues. This is particularly true of those in settings where they are the only teacher at that grade level. By focusing purely on numeracy, many local and systemic issues were identified by our group. As such we would recommend the regular meetings continue so that we may continue to address them (8)
- Be involved in some kind of numeracy network team in order to collect and share resources as well as Professional Development. (14)

Parent Involvement:

- Continued parent involvement (19)
- Better communication between school and parents (20)

> "One of the greatest inhibitors to change in any mathematics program is parental perceptions of what Maths is. To an extent this is also true of Secondary teachers who whilst having an excellent subject knowledge tend to have a more blinkered and traditional view of mathematics.
> In many cases we have experienced primary students who have already decided they "hate maths". By focusing on engagement and developing a positive attitude to maths learning student numeracy can be improved. However, concern continues to exist amongst many Primary teachers at the Middle Years about how capable and positive students can be turned off within 12 months of attending Secondary College.
> A challenge for us then is to focus on informing parents and Secondary colleagues of the value of this approach. The challenge for them is to accept that this is a valid and alternative approach to textbooks.
> Parents too need to be aware of the value of including their children in household tasks using Maths concepts such as cooking, building etc where measuring (particularly including fractions such as ½, 1/3, etc- since we now use mostly whole or decimal numbers, eg. 125 grams, 1250 ml 2.4 metres etc). We have used Maths Share before but have found it difficult to continue organisationally. Newsletter items and parent meetings etc may be best for dissemination of this information." (School 8)

Improved assessment/monitoring:

- Continue the development of assessment tools which can identify learning strategies used by children and then been able to access programs which can use the identified skills (9)
- A good assessment kit in order to test students at the beginning of the year and monitor progress at the end of the year. Resources for rich assessment tasks. (14)
- Raising the expectations of and the expectations from students. Not rewarding students for poor quality work. It is difficult to obtain the work from students no matter how well it is presented. They are often promoted to the following year level even though their knowledge of the work and their work ethic does not warrant this promotion. It just means that their problems are even more difficult to overcome in the future (20)

Early intervention:

- Should introduce the definition of numeracy and the skills we've been concentrating on right from the beginning, that is, from Prep. (11)
- Withdrawal of the weakest students for intensive help in numeracy skills (20)

8.7 Action Plan Features Associated with Improved Numeracy Performance

Improvements in student numeracy performance were achieved by all Trial Schools over the course of one school year (see Section 6). The fact that some invariably improved more than others is *a source* of information about what *might* work in other settings, but there are no guarantees. Individuals are critical to any change project as is the context in which the project/initiative is set. Hence, all Trial School Action Plans and feedback have been represented to date. However, in identifying the features most likely to impact improved student numeracy outcomes, the Action Plans and Final Reports of those schools that achieved the greatest improvement in student numeracy performance (5 primary, 3 secondary and 1 P-12) have been used to derive much of the following advice. This advice has also been informed by the Action Plans and Final Reports of those schools who were already achieving relatively high levels of student numeracy performance (2 primary and 1 secondary) but did not necessarily show such a marked improvement.

Once identified and considered in isolation, the Action Plans and Final Reports of these schools 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 advice is presented as propositions formulated on the basis of the strategies reported by the schools who made a substantial difference or sustained relatively high levels of student numeracy performance. They have been organised in terms of the Design Elements of the Hill and Crévola model, although it is recognised that in practice these overlap considerably. For instance, focussed professional learning teams and committed, effective leadership and coordination are essential to the building up of shared beliefs and understandings. In terms of relative importance, it needs to be kept in mind that professional learning teams and beliefs and understandings were rated as the most important aspects of the Trial School Action Plans (see 8.4 above).

Successful middle years' numeracy schools focus on ***school and classroom organisation***. They:

- provide regular, sustained periods of uninterrupted time to study mathematics (in the morning where possible);
- vary class sizes on a regular basis, for example, blocking maths time to support an additional group and teacher and/or vertical (multi-age) groupings;
- use a common, structured lesson format, for example, whole class introduction - small groups – whole class review/sharing;
- systematically review, renew and manage shared resources for teaching and learning;
- look for and use a wider range of flexible groupings within classrooms, for example, cross-age tutoring and mixed ability, like ability, "table teams" and interest based groups.
- involve additional teaching support where possible, for example, specialist teachers, teacher aides, cross-age tutors, parents;
- provide additional, alternative opportunities to learn, for example,

> "Restructure time table so first period after lunch is free, students who have not achieved outcomes go to new teacher who plans to teach unit differently – matching teaching styles with learning styles".

> "Arrange a Friday session to tackle individual problems or whole class issues that may have developed over the week."

> "After school maths tutoring class which students attended on their own volition or after recommendation from their teacher in consultation with parents".

> "The major change to the classroom was the introduction of small table teams in the [mathematics] classes from Year 7 to Year 9. This was deemed as a successful way of delivering the curriculum, and has been maintained during Semester 2 in all but one class. This will be introduced into English at Year 7 in 2001 with the same teacher taking both Mathematics classes and the same teacher taking both English classes – enabling some team teaching and/or aligned curriculum.
> The other change was the introduction of "Blast Off" multiplication sheets in Years 7 to 9 – all classes had a 5-minute session at the beginning of lessons 2 or 3 times a week. The students and teachers were all surprised at its acceptance and challenge!"

Successful middle years' numeracy schools focus on ***classroom teaching strategies***. They:

- regularly and systematically use open-ended questions, games, authentic problems, and extended investigations to enhance students' mathematics learning and capacity to apply what they know;
- focus on connections and strategies for making connections, for example, connections between prior knowledge and new learning, 'school mathematics' and 'real world' applications, and problem solving strategies;
- actively engage students in conversations and texts that encourage them to reflect on their learning and explain and justify their thinking, for example, discussion, debate, oral presentations, learning journals, rich assessment tasks, performance based assessment, class reviews and feedback;
- attend to the literacy aspects of mathematical texts and representations, for example, the meaning of terms, written expressions, how to read diagrams, tables, graphs, symbolic texts;
- plan teaching and learning experiences appropriate to learners' needs and interests using a balance of teacher-directed and student-centred approaches;
- provide opportunities for meaningful and enjoyable practice of essential knowledge and skills;

> "Grade 5 have been working at problem solving all Term being involved in a booklet put together by X, one of our Grade 5 teachers. The tasks were based on community texts and the Olympics. The students were given strategies to scaffold their methods of tackling the problems. Initially we feel it is imperative the students take the time to understand the meaning of the task. We feel a lot of the students' difficulties with problem solving are literacy related as well as feelings of 'this is not real maths' linked to maths anxiety.
> Giving students a list of strategies to help them find their own way through the 'mire' of problem solving not only values each strategy but gives students ways of going about the tasks
> The tasks were all rated on their level of difficulty and students gained gold, silver or bronze medals on completion of them. The building in of competition into the sessions gave an extra edge of motivation to the focus and all the students worked exceptionally well.
> Grade 6 have also been working on the gaining of meaning initially in working on word problems as well as giving the students strategies in coping with ' this problem is too hard!!!' feelings that are often the first reaction to many problem solving tasks. Teachers have also been encouraging maths dialogue in their classes, encouraging students to talk and explain their maths thinking.
> Students have continued to work together in problem solving sessions".

Successful middle years' numeracy schools focus on ***professional learning teams***. They:

- have a numeracy-focussed team who meet regularly to review and plan classroom learning activities, discuss student work samples, consider classroom structures, share ideas and resources, discuss issues;
- plan for and participate in targeted professional development activities, for example, the use of small groups to develop problem solving skills;
- involve interested others in their numeracy-related meetings, for example, teachers from other KLAs, other levels of schooling, specialist teachers, principals;
- develop and document shared teaching resources and approaches using teacher and student reflections;
- liaise with associated schools to explore joint opportunities for numeracy learning, discuss numeracy at Transition meetings

Successful middle years' numeracy schools focus on ***home, school and community partnerships***. They:

- inform parents about school and/or classroom practices related to mathematics and/or numeracy through information sessions, newsletters, exhibitions of student work;
- involve parents in aspects of students' mathematics learning and problem solving, for example, homework partnerships, student journals, parent evaluation notes;
- provide opportunities for shared mathematics where parents work with students on mathematical problems and/or rich assessment tasks at home or at school, for example, homework partnerships, family maths evenings;
- liaise with other schools to provide transition programs, share resources, support remote or isolated teachers, manage cross-age tutoring;
- celebrate student achievement, for example, classroom displays, special books

> "Students have a special book to use for rich assessment /problem solving activities where they keep a personal journal, parents teachers and students make evaluation notes with each problem."
>
> "At the start of the Term, Grade 5 invited their parent in for an evening to 'showcase' their efforts at school in poetry, dancing, maths and PE. The problem solving booklets were a feature with students showing their parents how they work and it was heartening to see the different generations working together on problem solving. It was evident the students enjoyed showing their parents their developing skills".

Successful middle years' numeracy schools focus on ***leadership and coordination***. They:

- appoint a coordinator with responsibility for middle years' numeracy who organises professional development, acts as a mentor, arranges and supports regular team meetings, keeps the team on track and helps locate and acquire relevant teaching resources;
- have the active and committed support of senior leadership;
- formally recognise numeracy improvement as a major goal of schooling, for example, numeracy is a charter priority and/or included in the mission/vision statement.

Successful middle years' numeracy schools focus on ***monitoring and assessment***. They:

- use a range of assessment strategies to evaluate and monitor students' numeracy-related knowledge, for example, open-ended questions, rich assessment tasks, projects, scaled tasks (that is, complex tasks which allow all students to make some progress and be challenged at some point);
- value and assess students' capacity to interpret, apply and justify their numeracy-related knowledge relevant to context;
- actively encourage students to reflect on their learning and use those reflections to inform subsequent teaching, for example, student journals, learning portfolios;
- develop assessment tasks and scoring rubrics to assess numeracy performance on a regular basis;
- monitor the individual progress of each student using learning plans, tracking sheets and/or individual interviews to probe students understanding where necessary;
- conduct specific audits of key ideas and/or strategies, for example, a school-wide audit of mental computation strategies.

> "Following the initial individual interviews teachers gained a wider perspective of the range of approaches used by children when doing maths tasks. This meant that teachers had to plan more broadly to cater for the individual learning styles of children and that no one approach was necessarily more suited."

Successful middle years' numeracy schools focus on ***beliefs and understandings***. They:

- have established processes for reviewing, deciding and documenting what they jointly believe and understand to be best practice in relation to the teaching and learning of school mathematics and numeracy education, for example, the development of a school numeracy policy, the appointment of a numeracy coordinator and an identified team (see above).

Successful middle years' numeracy schools focus on ***intervention and special assistance***. They:

- use a range of effective and efficient monitoring strategies to ensure students with special learning needs are identified and supported;
- have strategies and/or structures to support students who are performing either well above or well below the level that might be expected;
- provide special assistance to students from non English speaking backgrounds, for example, bilingual classrooms and/or maths programs;
- recognise the link between numeracy and literacy and adopt 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.

Successful middle years' numeracy schools focus on ***standards and targets***. They:

- have an agreed picture of where they want their students to be and set 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;
- recognise the importance of communication skills in relation to mathematics and numeracy and include standards and goals related to reading, interpreting, presenting, explaining and justifying mathematical ideas and strategies in context.

8.8 Observations on Trial School Action Plans – Is 'good' mathematics teaching sufficient?

It is interesting to reflect on the common features of 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. What the Plans fundamentally reveal is a commitment to excellence in mathematics teaching and learning. While it would appear that this is a necessary pre-requisite for improved numeracy performance, it is interesting to speculate on whether or not it is sufficient. For instance, in the features described above, there was very little reference to numeracy across the curriculum, the use of manipulatives, the role of technology, or the nature of current curriculum expectations. In particular, the notion of 'big ideas' and the scaffolding needed to support students move from one big idea to the next.

While building on school mathematics is a logical starting point and consistent with what we know about learning, it would appear likely that further gains in numeracy performance could 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 (for example, two useful resources are the Curriculum Corporation's *Maths Project 300* and *Measuring Up*, an Edusoft CD Rom developed for the adult numeracy area but proving useful in supporting key areas of middle years' numeracy);

- greater consideration was given to the use of numeracy-related tasks that involve the manipulation of concrete materials, particularly in Years 7 and 8 (for example, the Replacement Units available from the Curriculum Corporation);

- it was recognised that differential teaching is likely to be more effective than linear, lock-step approaches or differentiated curriculum (separate programs), 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;

A number of these suggestions will be revisited in the context of Section 10. The next section deals with the data derived from the Trial School teachers' perspective, that is, the teacher journals and survey.

9. The Teachers' Perspective – Journals and Surveys

9.1 Teacher Journals

Trial School Teachers were asked to submit at least 2-3 journal entries per term reflecting on their experiences in relation to the project. The purpose of this was to gain a deeper understanding of the issues involved in implementing school-based Action Plans aimed at improving student numeracy performance.
In practice, however, this turned out to be an unrealistic expectation. Access to the internet was not as widespread or as easy as had been assumed and the research team was unable to provide sufficient feedback to make the journal entries worthwhile from the teacher's point of view (due to an unexpected reduction in project personnel).

In the end, 119 entries were received from 42 teachers from 14 of the Trial Schools. Of these, 24 teachers contributed more than 1 entry, 1 teacher made 19 entries and another provided a single entry detailing a 2-week sequence. Most of the entries were made earlier in the year, the fall off towards the end of the year reflecting the project team's difficulty in responding to journal entries. The contribution of these teachers is gratefully acknowledged.

School ID Number	1	2	3	5	6	7	8	10	12	13	15	16	17	20
Number of Teachers	10	2	1	1	2	1	1	1	3	5	4	5	3	3
Number of Journal Entries	12	2	4	5	21	2	2	4	3	23	10	19	6	6

A number of common themes emerged from the Teacher Journal entries. These included a range of positive comments related to what worked well, primarily non-text based approaches to mathematics teaching (that is, open-ended questions, problem solving, investigations, task centre activities, discussion), and structured lessons involving a balance of teacher and student directed work. However, a number of the journal entries also reflected some of the frustrations experienced by teachers at this level of schooling. These are summarised in the list below.

- *Interruptions* - "Some weeks are just a right off - sport, curriculum days, holidays etc."
- *Crowded curriculum* – "no flexibility when other activities are added into a week"
- *Absenteeism* - "at secondary school it's not necessarily the weakest students who truant", "[I] give up on kids that don't turn up to class, rather spend quality time with kids who do attend"
- *Staffing issues* – "staff changes", "students don't like teachers going on camp etc, it's unsettling"
- *Resource issues* – "lack of equipment (overhead projectors etc)", "algebra – difficult to think of activities"
- *Disc pline* – "too much time wasted on crowd control"
- *Students' preparedness for learning* - "poor literacy knowledge", "poor fraction concept knowledge", "students still need concrete aids", "Year 8 not ready for lessons on time", "students daunted by working things out that require a number of steps"

- *Engagement* – "students not highly motivated/hard to engage", "students not able to complete work under normal circumstances but when given detentions finished the same work quickly".
- *Depression* – "some days I just want to give up"

The following quotes from the teacher journals illustrate the range of contributions and provide a flavour of the day-to-day experience of practitioners.

Specific topics:

> "[the students] recall of the previous years' work on fractions is weak but real life situations showed a growing understanding of concepts … I believe that fractions need to be talked about regularly as being part of our everyday lives rather than being relegated to maths sessions taken in the classroom every now and then." (primary teacher)

> "If we didn't get the times tables done each week, I don't think the kids would let me leave the school alive" (primary teacher)

> "Decimals seem to fit students' pattern of reasoning better than fractions perhaps they have more exposure to decimals" (secondary teacher, questioning place of fractions in the curriculum)

Group Work:

> "It is possible that several students are comfortable to work with a partner, but don't want to record anything. It would appear that some students are getting through on the 'slip-stream' of other students. This may be an area where we need to focus our attention in which tasks involve group interaction." (primary teacher)

Reading, writing, speaking mathematics:

> "explanations proved to be quite challenging for the students, many are unfamiliar with explaining and indeed identifying what they are actually doing to solve an equation. I think it is important to make students aware that real maths is not equations on the blackboard, but rather working out problems like those featured … the difference in ability to express themselves mathematically is amazing." (primary teacher)

> "I have found that in number the kids cope pretty well, but when there is no obvious process, or an equation, then they find it difficult to decide how to begin. With this sort of problem solving it is not so much the maths but the reading and interpretation of the actual problem that causes the most difficulty." (primary teacher)

> "they [the staff] all agree that while many of our kids can do the maths, it's often the language that stumps them." (primary teacher)

> "the kid's weaknesses in literacy came out when they were asked to write about their graphs. One student asked if instead of saying 'Jason had the most shoes", she could say that he had the "biggest shoes". I need to do a mini lesson on most, versus biggest number versus biggest. I'm used to that in the Language Centre, but this was a native speaker who asked." (secondary teacher)

Celebrating Student Learning:

> " Anyway, I do believe a lot of the reason for them doing so well [Year 8 students in relation to an algebra test] is that they questioned everything and wanted to know WHY!" (secondary teacher)

Another teacher included some feedback from her students in a journal entry.

> "In maths today we did a pizza menu worksheet. We had to work things out not just write the answer. Today I learnt that the answer isn't the most important. It's how you work out the answer. I enjoyed doing maths today. I think it was interesting." (Student 1)

> "You need to look at the question carefully and then break it into little bits" (Student 2)

> "You could measure the distance from Melbourne to Sydney in millimetres too, but why would you." (Student 3)

Catering for students with special learning needs:

> “contrary to my initial reservations that the students might in some way feel disinclined to take up the offer, [4 students withdrawn from class for one lesson/week for additional support] we almost have a bun fight when BB appears at the door on Thursdays. There is now a waiting list!” (secondary teacher)

> “although I am mostly able to provide extension work I am very conscious of making them do more just because they are smart.” (secondary teacher)

Teaching:

> “Early on, the things I found most interesting about teaching were the importance of relevance and the art of connecting what may at first seem to be quite disparate subject areas … it is possible to teach maths, art music, language, SOSE and elements of science in a completely integrated way.” (primary teacher)

> “As someone who has been teaching since the early seventies, I have been saddened to see the increasing reliance on set texts and repetitive questions, but I also know that so much of this has been a reaction to the increase in teaching hours overall, the excessive workload necessitated by the current VCE and the budgetary constraints limiting photocopying.” (secondary teacher)

The journal entries point to the joys and challenges of teaching and learning mathematics and/or numeracy in the middle years of schooling. If there is a common thread, it is about student opportunity to learn –demonstrated as much by the success of a student realising that the “answer isn’t the most important”, as by the observed difficulties experienced by students in relation to reading, interpreting and writing mathematically related texts.

9.2 Teacher Survey

Trial School teachers were asked to complete a written survey in November 2000. Of the 78 teachers who returned the Survey, 41 were primary teachers and 37 were secondary teachers. The year levels taught by these teachers are shown in the table below (secondary teachers generally nominated more than one year level). One survey was completed by a teacher who had a coordinating role and did not teach any of the year levels concerned.

Year 5 only	Year 5/6 composite	Year 6 only	Year 7	Year 8	Year 9
5	32	3	18	17	14

The first part of the survey requested information relating to classes taught, class size and composition, the amount of time allocated to mathematics per week, major resources and initial teacher qualifications. A relatively short Likert scale was used to evaluate teacher’s views about the impact (or otherwise) of the project on their immediate practice. Following this, a variation of Clarke’s (1988) Impact Procedure was used to explore teacher’s views about their teaching of mathematics and/or numeracy in greater depth.

The organisational features of the classes taught were summarised in Section 4. However, it is worth reiterating that there was considerable diversity in the way classes were organised. Although the vast majority of the Year 5 and 6 students were taught in composite classes, a number of primary schools used some form of like-ability grouping for some part of the instructional time. The majority of secondary classes were organised by Year level and were largely of mixed ability. However, some adopted a policy of fewer teachers at Years 7 and 8 and others made some sort of provision for students with special learning needs. A significant proportion of all classes had at least one student classified as learning disabled or special learning needs, that is, up to 2 CSF levels behind where they might be expected to be.

The average number of minutes devoted to mathematics per week and commonly used resources were described in Section 4. Teacher qualifications were generally as might be expected, that is, most secondary teachers of mathematics had at least one year of tertiary mathematics study and a maths method subject and most primary teachers were 4 year trained. However, there were some interesting exceptions to this with one Catholic secondary college (School 6) reporting 1 third secondary maths trained, 1 third secondary non-maths and 1 third primary trained. There was no apparent relationship between teacher qualifications and student numeracy performance.

Likert Scale:

Question 8 on the Survey asked teachers to indicate the extent to which they disagreed or agreed (five-point scale) with a range of statements about the impact of the MYNRP on their teaching of mathematics and/or numeracy. This data is summarised in the table below. Aggregated percentages, for example, Strongly Agree and Agree are shown in the shaded cells.

Comment	**SD**	**D**	**?**	**A**	**SA**
Involvement in the MYNRP has made me more aware of my classroom practices	**2.6**	**11.8**	**11.8**	**59.2**	**14.5**
	14%			**74%**	
I am unlikely to change my assessment practices as a result of my involvement in the MYNRP	**5.3**	**50.0**	**19.7**	**22.4**	**2.6**
	55%			**25%**	
My classroom practice has changed for the positive. I believe I am doing a better job now than I was this time last year.	**1.4**	**9.5**	**25.7**	**54.1**	**9.5**
	11%			**64%**	
My knowledge of numeracy and what is involved in the learning and teaching of numeracy has increased.	**2.7**	**20.0**	**29.3**	**42.7**	**5.3**
	23%			**48%**	
I am less likely to work as a part of a team. I am not convinced it adds any value to what I would otherwise do on my own.	**44.0**	**45.3**	**9.3**	**1.3**	**0.0**
	89%			**1%**	
I have a better understanding of the nature of student learning difficulties than I had at this time last year.	**2.6**	**22.4**	**32.9**	**36.8**	**5.3**
	25%			**42%**	
I do not believe that changing how classes are organised and/or selected will make any difference to numeracy outcomes.	**31.6**	**55.3**	**7.9**	**5.3**	**0.0**
	87%			**5%**	
I am unlikely to change much of what I do. I will continue to use the resources and approaches I have used in the past.	**14.9**	**55.4**	**8.1**	**20.3**	**1.4**
	70%			**22%**	
I intend using 'Rich Assessment Tasks' as a part of my assessment strategies from now on.	**1.3**	**5.3**	**34.2**	**48.7**	**10.5**
	7%			**59%**	
It is simply too difficult to cater for the full range of individual differences.	**14.5**	**44.7**	**22.4**	**13.2**	**5.3**
	59%			**19%**	
I am more committed to focussing on structured classroom lessons involving whole class discussion and review.	**1.3**	**14.5**	**36.8**	**44.7**	**2.6**
	16%			**47%**	
If only I knew more about what I was trying to achieve, it would be easier.	**7.9**	**35.5**	**25.0**	**27.6**	**3.9**
	43%			**32%**	

This data suggests that the majority of teachers felt that the MYNRP had a positive impact upon their classroom practice. For example, most reported that they were much more aware of their classroom practices, more likely to change what they do including their assessment practices, and marginally more knowledgeable about numeracy and student learning difficulties. Most believed they were doing a better job than they were the previous year and strongly endorsed the value of working in teams. However, it is interesting to note the ambivalence surrounding classroom organisation and structures. While 87% appear to believe that changing how classes are organised and/or selected *will make* a difference to numeracy outcomes, what this means in practice is clouded by the fact that 81% either disagree or are undecided about it being "too difficult to cater for the full range of individual differences". Suggesting that selection based on ability is not necessarily the most obvious or desired form of classroom organisation from the teachers' perspective (as accommodating difference is, by implication, *not* too difficult). Alternatively, the 81% could simply mean that teachers were reluctant to admit that this was an issue.

Modified Impact Procedure:

The modified Impact Procedure provides teachers with an opportunity to reflect on issues affecting their practice, what they have learnt and what they would like more help with. This process 'tests' the relative strength of key issues impacting teacher effectiveness. As such, although it is inclined to be repetitive, it is a useful tool for identifying and prioritising strategies for school improvement. Responses to each question were classified into categories and summarised. These are presented below.

What were the two best things to have happened this year in relation to your teaching of mathematics and/or numeracy?

Structural/organisational change: having a regular, set time for numeracy (the "numeracy block"), trialing small table teams, cross-age tutoring, a reduction in class size, and additional time (longer lessons and/or 'extra maths').

Aspects of classroom practice: access to an expanded range of teaching resources and strategies (open-ended questions, problem solving, rich assessment tasks), effective group work, increased classroom discussion, practical applications of mathematics in meaningful contexts, more enjoyable and rewarding forms of 'basic skill' practice, more student choice and increased use of technology to support learning.

Professional Development: the experience and value of working in numeracy-focussed teams to trial, reflect and share ideas and resources, targeted professional development, realising how literacy impacts numeracy and participating in a broader professional network.

Assessment related: conducting the individual interviews, increased awareness of student learning and problem solving and developing 'rich assessment' tasks and scoring rubrics.

Evidence of student learning and/or preparedness to learn: improved student attitudes and dispositions, observable improvements in student learning and problem solving, increased student success, greater willingness to 'have a go' and persist for longer and personal satisfaction in seeing students succeed.

> "Receiving a letter of thanks from a parent for improving a student's confidence in maths".
> "The look on a student's face when she passed her first maths test in a year".

Thinking about your teaching of mathematics and/or numeracy, write down one new teaching strategy and/or approach that you can do now.

Organising for learning: use a structured lesson format involving a balance of teacher-directed and student-directed activity, employ cross-age tutoring, cater for a range of outcomes at the same time and manage group work more effectively.

Assessment strategies: develop and use wider range of assessment options, specifically, rich assessment tasks and scoring rubrics.

Teaching Strategies: use an expanded range of teaching strategies including problem solving, open-ended questions and extended tasks that offer degrees of success but always some success for all students, engage students in discussion, debate and elaboration, deal more overtly with the language/literacy aspects of mathematical tasks and the learning process itself, make greater use of student self-reporting and reflection and place more emphasis on mental computation and technology as a tool to support learning.

> "Teaching students the skills and tools of maths that Charlie Lovitt talks about (that is, find an interesting and worthwhile problem; explore it, play with it using concrete materials etc to generate data; use data to form hypotheses/conjectures; use tool box of known problem solving strategies and tool box of known

mathematical skills and strategies to prove/disprove theories; generalise and ask, 'What else can I learn?', then publish the findings".

Thinking about your teaching of mathematics and/or numeracy, what would you most like more help with?

Strategies for dealing with difference: how to support the learning needs of all students at the same time in the same class, 'realistic' and organisationally effective strategies to support students 'at risk' and improve student numeracy skills.

Knowledge and resources to improve teaching: activities and resources to teach in a more inclusive, authentic and 'hands-on' way, specific advice in relation to fractions, decimals and percent and the use of technology to support learning, greater awareness/knowledge of problem solving and relevant research findings.

Assessment: developing rich assessment tasks and rubrics and how to manage and/or interpret assessment information and individual interviews.

Planning, organisation, time management: more time to plan stimulating, engaging learning activities, balancing demands of curriculum and desire to involve students in extended 'real life' investigations and problem solving, managing group work and organising meaningful whole class activities.

> "Time to fit everything in, time to plan, time to coordinate & extend program, time to organise, time to share"
> "Planning exciting and stimulating lessons making maths fun, interesting and innovative"
> "How to ensure all sections of CSF 4 maths are covered while including as many open ended & real life maths situations as possible"
> "Reconciling basic numeracy with the foundations of senior maths in a content heavy course of realistically 3 lessons per week"

Engaging students: how to motivate students to achieve their best, strategies to engage the 'reluctant learner' and 'quiet under-achiever'.

> "How to inspire learning for students who continually say, "I can't do it" and won't try".

What is the biggest worry affecting your work in relation to your teaching of mathematics and/or numeracy at the present time?

Time issues: not enough time to cover curriculum, plan more interesting, relevant learning activities, and/or support individual learning needs, crowded curriculum, interruptions, inflexible timetable and competing workload commitments.

Dealing with difference: catering for large range in student knowledge and confidence, how to provide relevant and challenging mathematics for every child and concerns about student readiness to proceed to further learning.

> "Catering for all individuals … Whether or not the grade 6's are prepared for Year 7, how some of the lower level students in grade 6 will cope in secondary, what can I best do for them"
> "Not catering fully for those who are strong mathematically"

Student engagement and attitude: how to cope with lack of student interest, negative attitudes, poor behaviour and students who refuse to participate and how to change the negative culture.

> "Students who basically refuse to participate & consistently underachieve"
> "Lack of motivation of students-especially boys"
> "Students who simply have 'maths shut down' from years of negative feelings and experiences"

Curriculum-specific/teaching issues: students' capacity to work with fractions, communicate their mathematical thinking, "show their working" and lack of appropriate resources.

Wider school issues: class size, lack of qualified mathematics teachers and physical accommodation.

Personal: keeping a sense of perspective, concerns about effectiveness and relevance

What is the most important thing you have learnt from your teaching of mathematics and/or numeracy this year?

The importance of discourse: value of explanations both to students and teacher, need to encourage culture of explanation and oral expression.

"How important being able to explain your working is to the student and the teacher"
"Consistent regular feedback from students about how they go about their work is not only a valuable assessment tool, it also helps other students"
"Open-ended activities are important and encourage individual thought, kids often know more than we give them credit for. By providing more open-ended tasks we allow them to express all that they know"

Nature of student learning: the considerable variation in student thinking and solution strategies, that students learn at different rates in different ways, achieving some success is critical, basic skills can be practiced meaningfully and effectively, all students want to learn, learning needs to be relevant and challenging, the importance of getting students to think how and why and to be flexible with groupings.

"Children solve problems in ways that I never thought of"
"All students learn at different levels and need to be given work accordingly"
"Maths need not be a regurgitation or rote learning of methods but challenging students to solve problems in their own way"
"The 'bad' students will work if they are given work they can do, that most students are willing to learn if they can be confident of succeeding"
"I can use creative tasks to achieve results"

Planning for teaching: need to provide time to plan and prepare learning experiences and teaching resources, meet and share with others, maintain a balance of skills and problem solving, value of a consistent/structured approach and the need to plan for all learning needs

"Lack of preparation = disaster, planning is paramount and anticipation of student responses"
"Prepare extra, students often work very fast, variety of mode and working style is very important"
"Structure is vital in any class … how important the structured lesson is"

Personal knowledge and confidence:

"Realised I can teach mathematics"
"That you need to persevere"
"That your confidence as a person is by far the most important factor in teaching. If you've got it, you CAN communicate. That's what works"

How do you feel about teaching mathematics and/or numeracy at the moment?

Most teachers expressed very positive feelings about their teaching of mathematics and/or numeracy, for example, "love it", "really enjoy it", "better than ever", "appreciate the challenge" and "very confident".
However, a few teachers expressed some doubts about their effectiveness in the face of competing demands on their time and their capacity to deal with the large range of student ability.

"Frustrated at the pressures imposed on teachers that take them away from the students such as paperwork, administration, VCE course changes and assessment requirements"
"I enjoy it but I feel I am walking a tightrope between the need to cover CSF Level 4 maths concepts & the need to program open ended activities"
"Very challenging with mixed abilities"

It is interesting to note that all the negative responses came from secondary teachers. This is possibly because they are confronted with a greater sense of urgency. That is, they are more likely to be aware of what it is students need to proceed to further study and employment and are therefore more inclined to 'push on' even though this exacerbates the situation for those students who do not have access to foundation ideas and strategies.

How do you see your task as a teacher of mathematics and/or numeracy?

While it is clear that all teachers see their fundamental role as supporting and promoting student learning, how they choose to describe their task often suggests or draws directly on metaphors such as 'facilitator', 'guide'or 'mentor'. As these metaphors imply possible differences in the assumptions and personal philosophies of individual teachers, an attempt has been made to identify the metaphors implicit in what teachers have written with a view to providing advice relevant to how teachers perceive their role.

Facilitators tend to see their role in terms of resourcing student learning. That is, to source relevant content, provide appropriate learning experiences and suitable learning environments and be available to assist students as required. They are more inclined to regard learning as the student's responsibility and do not generally see themselves as interventionists in student learning although they will intervene to ensure learning conditions are optimised. For example, they will endeavour to provide sufficient time for learning, ensure noise levels are kept to a constructive and workable level and inappropriate behaviour is managed.

> "To challenge, inspire and lastly teach"
> "To give students as much opportunity as possible to experience and explore maths on all different levels"

Personal Trainers or *coaches* tend to see their role in terms of managing and motivating student learning. That is, keeping students on track, motivating and inspiring students, "giving students confidence". They are more inclined to focus on skills and strategies to enable students to "achieve their potential".

> "My task is to allow each student to achieve to their full potential in a caring environment"
> "Allow each student to reach their potential and extend beyond that if possible"
> "Build up problem solving skills"
> "To give the students the skills to further their maths as far as they wish to go"
> "As a motivator and an inspirer … encouraging students not to give up"
> "To provide skills students need in terms of mathematics and numeracy for everyday life"
> "Always being positive about the students who work, coaxing those that don't. Trying to keep all levels challenged and interested during teenage years when there are so many things outside school in their agenda"

Guides tend to see their role as leaders of student learning. That is, to identify the paths to student learning, ensure the route is safe, make the journey interesting, set appropriate challenges along the way and be a role model. They are more inclined to intervene to maximise student learning.

> "To provide guidance and an interest for the children to follow into secondary school"
> "I believe I am a guide, but I have to intervene to teach processes and numeracy understanding"
> "To guide the students through their learning & development. Also to ensure that I am making Maths fun with new resources and new learning strategies"
> "Lead by example. If I am passionate and like being challenged then I hope that my students see this as a positive reason to enjoy maths"

Scaffolders tend to see their role as catalysts of student learning. That is, identifying 'where students are at', setting clear goals and actively assisting students to build links from prior knowledge to new knowledge. They are pro-actively interventionist believing that it is their responsibility to directly engage with student learning at key points to help prompt new insights and understanding.

> "Providing experiences that meet students zone of proximal development"
> "To teach students the basics and build on this with problem solving strategies"
> "Explain the concepts, keep the students enthusiastic and/or confident and provide all students [with] the opportunity to succeed"
> "Provide meaningful and relevant activities to reinforce concepts covered in targeted teaching sessions".

What three things would you most like to change in relation to how you teach mathematics and/or numeracy in your classroom?

Teachers provided a fairly long and comprehensive list of things they would like to change. A frequency count of comments by category is included below.

- Teaching resources (32) – mostly about access to non-text based resources, hands-on materials, relevant

software, games and activities to support learning.
- How maths is taught (31) – mostly about non-text based approaches, classroom discussion, relevance, problem solving, reflective writing.
- Time, timetabling issues (25) – mostly concerned with time on task, time for planning and preparation
- How difference is addressed (19) – mostly about grouping, identification of learning needs, how to cater for the range of learning needs.
- Students' attitudes to mathematics, level of student engagement (9) – mostly about improving student interest and motivation to learn.
- Personal attributes, professional relationships (9) – mostly about teams, need for vision, patience, greater knowledge.
- Assessment strategies (7) – mostly about expanding strategies and better information management.
- Curriculum expectations (4) – concerned with the number of outcomes and the crowded curriculum
- Way teaching is organised (4) – mostly about lesson structure, group work, physical facilities, staffing allocation (team teaching)

Please complete as appropriate: "In hindsight, I believe that we would have had more success in improving numeracy outcomes this year if …."

This question also attracted an extensive list of responses. These were categorised and are listed below as strategies. The number of responses pertaining to each strategy is shown in brackets.

- More time was available to plan, meet, share, focus on student learning, cater for individual learning needs, build resources, reflect on practice (32)
- Classes were appropriately grouped (15)
- Students were better prepared for learning (10)
- Teamwork was supported more effectively, there was more sharing (9)
- Specialist staff and/or additional assistance was available (8)
- Greater access to more appropriate teaching resources (8)
- Better planning (6)
- Smaller class sizes (6)
- Targeted professional development, mentoring was provided (6)
- Greater, more effective use was made of an expanded range of teaching strategies, for example, open-ended questions, problem solving, cross-age tutoring (5)
- Greater commitment from school and colleagues(5)
- Access to appropriate rooms, IT resources (4)
- Goals were clearer, there was a better shared understanding of what we were trying to achieve (4)
- Greater understanding of and capacity to identify individual learning needs (3)
- Learning trajectories/pathways were clearer and/or more appropriate (3)
- Greater support from parents, home (3)
- Less interruptions (2)
- Students were given more choice (2)

This question also attracted a number of comments in relation to what was expected of the MYNRP research team, for example, "more support from the MYNRP team", "more funding was available for release to visit other MYNRP schools" and so on. In some cases, these comments were made in relation to other projects. Unfortunately, the MYNRP was never going to be able to provide the level of support that other projects were providing, specifically the *Early Years Numeracy Research Project* and the *Middle Years Research and Development* project. Nonetheless, such comments point to the need to clearly establish the scope and funding parameters of projects like this in an even more 'up-front' manner than was the case on this occasion.

9.3 Observations on Teacher Journals and Teacher Survey.

It is evident from the teacher journals and the surveys that being involved in the project, although sometimes difficult and not as well resourced as some expected, was a professionally rewarding experience for the majority of teachers. Teachers acknowledged that among the best things to come out of the project from their perspective (apart from the improvement in student numeracy performance) was what they learnt about their classroom practice. In particular, that

- carefully chosen, essentially non-text based activities and resources were more likely to accommodate learners at different levels,
- 'rich' assessment tasks and scoring rubrics could be used to identify students' thinking, and
- a structured approach which routinely expected students to explain and justify their thinking was a valuable learning tool for all concerned.

While it is not possible to draw too many conclusions from the journal entries, they do provide a window into the hearts and minds of teachers at the core of the project. These teachers clearly care about their students and are endeavouring to do their best, often in difficult circumstances, in the interests of student understanding, engagement and enjoyment. Their 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 particular, their observations in relation to the importance of teaching students how to read/interpret mathematical texts, apply what they know and communicate their reasoning suggests that considerably more attention needs to be given to this aspect of classroom practice.

The responses to the survey questions provide a clear indication of what is needed to improve student numeracy from the teachers' perspective. In recognising that 'good' mathematics teaching is the starting point, some consideration also needs to be given to what teachers see as impediments to more effective practice. With this in mind, the analysis of the teachers' responses gives rise to the following observations.

- Dealing with difference is a major issue for middle school teachers. While it is clear that many teachers believe that they are able to support different levels of ability in the same class at the same time (Likert scale data) the reality is that many teachers find this a significant challenge in day-to-day practice (Impact procedure).

- 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. While this suggests that there is an urgent need to provide valid and reliable assessment tools, it begs the question of what those tools should be assessing.

- Access to more appropriate resources is high on the list of what teachers identify is needed to improve numeracy outcomes. While this orientation is welcomed as an important recognition that the 'one-size-fits-all' approach of most textbooks is inadequate, it also begs the question of what those activities should be designed to achieve.

- The sheer size and form of what is perceived to be expected of school mathematics is weighing heavily on practice in the middle years. The perceived amount of 'what is expected' leads teachers to push ahead regardless of the consequences for those who 'fall behind'. Highly atomised 'bits of content' lead to highly atomised, topic-based approaches which tend to mask the 'big ideas' and literally 'crowd the curriculum'.

- This contributes to an overwhelming perception that there is insufficient time to "do everything that needs to be done". This is a multi-dimensional issue that needs to be addressed. The amount of time is a function of many factors - the perceived enormity of the task, class size, the frequency and length of class time, interruptions and the pressure of other duties.

- How teachers' perceive their role would appear to be quite critical to the task of improving numeracy outcomes. It is unfortunate that simplistic messages like "I'd rather be a guide on the side than a sage on a stage" have gained some recent currency as they suggest it is entirely the student's responsibility to learn. While learning is a task that can only be performed by the learner, it is the task of teachers to go beyond 'facilitating' and 'guiding' to actively and purposefully scaffold student learning.

- 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.

- Engagement undoubtedly increases the likelihood that learning will occur. However, if the activity is not carefully targeted to the learner's needs, if it does not allow a genuine start to be made, if access or further progress is denied because the student does not have the means to participate in the conversations and texts which the activity generates, then it will not have achieved its purpose.

- Teachers, and students, recognise and value the important role of discourse in building understanding and confidence. Classroom structures and organisations which expect students to work collaboratively, explain their thinking and communicate their findings are more likely to support improved numeracy performance as they expose and model the processes required to apply what is known in a particular context to achieve some purpose. They also serve to value different representations and strategies.

- Expecting all students to be similarly prepared to engage with what teachers believe should be offered in the middle years of schooling is hardly realistic or fair to the students involved. It is not entirely the students' fault that they have poor attitudes or are disengaged, reluctant learners. A culture which attributes blame to others or sees the solution only in terms of ability ghettos is hardly likely to be conducive to improved numeracy outcomes.

- 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 are clearly interested in targeted professional development. Professional development is needed to help teachers deal more courageously and effectively with difference, develop 'rich assessment tasks' and scoring rubrics and better understand the nature of student learning difficulties and how they can be addressed.

The implications of these observations, together with those derived from the student numeracy performance data, the student interviews and the Trial School Action plans will be considered in the following Section.

10. Strategies for Improving Numeracy Learning in the Middle Years of Schooling – Main Findings, Recommendations and Implications for Further Research.

"Change the way it's explained … they need to think about how you understand not how they explain."

(Vincent, Year 9)

The *Middle Years Numeracy Research Project* was undertaken in a structured sample of Victorian primary and secondary schools from late 1999 to December 2000. 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 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 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 is 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.

This section will draw on the data and observations reported in the preceding sections to provide advice to the three sectors that will lead to the development of a coordinated and strategic plan for numeracy improvement. This advice is grounded in the experience of the Trial Schools who helped identify what works and does not work in numeracy teaching particularly in relation to those students who 'fall behind'. This section will provide a summary of major findings and some recommendations for implementation and further research.

10.1 Main Findings

The following advice is 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. It is presented in terms of the research questions posed at the outset to this study.

10.1.1 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 Benchmarks 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 (CSF II, 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.

10.1.2 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 Performance tasks (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.

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. 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 included below although it is regarded as work in progress. Further research is needed to tease out and enrich the levels.

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 solution).*
G	*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.*
F	*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 (ie, evaluates what they are doing for sense and relevance).*

E	***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).***
D	*Beginning to understand and represent simple fraction situations. Generally solves one-step problems involving 3-digit whole numbers, ones and tenths. Describes simple patterns.*
C	*Able to use a number pattern to solve a problem. Monitors cognitive actions and/or goals some of the time (eg, recognises relevant information but unable to use it effectively).*
B	*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, eg, estimates or calculates without regard for meaning or applicability.*
A	*Uses make-all, count-all strategies to solve a simple number pattern problem*

The MYNRP Emergent Numeracy Profile

10.1.3 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 mean score of 53.9%. Given that the majority of mathematical content was representative of CSFII Levels 2 to 4 for a Year 5 to 9 sample that might be expected to be operating at CSFII Levels 3 to 6, the overall performance could be viewed as disappointing. Especially given the emphasis on mathematical problem solving and the use of mathematical tools and procedures in Victorian curriculum framework documents and policies over the last ten to fifteen years. Even if the reference to CSFII is discounted on the basis of the relatively small number of items used, this result at least suggests that there is scope for improvement in terms of the Emergent Numeracy Profile.

The significant 'dip' in numeracy performance between Years 6 and 7 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 (see Section 6 for further details).

The distribution of students across 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.

10.1.4 What aspects of current practice appear to be associated with successful and unsuccessful numeracy performance at this level?

This question referred to the School Surveys collected in the course of Phase 1. The school-wide policies and practices reported by schools with relatively high numeracy performance were used to identify aspects of current practice that appeared to be associated with successful numeracy performance. This data was used to inform the draft advice to Trial Schools (see Section 8). This question will be addressed in more detail in the context of 10.1.9 below.

10.1.5 To what extent can the Design Elements be used to frame the initial advice to Trial Schools and support the action planning process?

The improvement in student numeracy performance achieved by all Trial Schools (significantly so for 18 of the 20 schools), evidences the value of the Design Element approach to the preparation of draft advice and the action planning process. Trial Schools were asked to rate the importance of each of the Hill and Crèvola (1999) design elements to the success of their Action Plan on a scale of 1 to 10. The three most important elements on the basis of the Trial Schools’ experience were *Beliefs and Understandings*, *Professional Learning Teams* and *School and Classroom Organisation*. Although *Structured Classroom Programs* and *Leadership and Coordination* also featured as important elements.

As might be expected there were differences by school type. Primary schools rated *Structured Classroom Programs* as the most important element from their perspective. Secondary Schools rated shared *Beliefs and Understandings* and P-12 schools rated *Professional Learning Teams* and *Monitoring and Assessment* as the most important elements respectively. Secondary and P-12 schools rated *Standards and Targets* significantly higher than Primary schools.

From the perspective of the members of the research team who interacted with and visited the Trial Schools, *Leadership and Coordination* was seen to be crucial to the successful implementation of the action plans and the delivery of improved student numeracy outcomes. Although there were a whole range of factors that hindered the implementation of Trial School Action Plans, without strong, effective and committed professional leadership, schools faced a very significant up-hill battle to engage effectively with the project.

10.1.6 What aspects of the design elements under consideration, that is, structured classroom programs, special assistance, parent participation, and professional development for teachers, appear to be associated with successful and not so successful numeracy performance?

The analysis of the Phase 1 School Surveys suggests that structured classroom programs and professional development were strongly related to successful numeracy performance. However, the evidence concerning the provision of special assistance and the extent of home, school, community partnerships is not so clear. Of more apparent relevance was the role of effective leadership and coordination and professional learning teams. This question will be also discussed in more detail in the context of 10.1.9 below.

10.1.7 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’.

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 ‘furtherest to go’, that is, with lower Phase 1 student numeracy performance scores, generally made the greatest improvements. As might be expected primary schools were more likely to be represented in this group.
- 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. 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.

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.

10.1.8 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.

10.1.9 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 (see Section 8.6 for further information). 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, it would appear likely that further gains in numeracy performance could 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;

10.1.10 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.

10.1.11 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 as a major section in its own right (see 10.2 below).

10.2 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 school-based action planning was a significant factor in the success of the Trial schools it is recommend 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 approaches based on linear sequences of topics 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 Approaches:

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 the organisation of schooling. The work of the MYRAD project 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 Research and Development* project is 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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