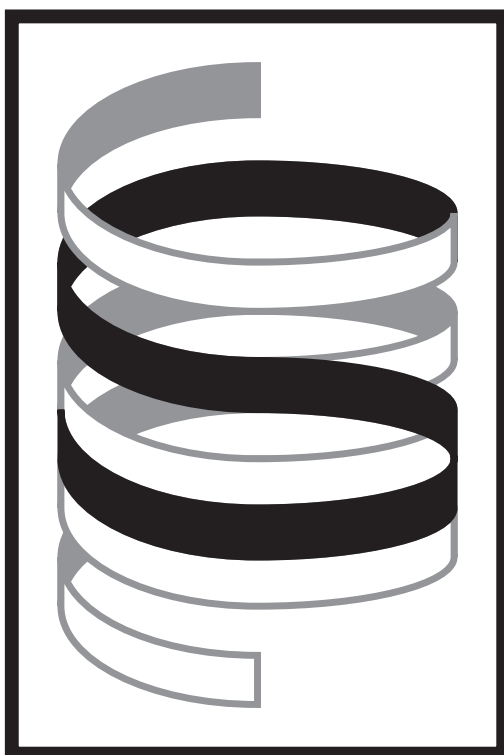


**SPRINGBOARDS**  
*into numeracy*



**PROCEEDINGS OF THE  
NATIONAL NUMERACY CONFERENCE  
4-5 OCTOBER 2002**



PROCEEDINGS

Springboards into Numeracy  
Proceedings of the National Numeracy Conference, 4–5 October 2002

Edited by Will Morony & Peter Brinkworth

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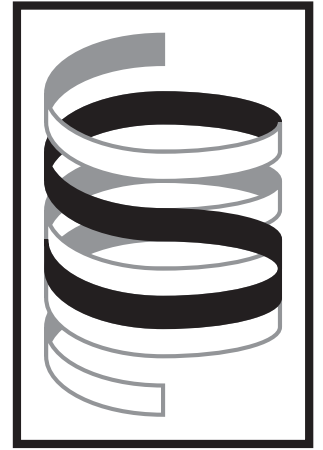
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# Contents



Foreword .....5

## Section 1: Conference summary

## Section 2: Showcases of Practice

Early numeracy  
– Self and peer assessment as a way to improve learning .....44  
*Andrea Hillbrick*

An introduction to critical numeracy .....47  
*Rex Stoessiger*

McPizza... the shape of things to come? .....52  
*Geoff Gillman*

Mental munchies – Putting theory into practice .....64  
*Kristen Moane*  
*Gai McKenzie*

Indigenous Outback Numeracy Project .....70  
*Sue Hendricks*

Numeracy at Bridgewater School .....75  
*Kay Hosking*

Projects as strategies for the Essential Learnings .....82  
*Tamara Chen & Jo Goldfinch*

Catering for diversity – ‘This is Maths and it’s fun!’ .....86  
*Ruth Court & Sally Gill*

Supporting all learners  
– Effective strategies for working with ESL students .....93  
*Vicki Rubino*

Connecting numeracy across the curriculum .....101  
*Jan McCarthy*

Quality experiences equal quality numeracy .....108  
*Liz Irwin*

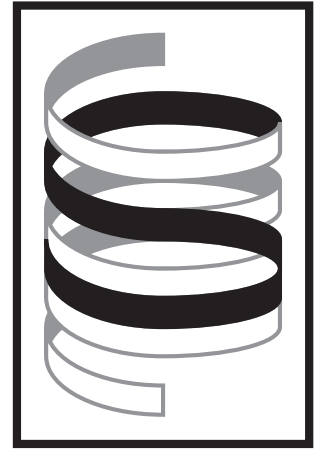
Promoting deep understanding .....111  
*Tracey Muir*

Motivation and enjoyment through numeracy across the curriculum . . . . .	114
<i>Peter Mobey</i>	
Early Years Numeracy Interview – An assessment tool for P–4 . . . . .	119
<i>Heather Norbury</i>	
Supporting numeracy through student-initiated curriculum . . . .	125
<i>Peggy O’Connor &amp; Tara Hall</i>	
Beneath the surface – Understanding the mathematics in children’s minds . . . . .	130
<i>Penny Lane</i>	
Outcomes From INISSS (Improving Numeracy for Indigenous Students in Secondary Schools) . . . . .	134
<i>Greg Allen</i>	
Counting on parents’ support – A vast , untapped resource . . . .	137
<i>Alice Lockrey</i>	
Improving classroom practice – Gateways and barriers . . . . .	140
<i>Christine O’Halloran</i>	

## **Appendices**

Appendix 1: The Commonwealth Numeracy Research and Development Initiative . . . . .	144
<i>Max Stephens &amp; Vicki Steinle</i>	
Appendix 2: Around the States and Territories... according to the education authorities . . . . .	156
Appendix 3: Commonly used acronyms . . . . .	175

# Foreword



Issues around numeracy education have emerged, and are being dealt with in various ways in educational jurisdictions around Australia over the last decade or so. At the Commonwealth level, *Numeracy: A Priority for All* sets out its numeracy policies in the context of its support for the National Literacy and Numeracy Plan. Through their commitment to the Plan, the state and territory education authorities have also undertaken significant work in numeracy education.

As a result, there is a great deal of effort in numeracy education around the country. As part of its role as national ‘honest broker’ in the mathematics/numeracy area, the Australian Association of Mathematics Teachers convened the Springboards for Numeracy in Australian Schools National Numeracy Conference. The AAMT acknowledges and appreciates the support provided by the Department of Education, Science and Training under the Quality Outcomes Programme, and the support of many colleagues in Tasmania.

Attendance at the conference was ‘by invitation’ only. The delegates were teachers, officers of all state and territory education authorities and representatives of national non-government authorities, academics, private consultants, etc. There were approximately one hundred in all, fairly evenly split between the three categories.

The Conference was held in Hobart on 4–5 October 2002. The Conference Summary (Section 1) is the result of conferees’ discussions and input. It is designed to inform the community of professional educators, education authorities, professional groups, schools, universities and individual teachers, academic researchers and teacher educators.

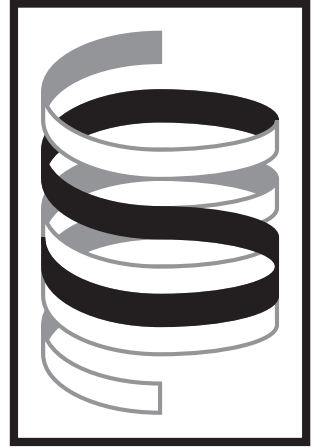
Section 2 of this document consists of the papers prepared and presented by teachers identified as being at the cutting edge of practice in numeracy by their colleagues in various education authorities around the country. The papers are a snapshot of some of the best practice in place in Australian classrooms.

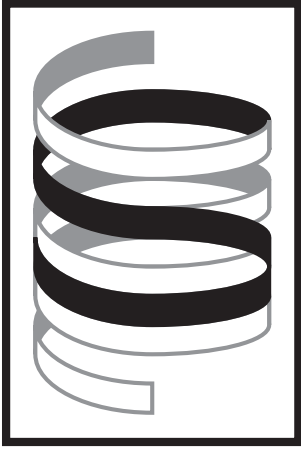
Finally, the Appendices contain information about important current initiatives of the various education authorities.

Will Morony & Peter Brinkworth, February 2003



# Section 1: Conference summary





## Overview of background and process

Conference delegates took part in small group discussions of two kinds. In each case, detailed notes were kept and this Conference Summary is based on those notes.

On the first day of the conference a number of expert numeracy teachers and consultants from all Australian states and territories showcased their current practice in numeracy education in 30 minute presentations – the *Showcases of Practice*. Papers associated with the presentations by the teachers in the showcases can be found in Section 2 (pp. 43–142) of these Conference Proceedings.

Following each Showcase, conference delegates were asked to distil what was presented, with a view to identifying the messages contained therein, as well as their implications for policy and practice. Arising from this process of distillation, it was envisaged that a general view of current (best) practices in numeracy education might emerge, so that issues could be highlighted and suggestions for future actions for improvement might be proposed.

On the second day of the conference, delegates took part in small group discussions around key themes in numeracy education. In the lead up to the conference a number of themes for further discussion were identified. At the end of the first day, conferees had an opportunity to add to and modify the existing suggestions. Thirteen themes were identified and conferees were able to contribute to two of these. Each *Theme Group Discussion* had a ‘leader’ who ensured that the conversation moved along and that detailed notes were kept.

During the preparation of the initial draft, it became apparent that material could be divided into three broad areas within which more specific themes were located. These areas are:

- numeracy, diversity and society;
- numeracy in the school curriculum;
- enhancing numeracy practice.

Under each heading the first section is the synthesis of the discussions of the Showcases of Practice. The relevant Theme Group Discussions follow.

The initial draft was circulated to conferees and their input was used to refine subsequent drafts.

**The Conference Summary does not contain a consensus position reached by the conferees and no support for its contents from them or the organisations they represented is implied or should be inferred.**

Rather, the Summary is nothing more or less than well-informed synthesis and advice to the education and wider communities. Education authorities, professional groups (including the AAMT), schools, universities and individual teachers, academic researchers and teacher educators are invited to consider this Conference Summary and its potential to inform their work.



## Numeracy, diversity and society

### Distilling the showcases

Since it was first articulated as an issue for schools and society, the concept of numeracy has evolved considerably, from a focus on fairly narrow and specific mathematical and numerical skills to a much broader notion of the ability to critically choose and use mathematics in a range of contexts. While current best practice, as showcased at the conference, reflects the broader view, it is clear that the concept will continue to evolve as an increasingly complex and information-rich world places greater demands on the numeracy of its citizens. In response to this, practices in numeracy education will need to evolve too. Despite its evolution, the concept of numeracy still carries a diversity of meanings across society, among students, teachers, schools, administrators, parents and politicians. This has serious implications for the possibility of meaningful dialogue among various stakeholders in education. In addition, the persistence of a narrow view of numeracy (such as the basic skills view) is both worrying and problematic.

It was recognised in discussion that the most progressive and innovative numeracy educators tend to view numeracy in the following terms:

- numerate behaviour requires a sound basis in mathematics;
- being numerate empowers people and allows them to be critical users and developers of mathematics within specific contexts;
- there are many kinds and levels of numeracy, and these reflect the diversity of learners and the individuality of their learning, work and play as well as the actual context of its application;
- being numerate is as much about attitudes to using mathematics in context (e.g. confidence) as about the critical ability to do so;
- numeracy is the business of all teachers, parents and the community, and all areas and levels of curriculum.

Effective numeracy development takes account of all these aspects.

A major concern for numeracy educators is that of the distinction and relationship between the terms ‘mathematics’ and ‘numeracy’. A diversity of views prevails; witness the use of statements such as ‘mathematics = numeracy’ and ‘mathematics is the springboard for numeracy’, and terms such as ‘quantitative literacy’ and ‘mathematical literacy’ in the wider community. The view that is taken within a school has important implications for core areas of its work:

- the curriculum (Where are mathematical skills and applications learned? What is the appropriate balance between integration and differentiation of mathematics within the curriculum?);
- teaching (Whose responsibility is it to look after numeracy within and beyond the mathematics curriculum?); and
- the professional development and preparation of teachers of numeracy/mathematics (How do you best support teachers for their roles in mathematics learning and numeracy development?).

It is important too that, for informed discussion and debate, participants are prepared to articulate what they mean by the terms ‘mathematics’ and ‘numeracy’, and how they relate to each other both conceptually and in practice. How the terms are defined is also relevant to their ownership within the school curriculum.

Catering for the diversity of numeracies and learners is an important consideration for those involved in numeracy education. Diversity in the classroom can be viewed as a problem or, much more positively, as both a

challenge and an opportunity to enrich, empower and enthuse all students. Children with special needs, in multicultural settings and in Indigenous communities afford teachers with opportunities to consider the individual needs of all learners. Successfully catering for diversity involves responding to the needs of learners by embedding their learning experiences in meaningful and culturally relevant environments both within and beyond the school curriculum. Approaches for achieving this may include integration of units of work across various learning areas, open-ended activities, use of out-of-school environments, relating activities to real problems in real contexts, and giving students choice within defined settings. Diversity of needs often requires a diversity of responses that go beyond the constraints of the prescribed curriculum in order to take advantage of opportunistic ‘numeracy moments’.

## Numeracy and mathematics

### Now

The actual topic of this Theme Group was the question

What is the effect on the Mathematics Key Learning Area in the light of the emphasis on numeracy?

In fact, questions relating to the distinctions between mathematics and numeracy arose throughout the conference, particularly during small group discussions on just about any topic. These discussions are reported in context elsewhere in this summary.

It is essentially an issue of definition that, wherever it comes up, boils down to:

Are we talking about maths here, or is it numeracy?

Current curriculum structures in all Australian jurisdictions give fairly clear indications that ideas, techniques and ways of thinking and doing that are part of the discipline we call mathematics will be taught and learnt in our schools. As outlined elsewhere in this Conference Summary (*Numeracy across the curriculum* section on pp. 18–23), students are also helped to become numerate (able to use their mathematics) in different contexts through a wide range of experiences outside of their learning of mathematics. In other words, at times the purposes of teachers and students will be about mathematics; if a label is needed it should be ‘mathematics’. At other times the purposes will be about using some mathematics to do something else (to learn in another discipline; in the context of a work-related, leisure-related or civic pursuit); if a label is needed it should be ‘numeracy’.

The capacity to resolve the definitional issue is made more problematic again in the light of the use of other terms such as ‘mathematical literacy’, ‘quantitative literacy’, ‘matheracy’, etc., in discussions that are essentially about this issue<sup>1</sup>.

### Issues

The current sense of a lack of clarity is evident in a range of ways — the following are all issues that need to be addressed.

- The looseness of language use by politicians, policy-makers, teachers, schools and the public, where often the terms ‘numeracy’ and ‘mathe-

1. See, for example: Paulos, J. A. (1988). *Innumeracy: Mathematical Illiteracy and Its Consequences*. New York: Vintage Books. Steen, L. A. (Ed.) (2001). *Mathematics and Democracy: The Case for Quantitative Literacy*. Washington: National Council on Education and the Disciplines. Developments in thinking and practice in Australia can be informed by international perspectives, but directions and solutions will be unique to this country.

matics’ seem to be used interchangeably. Indeed, in some cases the term ‘numeracy’ is linked with the Number strand of the mathematics curriculum and computational skills<sup>2</sup>.

- The tendency for numeracy to be equated with ‘low level mathematics’: this is clearly erroneous if one considers the expectations for the numeracy of engineers in their professional work — their work is hardly associated with low level mathematics.
- The expansive descriptions of numeracy compared with the ‘working’ definition that many infer from the National Benchmarks and associated state-wide tests<sup>3</sup> — these focus almost exclusively on mathematical underpinnings of numeracy. In other words the instruments and outcomes that are called numeracy in this context are actually about mathematics.

There is nervousness among secondary mathematics teachers (‘Is this a way of undermining emphasis on and care for mathematics?’) and among secondary teachers of subjects other than mathematics (‘Does this mean I have to become a maths teacher as well?’ or, worse, ‘Is this a takeover bid from the maths people?’). In other words, clarity is needed to reassure people and help them take constructive action in line with their responsibilities.

### Future

Clearly, mathematics and numeracy are not distinct; all of the systemic advice talks about numeracy being about ‘using’ mathematical ways of thinking and doing. Developing common views is important for understanding responsibilities and emphases in action. Professional discussions that seek to tease out differences and interrelationships are valuable for teachers to begin to think about the issues.

A range of key people needs to actively engage in continuing and leading discussions and debates around the differences and interrelationships. These include teachers, policy officers and others from education authorities, researchers, consultants and teacher educators. It may be politically expedient for some to reach simplistic conclusions (e.g. that mathematics and numeracy are synonymous in practice in the school setting) but these are as unhelpful as they are untenable.

However, concern about definitional issues must not lead to a deflection from teachers and schools implementing effective numeracy programs that are based on a shared working view of numeracy. It may be that these issues remain problematic. Energy directed towards resolving them should be proportional to the likely gains in terms of students’ learning that will accrue as a result of their resolution.

Further attention to the emerging focus on the ‘critical’ aspects of numeracy will help boost the profile and importance of numeracy. These aspects go beyond viewing numeracy as being about operating in the world to achieve personal aims, to encompass the capacity to analyse and critique others’ behaviours and the resultant power structures.

## Indigenous numeracy

### Now

At the outset it needs to be clearly stated that reducing the gap between the numeracy/mathematics performance of Indigenous students and that of their non-Indigenous peers<sup>4</sup> should be a matter of urgent priority for all those who care about numeracy as a component in creating fairness in

2. This could be seen as akin to equating literacy with spelling — a narrow and unhelpful usage.
3. It should be noted that the Benchmarks do not claim ‘to represent the whole of numeracy learning... they represent important and essential elements of numeracy’. (Curriculum Corporation (2000). *Numeracy Benchmarks Years 3, 5 & 7*. Melbourne: Author.)

4. As measured, for example, by cohort testing in Australia and international student assessment studies such as the Third International Mathematics and Science Study (TIMSS) and the Programme of International Student Assessment (PISA).

Australian society and opportunity for all our young people.

This differential in performance is not uniform across or within communities, however. Indigenous students are by no means a homogeneous group. Those discussing this theme identified two very important characteristics that range across full ‘spectra’ for Australia’s Indigenous students:

- their language ranges from English as a foreign or second (or third or...) language through Aboriginal English to Standard Australian English;
- their geographical contexts range from urban, through rural to remote (and within these categories there is further diversity).

Conference participants involved in these discussions did not have sufficient detailed knowledge of work in Indigenous numeracy across the country to be able to create a complete picture. Some initiatives about which information was shared include:

- projects in a number of New South Wales schools to develop processes for consulting and engaging Aboriginal communities in the development of units of work that have a local Aboriginal perspective, resulting in high levels of local ownership and commitment;
- a component of *Getting It Right*, a system wide project in Western Australia that is directed towards Indigenous learners;
- the *Count Me In Too: Indigenous* project is providing professional development tailored for teachers of Indigenous students and Aboriginal Education Assistants in New South Wales and the Australian Capital Territory;
- a range of initiatives to provide professional development in numeracy for Indigenous learners for teachers and para-professionals in New South Wales and the Northern Territory;
- the Northern Territory Literacy and Numeracy Strategy and the Northern Territory Literacy and Numeracy team have extensive and explicit focus on developing the numeracy of Indigenous learners as part of targeting support to areas of greatest need.

In addition there are other important initiatives around the country. The incompleteness of this outline serves to emphasise a critical factor that can be observed in many jurisdictions: efforts at addressing issues in Indigenous numeracy education are largely located in Aboriginal or Indigenous education sections or branches of departments that seem not to be closely associated with the ‘mainstream’ systemic personnel and efforts in numeracy and mathematics. By and large these latter were the people representing systems at the conference.

There are other factors that are important to note. First is that there has been a substantial imbalance in the number and scope of projects and initiatives in Indigenous numeracy when compared with those focussing on literacy. For example, this can be traced, at least, to the *Indigenous Education Strategic Initiatives Programme – Strategic Results Projects* (IESIP SRP) of the late 1990s. Of the more than eighty highly informative and useful projects in this project, only a few dealt seriously with numeracy development<sup>5</sup>.

There is a relatively limited amount of research in Indigenous mathematics and numeracy education. While a few researchers are committed and involved in the area and do good work, the depth and breadth of the issues suggests that a much increased research effort is required. A factor in this is the legitimate concern of both Indigenous and non-Indigenous peoples in relation to matters of access, intellectual property and mutual respect. Negotiating these sensitive issues to the satisfaction of all often requires

5. See McRae, D. et al. (2000). *What works? Explorations in improving outcomes for Indigenous students*. Canberra: Australian Curriculum Studies Association & National Curriculum Services.

substantial effort. That these issues can be satisfactorily resolved is evidenced by the fact that a number of researchers continue to work in the area.

A final factor is the existence of the Commonwealth's National Indigenous English Literacy and Numeracy Strategy (NIELNS). This is a major program that provides a great opportunity for furthering work on improving Indigenous students' numeracy development. In fact, several of the initiatives above are part of NIELNS.

### Issues

Mainstream workers<sup>6</sup> in numeracy and mathematics education (officers of education authorities, academic researchers, leaders of curriculum and professional development, professional associations and teachers) are not, on the whole, sufficiently engaged with the issues around Indigenous students' numeracy development.

There appears to be a lack of co-ordination of efforts and sharing of information, both between and within states and territories, and between the different sections of the state and territory departments. This results in ignorance of previous work that could be built upon and current opportunities for collaboration.

The apparent overall imbalance between effort (funding, research, projects etc.) on Indigenous numeracy, in comparison with that on literacy, may be changing somewhat, but it remains a major issue. In many respects, making progress in the area is dependent on substantially increasing effort on Indigenous numeracy initiatives, given the current and historical differential.

Educators' understanding of characteristics identified above and the implications for the learning of Indigenous students of where they 'are' on the related spectra create profound issues for educational planners, practitioners and researchers. Addressing this in ways that incorporate Indigenous knowledge would create a solid basis for actions.

The diversity of Indigenous learners in relation to the spectra as well as their particular cultural identity often creates a need for empowerment at the local level, and achieving this is a major issue, especially in relation to mathematics/numeracy. This diversity and the need for local empowerment and ownership means that the details of successful approaches most often cannot be readily transferred to other contexts.

Another key issue is that of mobility of both students and teachers. Many<sup>7</sup> Indigenous students are described as transient in that they move from school to school. In addition, absenteeism has been identified as a major problem for some Indigenous learners. These factors make ensuring steady progress in numeracy a challenge for students, teachers and schools. In addition, where there is a relatively high turnover of staff — and this can be a characteristic of some schools with large cohorts of Indigenous students due to remote location, for example — it is difficult for schools to maintain continuity in teaching. In particular, gains made within a particular initiative may be lost to the school when the teacher(s) involved move on.

### Future

A clear picture (map) of current initiatives is needed. This could build on the project currently being conducted by Deakin University and funded by the Commonwealth Department of Education, Science and Training, *A Mapping, Review and Analysis of Australian Research in Numeracy at the Primary School Level* (see the paper by Stephens & Steinle on pp. 144–155).

6. Those whose duties do not expressly emphasise a focus on Indigenous students' numeracy development.

7. But certainly not all — perhaps this is another example of a characteristic 'spectrum'.

There needs to be a sustained period of ‘positive discrimination’ in favour of numeracy initiatives for Indigenous learners where funding is targeted at literacy and numeracy.

Research needs to focus on:

- better understanding of the implications for numeracy development of the diversity of Indigenous learners in terms of geographical context, languages and their cultural heritage and practices;
- finding out what Indigenous students know and can do;
- identifying ways of building on what they know and can do;
- understanding the most effective strategies — what they are and why they work.

Other actions within the specific context of mathematics learning and numeracy development should focus on efforts to create curriculum that is truly relevant for Indigenous students’ future lives<sup>8</sup>. These include:

8. Clearly this is an important strategy in addressing the issue of absenteeism for many Indigenous students.

- undertaking initiatives that focus on activating community engagement, building partnerships (school–community; school–school; school–system; system–system) in order to achieve shared vision, ownership and responsibility;
- investing in the knowledge and capabilities of para-professionals to support Indigenous students’ numeracy development;
- developing resources at the local level, either from the ‘ground up’ or by modifying successful ideas from other communities.

## Language

### Now

There has been a considerable acknowledgment of issues around language and mathematics learning in the past twenty or more years, particularly in curriculum documentation. It could be argued that in most classrooms, practical attention to the issues has been relatively superficial — mathematical discourse is built on an understanding of much more than a vocabulary of mathematical terms.

Recent times have also seen many educators looking carefully at literacy. As a result, many teachers appear to be much more careful in their use of language in literacy than is generally the case in the numeracy/mathematics area. This focus on literacy has also led to the development of ways of thinking about language, literacy and learning. Applying this knowledge base and means of analysis to mathematics and numeracy in the school setting is seen as an approach that could serve to inform practice significantly.

Many students are found to be inarticulate (orally and in writing) about their learning in mathematics/numeracy, what they can do and the social connections of their learning. In most cases, this may be the result of not having practice at doing so — this kind of mathematical communication seems to be undervalued in many classrooms. It was suggested that in mathematics, many teachers have a ‘conversation in their head’ about the mathematics in ways that does not characterise other subjects where the discussion is much more open and public.

### Issues

Several issues relating to the communication of and about mathematical ideas were identified by members of this Theme Group:

There is clarity in the community about the substantial negative consequences of illiteracy in current society: people are clear about the kinds of

disadvantages that are associated with an individual being ‘illiterate’. There does not seem to be the same clarity in relation to innumeracy; in fact a disturbingly high percentage of people seem to be happy to claim to be ‘no good at maths’.

Mathematics provides a ‘professional’ even ‘technical’ language that is required for entry into mathematical conversations. Access to the conversations is difficult without the appropriate language — conversations appear abbreviated and secret<sup>9</sup>. Knowledge and fluency with this language is derived from students’ experiences and the examples they observe. This underlines the associated issue of the importance of students making meaning from the activities with which they engage. Mathematical and other language is both a vehicle for and one of the outcomes of this meaning making.

9. This can be as true for teachers as it is for students.

Assumptions about students’ understanding of terms can go untested in the classroom, and this can lead to students being left behind.

The use of language in the community and the home, and the students’ own colloquial use, can be different from ways the same language is used in the (sometimes technical) discourse of mathematics at school. This can make it difficult to share understandings about mathematics activities and learning in schools with the other communities.

Mathematical language includes its own shorthand using symbols. Written mathematics is concise and precise. Contrast this with the high level of speaking and listening in the ‘authentic’ text of the classroom — the conversations, questions, discussions and arguments about mathematics. It is through these conversations (i.e. orally) that students connect with other students and the world outside.

Teaching that focusses on the symbols and shorthand of mathematics without building in richer conversations about them and the mathematics itself can clearly limit students’ deep understanding.

## Future

The practice of ‘immersing’ students in the use of appropriate, accurate, technical mathematics language in the classroom should be emphasised in relation to mathematics and numeracy. This draws on immersion strategies in contemporary approaches to literacy development and might include relatively simple classroom strategies such as posters, use of classroom mathematics dictionaries and linking numeracy concepts and terms into literacy practices (e.g. spelling).

Inherent in efforts to ensure more effective attention to the language issues in students’ mathematics learning and numeracy development are the knowledge and skills of the teacher. Teachers’ confidence with the mathematics they are teaching depends on, among other things, good control of the language issues and the ability to have mathematical conversations with their students. Where teachers lack this confidence, they need access to programs that support professional learning in these areas.

The case for greater and more comprehensive attention to issues in numeracy education is likely to be strengthened by clear identification of the consequences to individuals of innumeracy in contemporary society.

A range of applied research investigations are required:

- Further work to identify the nature of classroom and other mathematical conversations, with the ultimate aim of enabling and promoting ‘good’ conversations in all classrooms.
- Mapping how classroom conversations can, do and should develop and change over time, as students mature.
- A particular focus on the wide range of informal mathematical

10. In primary schools in particular, it may be that the ways teachers model language in mathematics is substantively different from the ways they do this in literacy.

language used in classrooms to describe and understand their experiences. In particular on the assumptions made about common terms, understandings and the implications of these being unfounded; and on the inconsistencies in the ways teachers model mathematical language<sup>10</sup>.

- Explore approaches of other cultures to the symbols and shorthand of mathematics as a means of reinforcing conventional meanings and usages.
- Investigating numeracy as practised in the local community, particularly in terms of the language used.
- Finding ways to demystify mathematical language in communicating with the school community so that there is a greater understanding of what the school is trying to achieve (and incidentally perhaps raising the level of discourse among members of the community).

## Diversity

### Now

Current usage of the term ‘catering for diversity’ tends to carry negative connotations: it is seen as ‘an issue to deal with’ rather than providing an opportunity for enriching students’ learning experiences. The group discussing this theme was keen to promote the view of diversity as an opportunity for teachers in the numeracy/mathematics area.

### Issues

‘Labelling’ students (as ‘ESL’<sup>11</sup> or ‘hearing-impaired’, for example) can alert teachers to potential issues, but can have a negative effect by limiting their vision of the individual and their particular learning style and needs.

The concept that there is a ‘package’ for dealing with diversity in the mathematics classroom is seriously flawed. Almost inevitably several solutions or ways forward will be possible in response to particular teaching challenges that are derived from diversity in the classroom.

The assessments in the mathematics/numeracy area that receive the most publicity and have highest status in the wider community are the population tests of ‘numeracy’ at Years 3, 5, 7 (and 9). The challenge for teachers and schools is to maintain their efforts to meet students’ diverse needs in the face of broad-scale external assessment that cannot be sensitive to this diversity.

Respect for diversity in learners’ informal mathematics and commitment to building on their informal and diverse ways of thinking about mathematics needs to be matched with providing access to mainstream mathematics (the ‘valued mathematical thinking’) as well. Providing access to the mainstream does not imply devaluing diversity.

Since diversity among learners in mathematics is located in the classroom, non-teaching researchers need to work with teachers as co-researchers in order to investigate issues in diversity (below) — diversity cannot be divorced from the social context of the classroom.

### Future

There needs to be clear acceptance that all students can learn mathematics and become powerfully numerate. This should be a commitment and a shared responsibility of all members of the profession, and a guiding principle for their daily work.

11. English as a second language.



A range of strategies should be used to support teachers and other researchers to explore diversity in the classroom. Many teachers need help to ‘see’ students’ thinking that is different from theirs (they tend only to see students’ thinking that matches theirs). Hence the sharing of images and stories of inclusivity in action (i.e. in real classrooms) is likely to be most effective. These cannot be ‘perfect’ or universally transferable, but will assist teachers to design the approaches for their own unique classroom.

There are some simple classroom management strategies that can assist teachers to ensure equity in terms of the inclusion of all students in the classroom. Being alert to the issues can result in teachers monitoring and modifying their patterns of contact and interaction with students — the display of students’ work, for example. There is a continuing need for professional learning programs — for para-professionals who work with students as part of their learning programs, as well as teachers — to maximise the capacity of educators to meet diverse learning needs.

## Numeracy enacted in the school curriculum

### Distilling the showcases

There is a strong body of opinion that effective organisation for numeracy development within schools goes beyond the mathematics curriculum, across other learning areas and makes links with the world outside. This is a consequence of the broadening of the concept of numeracy in schools, and has been supported by the increasing emphasis in systemic curriculum frameworks on essential learnings across the curriculum. How this organisation is expressed tends to be different in primary and secondary schools because of the differing patterns of curriculum and infrastructure, and of the changing views that students have of themselves as numerate people and the relevance of numeracy to their lives. The ways in which schools cater for numeracy across the curriculum are also influenced by the ways in which they resolve the connections between mathematics and numeracy, and how they express these in the curriculum. Catering for numeracy across the curriculum tends to be seen to be easier at the primary level<sup>12</sup>.

12. This is not to claim that it is actually done widely or well, however.

The most critical factor in successful enactment of numeracy development in schools, however, is the quality of their teachers. The showcases of practice demonstrated that the best practitioners are positive, passionate and committed teachers who tend to share a number of common characteristics:

- **Planning**

They have often participated in action research or curriculum research projects that have made them aware of new possibilities and other research findings. They plan programs on the basis of clear goals; an intimate understanding of their students' existing knowledge, needs and environment; a sensitivity and an openness to new situations incorporating mathematics or numeracy related activities, often invisibly embedded in daily life; a willingness to go beyond the normal bounds of the curriculum and a preparedness to make links with parents and the wider community. They are concerned with developing understandings, attitudes and values as much as procedural knowledge and skills. They plan tasks that are embedded in the real world and are both meaningful and stimulating to students.

- **Teaching and learning**

They choose a variety of approaches that reflect a student-centred approach to their teaching<sup>13</sup>. They emphasise the use of concrete activities, visual representation and both written and oral language as a means of exploring mathematical ideas and engaging with rich tasks. They encourage the use of consistent and accurate language, provide opportunities for students to talk about, share and reflect on their thinking, and they listen to and value their students. They select rich multiple-entry tasks, that challenge and engage students, and that provide students with positive, successful experiences. They encourage active and purposeful activities within a well-structured and supportive environment in which students make choices, take risks and assume shared responsibility for learning. They tolerate a certain amount of noise, mess and uncertainty in the classroom in recognition of the fact that learning is not usually tidy, linear or private.

13. For many, this is articulated as a constructivist philosophy.

- **Assessment**

They accept that assessment is a major influence on the curriculum and thus use a variety of approaches for a variety of purposes to reflect the breadth of their views of what is important in the curriculum. Assessment is used not only to identify individual students' knowledge, but also to provide a basis for modifying the curriculum, informing their practice and trying new approaches to teaching and learning. Their assessment tasks stress the practical and contextual aspects of numeracy, although they acknowledge a role for traditional tests<sup>14</sup>. They prefer to use rich assessment tasks that create opportunities for students to solve problems in their own way.

State of the art practitioners are willing to challenge old orthodoxies and are enthusiastic about melding 'old' practices with the 'new' in order to develop new and exciting approaches.

14. Pencil and paper and computer-delivered tests.

## Numeracy across the curriculum

### Now

As part of the process of gathering material to inform the discussions at the Springboards into Numeracy Conference, representatives of each of the state and territory education authorities were asked to present a 'snapshot' of policy and programs relating to numeracy education — material that provides an indication of the existing state of play. This information was published in the Conference Handbook and is available on the AAMT website (<http://www.aamt.edu.au/springboards>).

Although expressed in different ways, each jurisdiction adopts a view that numeracy is a cross-curricular concern. The following statements are taken from submissions made to the Conference.

#### *Northern Territory*

While numeracy development pathways are expressed within the NTCF's Mathematics Learning Area component, numeracy is fundamental to learning across the eight Learning Areas and EsseNTial Learnings, and hence is the responsibility of all educators. Opportunities to develop numeracy are identified within all other components of the NTCF to support all educators in contributing to the numeracy development of all learners.

#### *South Australia*

In summary, the SACSA Framework identifies numeracy development

- in all learning areas, across all curriculum bands
- throughout the Essential Learnings, in particular, through communication
- as being underpinned by learning in mathematics
- as connected with, and driven by, the increasing use of information and communication technology (ICT).

#### *Australian Capital Territory*

[A] broader and arguably more appropriate view of numeracy than has commonly been the case both historically and internationally. In the context of schooling this view of numeracy has been described as numeracy across the curriculum...

In planning for numeracy development in ACT government schools we recognise that doing mathematics well and numeracy across the curriculum

are not the same thing, but both are important for all students.

#### *Western Australia*

The Western Australian Curriculum Framework describes numerate behaviour as the disposition and competence to use mathematics in the service of endeavours other than mathematics... learning areas other than mathematics contribute to the enhancement of students' numeracy:

- providing rich contexts in which students can use their mathematics;
- expecting students to use their mathematics in other learning areas; and
- maintaining common and challenging standards.

#### *Tasmania*

[T]he Department of Education has re-examined curriculum and developed a new view of future curriculum provision. The Essential Learnings framework highlights the importance of students becoming numerate<sup>15</sup> and provides Tasmanian educators with further impetus to rethink approaches to curriculum, assessment and teaching and provides a framework for teachers to explore new and broader views of numeracy.

#### *Queensland*

[A] generic categorisation of numeracy that is independent of any particular key learning area – to highlight that numeracy is NOT just part of mathematics, and that all teachers of all parts of the curriculum have a responsibility to contribute to students' numeracy.

#### *New South Wales*

Numeracy is a fundamental component of learning across all areas of the curriculum. The development and enhancement of students' numeracy skills and understanding is the responsibility of teachers across different learning areas that make specific demands on student numeracy.

#### *Victoria*

Early years numeracy trainers, school-based numeracy coordinators and classroom teachers explore the definition of, and relationship between numeracy and mathematics as part of professional development in the area of early numeracy. Middle years numeracy trainers, school-based coordinators and classroom teachers explore this issue as part of the mathematics curriculum and other Key Learning Areas as identified in the *Curriculum and Standards Framework* document.

Many of these statements include a distinction between numeracy development and students' learning within the mathematics curriculum – an integral component of developing numeracy. This issue is addressed separately elsewhere, but it is of interest that the unequivocal policy line about Numeracy Across the Curriculum is not reflected as a major priority in the programs of some of the education authorities as outlined in the handbook. Few of the programs outlined appear to have this as an overt focus. Consequently it is little wonder that the policy line is apparently having so little impact on what schools and teachers do.

15. The Essential Learnings framework does not identify traditional curriculum or learning areas. It provides, among other things, 'values and purposes, a description of the learning that is recognised as essential, and a set of principles to guide educational practice' and is, in itself, 'cross-curricular'. 'Being numerate' is one of the 'Communicating' cluster of essential learnings.

## Issues

### *Policy into practice*

The policy positions of the education authorities represent, and often explicitly recognise that there has been an evolution in the thinking and values behind contemporary statements about numeracy across the curriculum. Such a change inevitably causes a mismatch between what is expected of teachers and schools (in this case to address numeracy across the curriculum) and the current views, knowledge and expertise of many of them, and the prevailing culture in many schools. When one considers the effort and time devoted to ‘literacy across the curriculum’ — an arguably more amenable issue in the eyes of many teachers, given that the well-documented ‘maths phobia’ among many primary teachers and non-mathematics secondary teachers does not have an equivalent in literacy — this issue looms large indeed.

Further, there appears to be a view among the public that impacts on the uptake of that policy and the seriousness with which it is treated, namely, that ‘society will accept innumeracy but not illiteracy’. In other words, some conference participants expressed a concern that there will not be sufficient public ‘will’ to drive meaningful efforts to address numeracy across the curriculum.<sup>16</sup>

### *Teachers’ orientations, knowledge and skills*

The different contexts of teaching in primary and secondary schools create different issues (and opportunities) in relation to Numeracy Across the Curriculum. Primary teachers have easily accessible opportunities to attend to Numeracy Across the Curriculum, given that they generally teach their class in all (or at least most) of the learning areas — and are aware of students’ learning in mathematics. The question is whether they can see and take those opportunities.

The specialisation of teachers in secondary schools means that it falls to teachers of other subjects — in the absence of knowledge of either the general mathematics curriculum or individual students’ mathematics learning — to use their knowledge within that specialisation to address students’ numeracy development. Again the question is whether they can see and take the opportunities. What is the view of what non-mathematics secondary teachers, and of primary teachers when it is not explicitly ‘mathematics time’, in terms of their knowledge and behaviours in relation to their roles in students’ numeracy development? Of course the same question can and should be asked about primary teachers when it is explicitly ‘mathematics time’, and of secondary mathematics teachers.

### *Literacy and numeracy*

Historically, literacy education has had longer term and greater levels of support for efforts that can be described as ‘literacy across the curriculum’. On the positive side, this creates a range of insights and strategies that can be useful in relation to numeracy, although simply adopting literacy-based models and thinking without critical analysis is not likely to be productive.

Conference participants expressed concern that numeracy has been the ‘poor relation’ but sensed that this may be changing. Any notion that there is some implied or actual hierarchy when the terms literacy and numeracy are used in tandem should be resisted as having no justification, and in no-one’s interests.

16. In this context it may be reasonable to include many teachers and other educators as ‘members of the public’ in terms of the values they appear to enact.

*Messages that appear out of tune with the policy*

A set of issues that mitigate against the policy stance on numeracy across the curriculum being carefully implemented by teachers and schools is related to assessment. The state-wide testing that relates to benchmarking is essentially about mathematics, yet these are called tests of ‘numeracy’<sup>17</sup>. Moreover, they are the only publicly and politically valued measure of achievement. The message this sends to students, teachers, parents and the community is that numeracy across the curriculum is not valued since it is not assessed. The lack of robust and defensible measures of achievement in numeracy in its broader, cross-curricular sense — or indeed the relatively small level of serious effort to produce such instruments — inevitably undermines the policy intention to treat numeracy as a cross-curricular concern.<sup>18</sup>

17. It was noted that the Student Numeracy Assessment Program (SNAP) test for Year 7 in NSW does try to focus more on cross-curricular numeracy.

18. It may be that practices in the Vocational Education and Training sector assessment of ‘competencies’ in action, rather than discipline-bound assessments can provide some insights into approaches to assessing numeracy across the curriculum.

The imbalance of program emphases between efforts to enhance the teaching and learning of the ‘mathematical underpinnings’ of numeracy and those directed towards numeracy across the curriculum has already been noted. It would seem that a realignment of priorities of education systems to conduct programs designed to address Numeracy Across the Curriculum is urgently needed.

*Teaching mathematics well*

Any argument for increased emphasis on numeracy across the curriculum should not be taken as suggesting that there should be any decrease in the emphasis on efforts to ensure that mathematics is taught and learnt well. On the contrary, effective use of numeracy across the curriculum requires heightened levels of understanding and fluency with mathematics that can only come from — and is indeed a part of — a good quality mathematics education.

**Future**

It follows from the first two issues outlined above that a concerted and sustained research and development program is required to address a myriad of questions including:

- Identifying and highlighting the consequences of innumeracy for adults in society.
- How can all teachers be drawn into enthusiasm for and commitment to numeracy across the curriculum, given that they need to see beyond school into contemporary numeracy practices in the workplace and home?
- What can we expect of teachers in terms of numeracy across the curriculum (orientations, knowledge, skills)? In the secondary setting it is neither feasible nor would it be desirable to expect all teachers to be ‘experts’ in mathematics teaching. They can, however, be reasonably expected to have or develop expertise in the numeracy demands and opportunities in their curriculum area(s).
- What forms of collaboration and structures will create conditions for success in addressing numeracy across the curriculum in both primary and secondary schools?
- Can (and how can) numeracy across the curriculum be effectively assessed and reported?
- Shifting community views and values. Many parents see mathematics/numeracy as ‘doing sums’ and ‘getting the right answer’, yet this is a long way from what their children need to experience in their learning.

Related to the numeracy/mathematics discussions, there needs to be new kinds of conversations around these words that help distinguish their nature and the relationships between them. These discussions need to be helpful to

teachers and the community and create succinct and clear statements for all to work with.

Other strategies suggested included:

- revisit and update the *AAMT Policy on Numeracy Education in Schools* (1997);
- the emphasis on numeracy across the curriculum needs to be reflected in pre-service teacher education; and
- learn from the experience of other cross-curricular initiatives such as the Studies of Asia as well as the implementation of literacy programs.

## Contemporary computation

### Now

While the relationship between mathematics and numeracy is contestable, it is generally held that numeracy depends on sound mathematics and effective mathematical procedures. Thus the choice of both mathematical content and pedagogy is an important concern for schools. A good grounding in computation, measurement and visualisation (space/geometry) forms the foundation for the development of numeracy. Since computation is arguably the most basic core area of mathematics underlying numeracy and is the subject of a Commonwealth research project in Tasmania (Developing Computation), it was decided that it would be discussed as a theme in its own right.

Recent and current syllabus documents are forward looking in their recommendations. They encourage the development of ‘mental computation through strategies’ and support the use of calculators. They advocate the development of secure but not necessarily standard written algorithms. Current thinking amongst mathematics educators in systems and universities also supports this movement.

However the reality in schools and classrooms is often very different. Some participants actually reported a growing emphasis on speed recall of number facts and the testing of them. There still appears to be very little effective use of calculators. Students, teachers and the community still often see calculators as ‘cheating’. The emphasis placed on formal written computations still appears to be as great as ever.

Where there is leadership and financial support for projects, whether from state/territory education authorities or Commonwealth funding, there is evidence of much more progress. However this progress is largely confined to the earlier grades and, as yet, rarely impinges on the teaching of traditional formal written algorithms. In general there is a growing awareness of the value of sense-making and of more research-based approaches to the development of children’s computation; but the development of structured programs to implement these recommendations is lacking.

### Issues

Participants in the discussion group agreed about the following set of principles as a basis for developing computation:

- computation should be based on number sense;
- mental computation is important and should be based on deep conceptual understanding;
- the development of mental computation through strategies, from initial schooling onwards, is central to the development of computational skills;

- a reasonable goal for almost all children is to be able to deal mentally with addition and subtraction of two-digit numbers and multiplication and division of two by one digit numbers;
- there is value in developing non-standard written methods but it is not currently clear how best to do this;
- the teaching of standard written algorithms should certainly be delayed (in comparison with traditional practice) and may eventually be seen as unnecessary;
- all children should have access to calculators from K–Year 12 and should develop efficient calculator skills — calculators should be used in the classroom as instructional aids as well as computational tools;
- the basic addition and multiplication facts/relationships are important and children should develop near-instant recall of them — however memorisation is not enough: children need to develop strategies for efficiently reconstructing forgotten facts.

Issues arising from these principles include the following:

- To what extent are these principles accepted and expressed in practice in schools?
- Knowledge and awareness of them is insufficient to guarantee knowledge of how to apply them in practice.
- How to confront teachers' (and parents') scepticism, nostalgia, inertia and lack of confidence about these principles needs to be addressed.
- There are widely-held myths about computation, calculation, basic facts (tables), written algorithms and the nature of number sense among students, teachers and the community. How these myths might be addressed is an ongoing problem for individual teachers, schools and systems.

### Future

Much more work needs to be done not only in this area of computation, but also in other mathematical areas that are important to students' numeracy. Some suggested ways forward were:

- Clear statements from the 'central offices' of education authorities could be helpful (for example, the UK statement that mental computation of two digits must precede the formal written algorithm<sup>19</sup>).
- Materials for teachers and children are needed, including background principles, goals and structured development. The materials need to be multi-faceted. They need to integrate mental computation, written computation and calculator use.
- Materials developed to aid the teaching of written computation (for example, MAB) may actually hinder the development of mental computation for which other models, (for example, the empty number line) may be more appropriate.
- Further extensions of research projects could be undertaken into the pedagogy of data handling, statistics and probability, measurement and space. All these areas of mathematics provide essential underpinning of students' numeracy.
- Effective dissemination and sharing of existing findings and work to ensure that it is widely available to teachers and others.

19. This is not to imply that all of the 'clear statements' from the central education authorities in the UK are seen in a positive light. The 'banning' of calculators in the primary years, for example, as has been done in that country could not be supported here.



## Assessment

### Now

This theme discussion group looked at the operational aspects within the classroom, as well as the broader issues of assessment. It was noted that at the State/Territory/System level, large-scale formal testing occurs at Years 3, 5, 7 and possibly Year 9, providing data for a variety of purposes. In addition, a range of system-wide tools such as the *Early Numeracy Interview* (Vic.) are in use. Furthermore, a number of State/Territory/System-wide projects exploring the assessment of numeracy are in progress; these are beginning to yield new ideas and insights into assessment processes relevant to numeracy.

At the classroom level, teachers are engaging in many kinds of assessment practices. Traditional assessment strategies (e.g. written tests) are in use, mostly in combination with alternative assessment strategies (e.g. self and peer assessment, moderated work samples with teachers analysing tasks to inform and refine their program planning). The strategies chosen seem to correspond to the definition of numeracy that has been implicitly or explicitly adopted by the teacher. For example, teachers who have a broad view of numeracy assess it by means of a range of tasks/ways that replicate/reproduce real-life situations and meaningful contexts; they value the provision of multiple opportunities across the curriculum for students to represent their learning.

Teachers see a number of purposes for assessment:

- collecting pre-instruction baseline data to develop a picture of where students are at; then post-instruction assessment data to find out what they have learned;
- collecting a range of data for informing:
  - program development,
  - reporting student progress to students/parents/significant others (in traditional and contemporary modes of reporting), and
  - their own teaching.

At the school level, aggregating assessment data can be a useful tool for analysing outcomes for different groups of students (e.g. students with English as a second language, boys) across the school. This can help identify areas of need and subsequently contribute to monitoring the success of strategies designed to overcome issues.

### Issues

Conference participants highlighted a number of elements of good practice in assessment:

- holistic (not just a test, gathering evidence from a range of sources);
- students would have the opportunity to articulate their own learning in many ways, recognising student diversity (different learning styles, socio-economic and cultural backgrounds, life experiences);
- assessment of numeracy outcomes would be made in relation to the context of students, the skills needed by students in a particular situation – but never limiting on the individual;
- numeracy would be assessed in everyday situations and not only between (say) 9 and 10 am each day;
- assessment tasks would be meaningful and related to students' real life (not tasks that can be easily marked by a computer!);
- there would be recognition that numeracy outcomes can be assessed in Learning Areas apart from mathematics;
- there is an undeniable link between teaching and assessing student achievement of outcomes. Assessment should be part of the teach-

ing/learning process and not seen as something separate and threatening (like the Friday Morning test). Assessment can drive good practice: e.g. a rich task (like constructing a scale model of an Egyptian Pyramid) can provide opportunities to gain evidence for a range of outcomes;

- importantly, teacher observations and judgements should be valued!

The extent to which these are put into place in practice raises substantial issues.

Another set of issues related to ensuring teachers have the ability, encouragement and opportunity to consider and make decisions about:

- WHEN to assess aspects of students' mathematics, and when to try to assess some aspects of their numeracy development?
- WHAT is it they want to assess in numeracy?
- HOW can they effectively validate/assess numeracy outcomes?
- WHAT does it mean? How will the data gathered be used to further student learning? Will the data be used for any other purposes; reporting, communicating, analysing, meeting system requirements?

Assessment practices in schools and across systems need to be evaluated against the qualities above. Thus the National Benchmarks and the instruments that enable students' achievement to be reported against them (i.e. the state-wide tests of 'numeracy') may be seen as problematic since they focus on mathematical content. The state-wide testing programs have limitations in terms of styles of questions that are feasible. They are only snapshots of student learning. All this has implications for the community view of numeracy and is strongly shaping both numeracy practice and what is perceived to be numeracy.

The following questions should be looked at:

- How is the data used?
- What value is the data? i.e. What does and does not the test tell us?
- What knowledge are the test items assessing? Is it testing what the community values? What teachers value?
- How can teachers gain access to the data? (e.g. Can Year 8 (secondary) teachers access Year 7 (primary) student data?)

At the operational level, there are some important issues to address:

- In regard to numeracy across Learning Areas, who has the ownership for assessing outcomes?
- There needs to be consistency in assessment practices at both the school and system level.<sup>20</sup> How this might be achieved and who would be responsible for the implementation/coordination of this task needs to be investigated.
- The implementation of instruments such as the Numeracy Interview (Victoria) can be problematic if funding and availability of relief teachers make it difficult to release the classroom teacher to administer the instrument.<sup>21</sup>
- The 'two-tier' nature of the pre-test / post-test approach to assessment can be problematic if it is seen as the only means for monitoring progress — assessment can be effectively undertaken during instruction, e.g. while students are working on rich tasks.

20. Although these are unlikely to ever be the same, given that teachers and systems legitimately have different needs in their assessments.

21. The Interview requires a one-to-one interview for perhaps 30 minutes for each student.

### Future

It was suggested during discussion of this issue that the National Benchmarks be reviewed in the light of developing understanding and views about numeracy and numeracy education. Any subsequent redevelopment of the Benchmarks should aim to better reflect the expanded view of what is

important in students' numeracy development. Any work along these lines may have implications for state-wide testing programs — in particular the emphases of the tests and the style of the items — since these are used for reporting against the Benchmarks.

It was suggested that it is necessary to articulate a rich, multi-dimensional common framework for numeracy performance that accounts for elements of numeracy valued by teachers from their classroom perspectives. This may be a developmental framework that provides a 'road map' of learning and delineates a range of behaviours. It may be a framework for interpreting student responses: how and why a student did something (when an answer alone is not sufficient). Such a framework informs the teaching/learning process and it also helps students to see where they are and how to go forward. The framework would not be a static document, but one that is continually reviewed.

The concept of multiple numeracies, akin to multiple literacies, needs to be further investigated and described. Multiple numeracies recognise the use and interpretation of mathematical knowledge in a range of contexts; e.g. what numeracy is required/relevant/an advantage to a student living in a remote Indigenous community may be different to those required/relevant to someone living in an urban community (although at no stage should individuals be limited in what mathematics he/she has the opportunity to access and learn).

In order to assess numeracy, teachers need a view of what numeracy is. Moreover, when this is established, teachers need to communicate these values overtly and explicitly to the community; in the content presented, how the knowledge and skills are measured and how feedback is provided to students. The development of rubrics was one means for showing to students what knowledge and skills are valued and what quality is expected. Students need to be able to answer the question: 'What do I need to do next?'. This would be seen preferable to allocating a 'mark out of ten' that was considered meaningless by the group.

In regard to the issue of numeracy across the curriculum, it was suggested that strategies that enable better communication between faculties in secondary schools should be the subject of research and development and, ultimately, widespread dissemination and implementation. A case study was cited in which one school developed 'curriculum overlays' in which decisions were made collaboratively to determine when outcomes were taught, practised and assessed.

It should be noted that Mathematics Learning Area outcomes can be assessed in Home Economics, Technical Studies, SOSE, Science or PE classrooms. An example will illustrate one of the key contextual differences between primary and secondary settings. Primary teachers will be interested in the performance of a mathematics skill, (for example both the concept and the numerical technique of working out an average in a Physical Education setting). They will also be interested in the outcome within the Physical Education curriculum that is the focus of the activity (for example, linking training with performance). This latter will be the sole focus for a secondary Physical Education teacher — part of this is an evaluation of how 'Phys. Ed. numerate' the student is (skills, fluency, disposition) and fostering this as part of achieving Physical Education outcomes (to be 'good' at Physical Education is to be good at the numeracy associated with that field). In other words, what teachers are attending to and what they see is qualitatively different in non-mathematics classrooms in primary settings compared with secondary.

## Enhancing numeracy practice

### Distilling the Showcases

While schools across the country are at various stages of implementing numeracy programs, those represented in the Showcases of Practice are probably among the most advanced. Presenters described both the features of their innovative and exciting programs and the means by which they created them.

The stimuli to change vary enormously. Changes in some schools are driven by undertaking well-conceived projects or being informed by research, others by individuals responding to local needs through action research activities. Some schools have engaged in a numeracy audit in response to a systemic curriculum imperative to develop numeracy programs, while others have taken advantage of consultants as change agents. Often, several of these and other elements come together in significant systemic initiatives. In all cases, it seems, change has been impelled by individual or group enthusiasm with the support of the school's leadership team.

Presenters reported that achieving change is always challenging, but the change(s) appears to have the greatest potential for implementation when the process is planned and managed as an accepted and explicit priority for the whole school. There needs to be a school-wide focus and a shared vision under the leadership and with the support of the school executive. The change process needs to have a long-term perspective, with the school operating as a learning organisation. That is, participants need time and space to talk, trial, reflect on their actions, take risks and make mistakes. They should be free to do things differently, to challenge existing practices, to go beyond accepted boundaries. They need opportunities and encouragement to work collaboratively with others. Valuable support may be gained from students, colleagues, para-professionals<sup>22</sup>, teachers from other schools and networks, parents, administrators, consultants, critical friends, university and project personnel, and officers of education authorities. Change has the best chance of success in an open and collegial environment.

Maintaining changes within a school needs careful monitoring and management. As improvements are made and new practices adopted, these need to be continuously supported by ongoing opportunities for professional development of all participants, and positive and public acknowledgement of success. This will assist the institutionalisation of changes in the school culture and can help ensure continuance of programs and practices, for example when staff leave the school and new staff arrive. Furthermore, the school needs to continue to evaluate its numeracy programs with a view to further change and improvement. It must try to be always responsive to changes that impact on its programs and be prepared to adapt to new demands and needs.

At all stages of change, professional learning and development are vital. It is advantageous if all stakeholders and participants are involved: teachers, para-professionals, administrators, parents and students, since all are affected by changes to the curriculum. Professional development can be enhanced by the establishment of relevant partnerships within and beyond the school, the adoption of mentoring programs and the use of networks with other professionals, schools and universities. Numeracy projects have contributed enormously to their success through their effective partnering, mentoring and networking activities. Professional development activities

22. This term is used to cover the range of people who work with students in schools but who are not 'teachers' *per se*.

work best when they are not ‘one off’, but are part of a long-term, sustained, planned and focussed effort that addresses the concerns of participants. This is best done within the school environment at the behest of local people with clear knowledge of what is needed. Enthusiasm, self confidence and a focus on in-house concerns however are not enough; teachers also need a knowledge of mathematics and an understanding of numeracy, as well as its pedagogy, and this requires connection with outsiders.

In order to ‘spread the word’ about innovative approaches to numeracy development or to ‘scale up’ as it was referred to, it is useful to create links between schools in order to communicate what it is like to achieve these innovations. This can be done through the establishment of networks of schools and teachers, or through documenting stories or ‘windows on practice’. Students themselves can also be effective ambassadors for numeracy.

Schools wishing to implement or improve their numeracy programs cannot easily adopt practices that succeed in other schools; they need to appreciate that changes are better achieved by working through the whole process of change for themselves, although successful practice elsewhere can provide promising signposts to action. Having new staff who already have a well-developed concept of numeracy and some practical knowledge of its pedagogy is an important asset. It is therefore incumbent on pre-service teacher education institutions to prepare prospective teachers in ways that make the appointment of new graduates an asset to schools implementing forward-looking numeracy programs.

## Whole school change<sup>23</sup>

### Now

Among showcase presentations were numerous examples of school-wide numeracy programs that embody effective practice. These programs were not overnight successes. Indeed some were established in circumstances that were positively daunting. While successes are to be applauded, the pathways to achieve them can be very tortuous and stressful for schools.

*Whole school change* is applicable to the implementation of a wide variety of educational innovations. When applied to numeracy education, there are several major contextual factors that have an impact on the emphases for processes and actions. Important among these factors are:

- numeracy is a systemic and political priority in Australia at present, and this puts improved numeracy outcomes on everyone’s agenda: improvement has been mandated, and schools need to find ways to make the necessary gains — engaging in a process of whole school change has obvious theoretical and practical appeal;
- many teachers lack personal confidence in mathematics/numeracy and, not surprisingly, in its teaching;
- many in the community have a relatively narrow view of what should be valued in mathematics and what it means to be numerate;
- the assessment instruments that are most recognised and valued outside of the school-setting reflect (and can tend to reinforce) this narrow view of what is important in the area: what is assessed (and hence perceived to be valued) is what is easily assessed (almost exclusively in pen and paper contexts) by the measurers.

These factors make the mathematics/numeracy area unique. They need to be accounted for in the totality of the processes for whole school change.

This theme discussion group set out to explore the ways in which schools

23. There was a discussion in the group that rather than use the term ‘change’ (with its implications of a ‘destination’ to be reached), that ‘continuous improvement’ gives a better sense of what was discussed. However, the term change has been retained here as it is in common usage, especially in the phrase ‘whole school change’.

were stimulated to change, how they developed and how they institution-  
alised their numeracy programs. It was evident that because of the diversity  
of size, kind, circumstances and history among schools, there was no one  
way in which schools have implemented or can implement change. It was  
agreed that lasting modifications to existing school programs require the  
commitment of the whole school, and that the failure to engage all ‘players’  
(school leaders, teachers and students) was a major barrier for the estab-  
lishment and extension of numeracy programs. Currently it was felt that  
although not enough schools had ‘taken the plunge’ into numeracy, there  
were now sufficient examples of good practice to show that it can be done,  
and how. The motivations to change are varied, but almost always are about  
improving children’s learning outcomes. In some cases the ‘springboard into  
numeracy’ has been the need to implement state or territory curriculum  
frameworks; in others, it has been the participation in a numeracy project.

The theme of school change cannot be addressed in isolation: it has to be  
considered along with professional development which is vital for achieving  
productive and lasting change.

### **Issues**

Since changing a whole school is such a complex and challenging business,  
the issues associated with change are legion. To begin with, there is the ques-  
tion of the transparency of the meanings of ‘mathematics’ and ‘numeracy’  
within the school. While an agreed definition of each term may not emerge,  
there must be sufficient common understandings about them to develop  
through discussion so that the school can commit itself to some clear goals  
for change. Just how many and what goals are set are important matters to  
agree upon: having too many priorities within a program of change in the  
numeracy education practices in the school can be counter-productive.

Schools need to accept and take account of the inevitability of conflict as  
change occurs, because changes in curriculum and teaching will always chal-  
lenge established patterns of practice and relationships, and cause discomfort  
(at least). Associated with this is the issue of how to deal with blockers/resis-  
tors, difficulties and setbacks. Accepting their existence as challenges and  
opportunities rather than as reasons to quit needs to be explored.

The role of assessment in the change process needs to be clarified. On the  
basis of what type of assessment will planned change occur and be moni-  
tored? Reliance on narrow population test results as a measure of  
improvement may lead to a narrow curriculum, simplistic pedagogies and a  
pressure to immediately improve results. Classroom-based assessments are  
more productive in the long run, but these require investment of time and  
effort by teachers and assessment specialists.

There is necessarily a huge gulf in quality of practice between teachers  
who are expert in developing students’ numeracy and those who are ‘novices’  
in the field. It is a gulf that can consist of knowledge of mathematics and how  
it is learnt, understanding of numeracy demands and opportunities in a  
particular context or range of contexts, awareness of strategies in the class-  
room, or any combination of these. A key issue is how to bridge that gulf,  
whether through sharing, modelling, mentoring or networking.

Other critical issues include how to find time to change within the school  
schedule, how to identify, enlist and use supportive resources, and how to  
effect an appropriate change plan within a realistic time scale. For some  
schools, it will be important to come to terms with issues of leadership and  
team building .

## Future

The discussion about how to ensure effective change processes in the future is summarised as comments on several ‘stages’ identified in the process. At all stages the positive impact of supportive school leadership (principal and others) was emphasised.

### *Getting started*

Schools wishing to make a start on planning for change should consider the possibility of:

- engaging in a national, local or systemic numeracy project
- involving a consultant or outsider
- joining a network of schools wishing to change
- undertaking a review of research findings or school data
- undertaking a numeracy audit
- targeting a year group, a learning area or the whole school
- adopting a whole-school planning procedure, such as the Early Years Numeracy Program (Vic.)

How this is done will depend on such factors as where the school is now with respect to its numeracy programs and what pressures exist to change them. Frequently, leadership comes from one or a few teachers with a commitment to change. These people ‘get the ball rolling’ and engage their colleagues over time.

It is also possible for change to commence with an influential and respected teacher (initially perhaps unwittingly) becoming a role model for others, or for a small group of teachers to agree to do things differently and bring about improvement without any vision of having any wider impact. Osmosis can become part of the process, and as a result the impetus shifts to the whole school.

### *First steps*

Initially, schools need to develop a commitment to a shared vision and clear, achievable goals developed in consultation with all stakeholders.

### *Maintaining momentum*

In order to maintain momentum for change, schools need to confront the issues listed above through:

- optimising participation, time and resources
- maintaining high priority and commitment for change
- emphasising collaboration, teamwork and leadership
- ensuring support for professional learning, open communication and sharing of problems and successes
- closely monitoring progress
- encouraging an action research/learning way of working
- building a culture of change and adaptability within the school
- seeking outside support from the community, systems, networks etc.
- paying attention to both mathematics and numeracy aspects.

### *Institutionalising change*

In order to embed or institutionalise the change:

- build the new program and practices into ‘the ways things are done’ in the school;
- implement a reflective review process to inform further developments;
- connect the changes with other initiatives;
- induct new teachers into the ‘ways of working at this school’.

## Professional learning

### Now

The field of professional development and processes that support teachers' professional learning is relatively well known. Underpinning principles, conditions for success, modes of activity and so on are well documented and should always be considered in professional learning programs.

The emphasis in the title of this group on 'learning' recognises that, unlike many other areas in education that are seen to require a program of teacher professional development, numeracy education requires 'deep transformational learning in terms of beliefs and values'. Nothing short of a deeper understanding of numeracy and its implications will allow teachers to work effectively in the area now and into the future. Consequently, effective professional learning by teachers is essential to making a difference in numeracy education. To achieve this, funding and programs at all levels (individual, school, cluster, system) need to be clearly targeted towards clear goals in terms of numeracy education.

This is not to say that numeracy is currently being neglected; there is a significant amount of professional development and learning in numeracy going on in programs all over the country. There is always an imperative to do more, especially in the light of the needs identified by conference participants. In particular, the evidence of the Springboards into Numeracy Conference is that there is not enough sharing and dissemination of good practice and learning principles, especially across the artificial boundaries of systems, states and territories.

### Issues

#### *Ownership and directions for professional learning*

The shift in language from professional 'development' to professional 'learning' suggests an emphasis on ownership by the teacher. It reflects a comment that system-driven professional development in relation to numeracy can be impersonal, and underlines the need for flexibility to meet individual needs. This is a well known success factor in professional development, but one that can often be ignored in the 'missionary zeal' associated with some efforts at teacher change in the mathematics/numeracy area.

#### *Participants in programs for professional learning about numeracy*

The reality of the adoption of a view that numeracy development is cross-curricular is that the cohort of people who need to undertake a professional learning program in numeracy education not only includes all primary practitioners and secondary teachers of mathematics — those who would be the focus if we were to consider only the mathematical underpinnings of numeracy. By definition, secondary teachers of subjects other than mathematics need to do likewise. That is, virtually all teachers need to undertake to learn more about numeracy and their roles in assisting their students' numeracy development. Para-professionals working with students (often in roles that support teachers and teaching) would also need to become engaged in learning about numeracy development.

Further, given the desirability of whole school change approaches and the crucial role that principals and others must play if these are to be successful, many educational leaders also need to learn about contemporary numeracy education and implications for their work.

In other words, most of the school-based workforce would need to be involved.<sup>24</sup> While daunting, a cohort like this has been contemplated previ-

24. Indeed, given their leadership roles in terms of whole school change, many office-based and executive service officers will also need to be involved.



ously in relation to literacy, as well as a range of other systemic priorities in the various jurisdictions.

### *Teacher confidence built through effective professional learning*

The diversity of the cohort outlined above will emphasise one component of many educators' personal response to numeracy and numeracy education. That is their lack of personal confidence with numeracy and mathematical ways of thinking and doing. Even if convinced of their role in numeracy development and despite the fact that as functioning adults they have a significant bank of numeracy skills, many will not feel comfortable. An important goal of the information and programs that are put in place will be to build confidence in teachers and others so that they are able to have a positive impact on students' numeracy through their 'normal' work with them.

## **Future**

### *Flexibility*

Good practice in professional development acknowledges that flexibility to meet participants' needs is essential — there is no single 'one size fits all'. In response to the extreme diversity in the participants (see above), flexibility at least in terms of starting points, commitment that can be expected and modes of engagement, will need to be built into programs of professional learning.

### *Foci for professional learning programs*

Programs to assist teachers to think about numeracy across the curriculum will need to begin from a non-mathematical starting point. That is, to use approaches that 'look into' other curriculum areas for numeracy-rich examples, opportunities and challenges.<sup>25</sup>

Other programs that address teachers' learning about the mathematical underpinnings of numeracy and how these can be developed to contribute to their numeracy will be directed towards teachers of mathematics (primary and secondary). While much that might be included will be about the teaching and learning of mathematics, explicitly framing this in relation to underpinning numeracy could require some re-direction of emphases. For example, in this context, the doing and using of mathematics, and developing confidence and positive attitudes to the use of mathematics, as well as personal self-confidence in students would seem to require special attention in numeracy programs — just as they do in a quality mathematics curriculum.

### *Processes within professional learning programs*

Again well-known, but perhaps not always attended to in practice, is the need to provide structures and opportunities for teachers to meet, talk and reflect together in ongoing and sustained networks.

Programs should draw on research of two kinds. Firstly, there is the research in the mathematics and numeracy education fields. Access to this will be greatly assisted by more effective dissemination of findings and translation of research into practice (see Further Research section on p. 35). Secondly, those responsible for providing programs for teachers' professional learning should also draw on the research about professional development in the design, conduct and evaluation of the offerings.

25. Some of the current research and development on Numeracy Across the Curriculum uses this methodology to try to help teachers create 'satisfying numeracy moments'.

26. This is the term adopted for discussion of the process of building on relatively small scale success(es) to make the knowledge and approaches developed much more widely spread within education systems.

## Scaling up<sup>26</sup>

### Now

It was noted that many of the teachers who made Showcase presentations at the conference had been involved in systemic projects. This may be a result of the means used for identifying these people. Many were suggested by key systems' numeracy and mathematics officers who would, naturally, have been drawn to those involved in projects — these are the people who are known by systems' officers and with whom they tend to work. However, it is reasonable to conclude that a high proportion of our best practice is located in projects of one kind or another — developing practice is very often the main aim of projects.

The establishment of a discussion topic with this title is recognition of a perennial challenge in education in this country. This is the question of how to 'spread the word' from development projects. This is, of course, an issue that is not confined to numeracy and mathematics education. It is of special importance in this area, however, given the substantial need for fundamental change, the perception of inertia among many teachers and schools and many teachers' lack of confidence in the area.

The general sense of the discussion was that, in the context of these features — perhaps because of them — 'scaling up' from the great achievements of the teachers involved in projects who presented at the conference (and many others like them) needs to be done well, and with much greater effect than has typically been the case in the past.

The matter of 'scaling up' project achievements to ensure that they are embedded widely in practice is related, of course, to at least two other discussion topics, namely those relating to whole school change and professional learning.

### Issues

#### *Multiple layers to consider*

Co-ordinated and intelligent effort needs to acknowledge that there are multiple layers of resources:

- projects have funding to do their work and achieve outcomes — they create and can be a focus (physical location, personnel, examples of practice);
- systems provide financial support, both for the projects and for the processes of more widespread take-up of the ideas and findings;
- schools and school leaders provide the local support (structures, resources) and guidance for innovations in the classroom and across the school;
- teachers provide the passion to change and improve students' learning and attitudes.

#### *Systems' roles<sup>27</sup>*

The roles and actions of systems, in particular, need to acknowledge that schools are different, and that local decisions about what and how to take up project results are an essential ingredient. This creates for systems the challenge of providing information and encouraging (or even insisting on) schools and teachers to take up results or become involved in a project, while still allowing for significant local control. Systems, and project personnel who often become resources for other schools, need to view theirs as a service and support role rather than one of control. Such an approach revolves around systems making more use of models that reflect 'trusting'

27. It is acknowledged that education 'systems' are not homogenous in their approach to these issues. Examples of systems operating in ways that promote effective 'scaling up' serve to prove that it is possible.

schools. In the same way, schools need to acknowledge difference between teachers and allow flexibility based on a trust of and respect for teachers' professionalism.

### *Supporting teachers' professional learning when 'scaling up'*

'Scaling up' requires teachers to undertake professional learning and implement changed practices as a result. Hence, the success will be significantly based on ensuring that some key success factors in professional learning are in place. These include:

- ensuring, supporting and valuing teachers' commitment over time;
- ensuring that there is a 'critical mass' of teachers (at least 2–3) working together;
- supporting teachers to form and participate in extended networks;
- providing access to a range of strategies — professional reading, online information, practical research etc.

### **Future**

- Set directions and priorities on the basis of identified needs of teachers, students and others in the school.
- Incorporate engagement with projects and take-up of results in a whole school plan.<sup>28</sup> This results in alignment of resources and the direction of development and professional learning of staff. There is also regular review, feedback and revision of directions, strategies and targets as necessary. Monitoring student learning will be undertaken in order to provide evidence of progress and further guide teachers' and schools' efforts.
- Systems wishing to promote a project consisting of an approach/ innovation/ teaching intervention etc. might choose a 'difficult' school to prove that 'it can be done'.
- The orientation for systems needs to be one of building on success generated in projects, and using the skills and expertise of project personnel to 'spread the word'. This needs to be a planned and overt intention that is given sufficient time and funding to be a lasting success. It is much more than 'dissemination'. Effective actions involve more than the production and dissemination of materials, documents etc. — it is a 'people' issue, not only a 'paper' one. Formal and informal networks are powerful mechanisms that require fostering and support.
- Support for efforts to scale up initiatives over medium and longer terms needs to be planned and budgeted for.

28. As discussed in the previous section on whole school change (see pp. 28–31).

## **Further research**

### **Now**

The paper *The Commonwealth Numeracy Research and Development Initiative* (Stephens & Steinle) is included at Appendix 1 (see pp. 144–155). This paper is a summary of the range of initiatives supported by the Commonwealth Department of Education, Science and Training. There are some projects at the national level, with the major efforts being projects conducted by education authorities at the state and territory level.

The Commonwealth-funded research projects represent a major program of research in mathematics and numeracy education. The work is designed within broad policy parameters defined by *Numeracy, A Priority for All: Challenges for Australian Schools* (DETYA, 2000). It does not represent the

29. The latest review for 2000–2003 is in preparation.

totality of research in the area, however. Defining the scope of this ‘other’ research was not possible within the conference — a good source is the series of quadrennial reviews of research published by the Mathematics Education Research Group of Australasia Inc. (MERGA).<sup>29</sup> Suffice it to say that Australian research in mathematics and numeracy education is broad ranging and of high quality in international terms.

As an organisation, MERGA exists to support mathematics education in this country (and New Zealand). It makes many and varied contributions to the strength of Australasian research, most noticeably through its journals and conferences. MERGA’s emphases and intentions complement those of the teacher oriented AAMT, with undoubted scope for cooperation between the two professional groups to ensure that research plays a prominent part in informing teachers’ work and students’ learning.

### Issues

Several clusters of issues were identified. There is some overlap, and certainly interaction between them.

#### *Research foci*

The Commonwealth-funded projects are perceived to be broadly about ‘supporting policy’. Building overt connections between research and policy is seen as valuable, and the fact that policy-makers are demonstrably more open to accepting research findings is welcomed by the research community. However, this connection with systemic policy directions necessarily limits the scope of the research questions being investigated in the Commonwealth-funded programs. Further, the emphasis on these programs is seen to limit the perceived need and funding available for ‘other’ research. In this setting there is the issue of ensuring appropriate valuing of ‘other’ research — national and international — by decision-makers and in the education community.

Two other concerns exist. The first is that there seems to be no current planning for longitudinal evaluation of the impact of research on student learning, nor of its dissemination. The second is the need to frame new questions from current research, how this should happen and who has responsibility and ownership for designing future efforts.

#### *The nature of research*

The emphasis on quantitative results from research, particularly those relating to ‘student learning outcomes’ requires the use of appropriate instruments to measure them. Expressions of concern about the nature of the current regime of cohort testing (see *Assessment* section on pp. 25–27) are clearly relevant when results of these instruments are used as part of research design. The issues are the extent to which these instruments can measure the range of outcomes expected from the project<sup>30</sup>; the legitimacy (real and perceived) of means for measuring other outcomes; messages in the reporting of the results of research. Researchers themselves are generally not able to develop reliable assessment instruments with the emphases they need, yet reliability is essential if results are to be trusted and used as the basis for making decisions. Hence researchers use the only suitable instruments available, and these are not really appropriate to their particular study.

30. Or indeed ‘before the event’ to restrict the range of outcomes considered in the design phase of the project.

Much current research in the mathematics/numeracy field involves teachers as active participants through action research and other strategies. Approaches and support that value teachers as researchers, and promote

this role as part of teachers' professional engagement are evident, and need to become more widespread through funded research and other more general practices of systems and schools.

### *Impact of research*

Dissemination and sharing of research results, in particular translating research findings so that they link to and impact on classroom practice, constitute a perennial issue in educational research. High-level research reports (whether for academic publications or as reports to funding agencies) are not seen as being 'teacher-friendly'. Developing and implementing different strategies and means for making these links in ways that maximise the impact of research efforts is a particularly relevant challenge, given the current investment in mathematics and numeracy research.

The DEST funding to the education authorities in the states and territories has allowed for significant levels of 'self-determination'. This is seen to be effective in producing projects that fit into broader agendas by supporting changes the local authorities see as desirable to investigate and about which to reach some conclusions. However, because of this self-determination, the processes for disseminating and sharing results to maximise their impact are potentially problematic. On the one hand this is the responsibility of the local education authorities within their constituencies; on the other it is seen that the Commonwealth would be missing an opportunity if it did not foster effective national sharing. This would be strengthened by articulation of the connections between the projects.

The impact of research is also diminished in some senses by the project 'orientation' of current systemic research. Through their involvement in research projects many teachers develop outstanding knowledge and skills, but there is a perception that in many cases this is not valued as a resource beyond the particular project. There is a need for there to be greater obvious systemic recognition of these people as a resource, and the development of strategies that foster these teachers' capacity to further develop and contribute in an ongoing way.

The project orientation, coupled with the challenge of dissemination contributes to a further issue that is summarised in the term 'sustainability of project outcomes'. This is covered in the Scaling Up Section. This is the challenge of maintaining the enthusiasm and commitment to the work initiated by the project once funding and support has been removed.

### **Future**

There needs to be enhanced support for smaller scale, more academic research<sup>31</sup> as the results of these feed into the directions of the major systemic projects. The quality of major systemic research projects ('applied' research) will languish without this creation of new knowledge.

There is an urgent need to address the issues above related to translating research into practice, dissemination and uptake of current good work. Strategies could include:

- funding for production of materials including videos from current work;
- greater use of the Internet for providing access to current research;
- increased and deliberate sharing of 'work in progress' in order to create anticipation and interest (the prominence of and subsequent interest in Commonwealth-funded projects at the Springboards into Numeracy Conference is a good example of how this can work — the Internet and other already existing events and means should be used as well as 'special events');

31. This might typically involve intensive study of a few subjects, or a detailed investigation of some fundamental, yet narrowly defined questions.

- DEST reports being tailored for different audiences;
- increased use of AAMT publications and other journals for teacher oriented reports of research;
- exploiting existing national networks to maximise awareness about the results of research projects;
- capitalising on the investment in teachers involved in current work by maintaining and exploiting their skills and knowledge in the short and medium terms (at least).

Further research projects that are funded at system levels should:

- contain appropriate strategies for translating research into practice, dissemination and sustainability in their overall design;
- enhance the capacity of ‘teachers as researchers’ through research partnerships between schools, systems and universities. This will encourage research as a form of professional learning;
- provide incentives such as HECS exemptions and time release from school duties for teachers to undertake further study with significant research components;
- form effective partnerships with universities by, among other things, creating incentives for university researchers to be involved in research with schools and teachers as recognition of both the importance of this kind of work and the extra time and other commitments it requires of academic researchers if it is done well;
- give more support for ‘replication studies’ to confirm results in other setting(s) as these add weight to the evidence gained from a single study;
- direct research and development towards finding effective dissemination strategies.

## Pre-service teacher education

### Now

The concerns around the supply of teachers were not covered in discussions at the Conference. They are acknowledged as a key aspect of the context, but in whatever ways the issue of teacher supply is addressed, a key intention must be to maximise the quality of pre-service teacher education. Indeed, a good quality preparation that is recognised as such in the community may be an important factor in attracting and retaining teachers.

Conference delegates did not spend time comparing and contrasting programs from different institutions around the country. Courses differ as a result of local conditions and history<sup>32</sup>. Conference delegates focussed mostly on thinking through the issues that impact on pre-service teacher education in numeracy in order to make some suggestions for the future.

Those present were virtually all mathematics educators and this needs to be borne in mind, especially in relation to the implications of the first of the issues identified below.

Overall there was a sense of commonality of intention for pre-service teacher education courses. This could be characterised as a care for their students’ preparation for their work as numeracy educators and covered a commitment to their students’ learning of and attitudes towards mathematics, and of their ongoing learning about teaching mathematics and developing numeracy (as ‘reflective practitioners’).

32. Some insights into this may come from the DEST funded project to identify innovative processes in the preparation of teachers in literacy and numeracy.

## Issues

If one of the broad aims of pre-service teacher education is taken to be for graduates to be ‘prepared for their first years of teaching’<sup>33</sup> then it is clear that core issues for pre-service teacher education will include addressing the emphases and context of teaching for numeracy in schools. These matters are covered in detail in other sections of this Conference Summary. It is their implications for pre-service teacher education that are discussed here, with some suggestions for addressing issues included in the next section.

The issues in schools that are particularly relevant in considering the construction and delivery of pre-service teacher education courses seem to be covered under the following headings.

### *Curriculum and learning expectations about numeracy in schools*

The main curriculum development in schools in recent times is the recognition through syllabuses, guidelines and frameworks in all jurisdictions that numeracy<sup>34</sup> is, at least in part, a component of learning across the curriculum. For primary teachers, this means a capacity to see and use numeracy possibilities in their children’s learning in other curriculum areas. In secondary schools it means that teachers in areas outside mathematics have similar responsibilities. These expectations of teachers have clear ramifications in pre-service teacher education in either level of schooling. They have impact in courses/aspects of courses both within and outside those that might be classed as ‘mathematics education’.

Another major development in school numeracy education has been the emphasis on accountability for students’ learning, and particularly the systemic accountability through state-wide testing related to reporting against National Benchmarks. Whatever teacher educators individually or collectively may think of this development it is a reality. It has certainly raised the ‘stakes’ around students’ numeracy development and the emphasis numeracy has received in schools<sup>35</sup> has certainly increased. The issue for pre-service teacher education courses is whether, and how, to respond to this kind of increased scrutiny on numeracy in schools.

### *Developments in teaching and learning strategies in numeracy education*

Mathematics education has been an area of sustained research and development effort. Many of the findings of research have been translated into contemporary curriculum guidelines in mathematics. These range from teaching strategies (for example, developing number sense and associated computational skills; addressing cultural and/or linguistic background of students etc.) through to more general orientations to teaching and learning mathematics (reflecting on students’ thinking; emphasising language and communication; promoting risk taking etc.). These developments are relevant and important in providing students with a robust mathematical basis on which to build their numeracy.

Many teacher educators are involved in these research efforts, and in professional development programs to help teachers with the implementation of findings. Therefore, there is great awareness of the usefulness of these developments — and their extensive range. When this is viewed in the light of both the school backgrounds of many pre-service teacher education students, existing school cultures and the perception of constrained resources (time in particular) for this aspect of pre-service teacher education (see below), responding to the expectation for graduates to be suitably prepared in terms of expectations of their teaching is an extremely difficult challenge for pre-service teacher educators.

33. At this level of generality, perhaps the other aim could be expressed as ‘graduates have the tendency to be life-long learners’.

34. Some insights into this may come from the DEST-funded project ‘The Preparation of Teachers to Teach Literacy and Numeracy in Primary and Secondary Schools’ being conducted by staff at Edith Cowan University.

35. This is not an argument that the emphasis through programs and funding has been adequate, just that it has been significantly greater in the past five or so years.

### *School culture*

Two aspects of school culture are relevant. The first is that teachers and schools are in a process of change in relation to numeracy education practices. It is a simple reality that graduates of pre-service courses will be working in schools and with colleagues that range from those who have moved a long way and adopted many contemporary directions to those whose engagement with new ideas has been minimal. The other component of school culture is the way in which new graduates are inducted into the school and the profession — in particular in relation to the expectations and support structures around their work in numeracy. Again, it is likely that graduates will experience processes that range from highly supportive to ‘sink or swim’. Creating consistency for the individual graduate within the move from university to a ‘real’ school is the challenge.

There is also a range of issues that are internal to pre-service teacher education courses. These vary from institution to institution, but some general categories are:

### *Nature of the past school experiences in mathematics of those entering primary teaching courses (in particular)*

It is fairly well accepted that many people who choose to become primary teachers do not have strong backgrounds in mathematics at school and that this is often associated with a lack of confidence in mathematics. To a large extent this results in these people ‘teaching the way they were taught’ and therefore continuing a cycle. These issues remain continuing and substantial challenges for pre-service teacher educators. In the light of the greater levels of complexity and heightened expectations placed on teachers in schools as outlined above, it is likely that the impact of these issues is intensified in current pre-service teacher education programs.

### *Pressures on staffing, class sizes, contact hours and resources within universities*

Many teacher educators report that pressure in these areas severely limits their capacity to address the issues identified. The pressure in these areas is acknowledged by non-university staff with grounded knowledge of workloads in the institutions, and may be exacerbated in some programs as the result of heavy emphasis on literacy in a way that reflects the imbalance many identify in the school sector.

### *An emphasis on creating productive links between universities and schools*

One of the strategies that has been promoted as a means of addressing many of the issues for pre-service teacher education courses is to strengthen links between universities and schools around mutual concerns for graduates’ capacities in numeracy education, among others. These links do provide potential for positive change (see below), but they have resource implications, and getting them going and maintaining the links do require investment of effort.



## Future

Underpinning many of the suggestions was a commitment to developing and strengthening links between schools and universities. Some of the key strategies to support courses that were suggested were<sup>36</sup>:

- enabling practising teachers to have input and involvement in university courses relating to numeracy education;
- providing pre-service teacher education students with examples of 'good practice' through demonstration lessons — a large national bank of suitably annotated video material on cassette or CD-ROM would provide a reusable resource;
- providing opportunities for pre-service students to work with individual children in classrooms in an extension of the practicum placement — such a scheme would benefit both the student (opportunity to observe and reflect on children's learning etc.) and the classroom teacher (through having an extra 'body' to assist);
- it was noted that the New South Wales program *Count Me In Too!* (CMIT) has been 'changing the culture of mathematics (in schools)'. For example children 'cheer when they know it is a maths lesson'. Key ingredients of the CMIT phenomenon were suggested to be enthusiastic teachers, children talking and an emphasis on teachers understanding how children learn. Now, while these are probably central to much of the teaching in pre-service courses relating to numeracy, they are the kinds of elements that need to be revisited and emphasised. More generally, there will be other lessons from teacher programs that could inform what happens in pre-service programs. An added advantage of these kinds of linkages will be familiarity with approaches when the graduates begin teaching.

Other strategies were related more to addressing the transition of graduates into the workforce and supporting that transition. Most seem to be general strategies that could have a numeracy-specific edge:

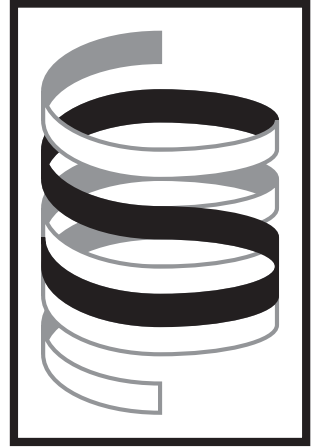
- a formal program of mentoring new teachers and other support structures;
- decrease the initial teaching load, and for schools to have more reasonable expectations of beginning teachers.

There was nothing in the record of discussion about methods courses outside mathematics, particularly in pre-service programs for secondary teachers, nor about numeracy across the curriculum in general. This is not to say that such programs do not exist, but it does signal that this is an area that may need investigation in some institutions.

36. It is noted that these may already be in place in some programs.



# Section 2: Showcases of Practice





# Early numeracy — Self and peer assessment as a way to improve learning

Andrea Hillbrick

Beaconsfield Primary School  
Victoria

Andrea Hillbrick is currently the Assistant Principal at Beaconsfield Primary School, which is situated in the southern metropolitan region in Victoria. She has undertaken various leadership roles including Early Years Literacy and Numeracy Coordinator and whole school curriculum leader. Andrea has shared her strategic approach and insights at both state and national level. Andrea was a recent member of the Early Years Numeracy Team of the Department of Education and Training. She developed and implemented strategies, professional development and support materials for schools in dealing with numeracy and coordinated the *Early and Middle Years Numeracy Professional Development Project*.

**B**eaconsfield Primary School is located in the fastest-growing area of Melbourne, yet retains the feeling of a quiet semi-rural school. In 2002 we recorded our largest enrolment growth in the history of the school, but maintained the strong relationships existing between teachers and students. We have 408 children in 16 grades.

Numeracy is a current priority of our school with a focus on whole school implementation of the Early Years Numeracy Program. My role is to strategically lead the implementation of this priority. Preceding initial professional development in implementing the Early Years Numeracy Program, each teaching team designed, implemented and evaluated an action research project based on the key understandings of the Early Years Numeracy Program.

From the four action research projects three common goals became evident:

- to develop a high profile for mathematics in the school community;
- to encourage students to view themselves as mathematicians;
- to model and implement self and peer assessment strategies to improve learning.

This paper explores the journey and findings of my action research project which was developed from the third goal: self and peer assessment as a way to improve learning.

As I explore my experiences and strategies with you I need to emphasise that my action research project had the strong foundations of three key beliefs and understandings:

- self and peer assessment provides reliable data to inform teaching;
- mathematical language is a key feature of self and peer assessment;
- self and peer assessment engages students in mathematics.

My key beliefs and understandings are directly linked to the Early Years Numeracy Program. Throughout the implementation of my action research project I explored strategies to make quotes from the program come alive in classrooms across our school.

Continuous monitoring and assessment should connect naturally within what has been taught and what will be taught.  
(*Early Numeracy in the Classroom*, p. 16)

Continuous monitoring and assessment ensures that our daily numeracy

block reflects the needs and interests of the learners. It involves the classroom teacher to be a reflective practitioner who is committed to flexible grouping in the classroom. Many strategies were implemented to ensure that self and peer assessment were implemented in a continuous manner rather than just at the beginning or conclusion of a unit of work.

- Each child in the classroom created a two-sided face displaying the feelings of exploring the mathematical learning experience. One side was illustrated to represent excitement and/or happiness and the opposite side was illustrated to represent confusion. Throughout the numeracy block the students indicate how they are feeling about the mathematics learning experience.
- Number lines provide students with a tool to assess their own mathematical skills. The teaching conversation focusses on the strategies for students to improve their rating.
- A classroom ‘Yellow Pages — Mathematicians’ enables students to identify and record their strengths in mathematics and provides a classroom resource for peer tutoring.
- Venn diagrams enable students to organise their thoughts through self assessment. Headings used in Grade 3/4 classrooms included ‘I like mathematics’ and ‘I am good at mathematics’.
- ‘Behind the door’ is created from paper with three doors to lift up to record. In a 5/ 6 classroom students worked in pairs to formulate reflective questions for their peer to answer. Both the questions and answers were most insightful.
- The provision of a framework for students to engage in peer assessment has been most beneficial. A simple proforma outlining tasks and feedback enables students to provide feedback with a mathematical focus. The peer assessment takes place prior to presenting the mathematical learning experience.

During each mathematics learning experience we talk with our students and listen to them; we explain concepts and models, pose questions, respond to students and provide feedback for their learning.

*(Early Numeracy Professional Development for Teachers, p. 129)*

A current focus of my teaching is to discover ‘what is happening in my students’ heads’. Modelling and promoting the use of mathematical language is strategically planned in my numeracy blocks. I plan the language I will model, introduce and revise with the students and provide opportunities during whole class focus, small group focus and whole class share time.

Strategies explored to enable teachers and students to employ mathematical language include:

- introducing and defining key mathematical terms during the whole class focus at the beginning of the numeracy block — the definitions are displayed as posters in the classroom or form a class mathematics dictionary;
- formulating advice for peers during whole class share time at the conclusion of the numeracy block — the advice has been delivered to other classrooms exploring the same mathematical topic and published in our school newsletter;
- supporting students to use mathematical language during the whole class share time they are provided with a ‘think bubble’ to record and rehearse the mathematical language;
- providing teachers with cards outlining highly effective prompts and

- questions to use with students during the numeracy block;
- providing students with models of mathematical language to support their reflection during whole class share time — the sentence beginners are presented on sticks for the students to hold while reporting.

A structure that begins with the whole class, moves to small groups and then back to the whole class enhances learning opportunities.

(*Early Numeracy Professional Development for Teachers*, p. 97)

The Early Years Numeracy Program outlines a structure for the daily one hour numeracy block:

- whole class focus
- small group focus
- whole class share time.

The whole class focus is the first ten minutes of the numeracy block. It is the time to set the scene and to build a community of learners. The teacher and students share and practise skills and understandings, while making connections between mathematical ideas. It is an opportune time to define mathematical language and to demonstrate a self and peer assessment strategy.

During small group focus, teaching groups and independent mathematics occur simultaneously. During thirty-five minutes, the teacher has one or two teaching groups and engages in teaching conversations while roving. It is the time for the teacher to provide focussed teaching and feedback. Opportunities are provided for students to engage in self and peer assessment and to rehearse their mathematical thinking and language for whole class share time.

Whole class share time is the conclusion of the numeracy block, approximately ten to fifteen minutes. It provides a focus time to reflect upon, articulate and celebrate the mathematics used and the ways of learning. The teacher supports connections between mathematical concepts and promotes mathematical language. It is a prime time for self and/or peer assessment!

By incorporating self and peer assessment in the daily numeracy block students are given authentic opportunities to articulate their mathematical thinking enabling teachers to build upon what they know and can do!

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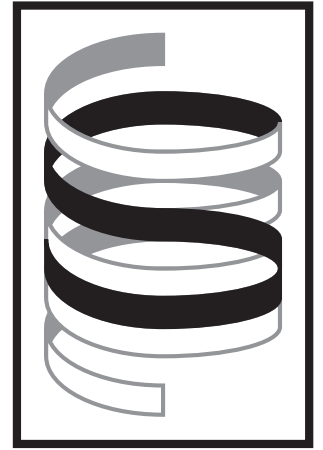
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# An introduction to critical numeracy

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This paper offers a brief introduction to the idea of critical numeracy, describing its characteristics, offering some examples and considering its significance for teachers of mathematics. In order to understand critical numeracy, we first consider briefly the related idea of critical literacy.

## Critical literacy

Critical literacy has been defined as emphasising how language and literacy, texts and discourses are implicated in the power relationships and face-to-face politics of everyday life. In other words, there is a focus on how language in all its forms is involved in our relationships to each other and the world.

Allan Luke and colleagues observe,

Critical literacy sets out to encourage students to begin to see that literate practice is always morally and politically loaded — and that to work with a text doesn't necessarily involve uncritically buying into its world position (1994, p. 148).

Consequently it seems that students ought to be encouraged to ask questions such as the following about text:

- Who produced it?
- For whom?
- Why has it been produced?
- Is it interesting or relevant to you?
- What are the implications for your gender or other social groupings?
- What is the author trying to do to you?
- What wasn't said about the topic? (Luke et al, 1994, p. 143)

## Numeracy and literacy

Literacy is a relatively new term in popular usage. It emerged with the education critics in the 1970s in the UK, who were concerned about the perceived problems with producing students who could not read and write adequately. The term literacy was popularised to cover reading and writing and subse-

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quently extended to comprise the whole area of language use.

The concerns were as much with the third R, arithmetic, as with reading and writing. The teaching of arithmetic had been well absorbed into a wider mathematics curriculum by this stage so some education critics used the analogous term, numeracy, as the popular focus of their attack. It became common to link the two and the back to the basics movement argued that schools should focus on the teaching of literacy and numeracy.

In recent times education authorities have attempted to put numeracy on a firmer footing. They have wanted to produce numeracy curricula, or numeracy outcomes, to make it clearer to teachers exactly what numeracy teaching is all about. To do this they have had to define numeracy and explain its relationship to mathematics, which has remained throughout this time at the heart of the school curriculum.

While some people may have wished to define numeracy simply as arithmetic, this has not happened. The increasing use of mathematics in everyday life is well known and the ability to use and understand graphs, for example, is seen by some people as more fundamental to numeracy than arithmetic. The result has been definitions of numeracy that emphasise the practical or everyday uses of mathematics.

Hence numeracy has been defined as the type of mathematical skills needed to function in everyday life, in the home, workplace and community.

Similarly,

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 (Tasmanian Department of Education, 1995, p. 6).

For some the content of numeracy is a subset of mathematics. It is that part of mathematics which is used in everyday life. However, as we shall see, the development of the idea of critical numeracy leads us into a new way of thinking about mathematics teaching and learning which may bear only passing resemblance to current practice.

## **We can define critical numeracy by analogy to critical literacy**

Critical numeracy is a focus on the ways in which practical mathematical situations are implicated in the power relationships and face-to-face politics of everyday life. It is a focus on how numeracy in all its forms is involved in our relationships to each other and the world.

Critical numeracy sets out to encourage students to see that mathematical practice is always morally and politically loaded — and that when mathematics is used in practical situations, students should understand and reflect on the world position of those using it.

In her review *Not Just a Number: Critical Numeracy for Adults*, Sandra Kerka (1995) suggests that real-life numeracy has the following characteristics:

1. numeracy is culturally based and socially constructed;
2. math(s) reflects a particular way of thinking;
3. numeracy reflects cultural values;
4. numeracy is not just about numbers;
5. math(s) evolves and changes;



6. numeracy is about procedural, practical knowledge;
7. numeracy involves different ways of solving problems.

An appreciation that numeracy is culturally based and reflects cultural values raises important questions. It becomes important to ask, 'Whose numeracy?' Does the numeracy of the school reflect the numeracy used on the streets or in the supermarket?

For example, when engaged in a typical everyday activity like calculating the cost of stamps, many people do not use a standard school algorithm. Educators need to ask how people in real life actually calculate and measure and reconsider their programs to better support what people actually do.

## Implications for critical numeracy

It is a common assumption that numbers, measurements and other mathematical objects and processes are value free and are merely tools for understanding the world and solving problems. There are two major problems with this view. Firstly, it is simply not true as the discussion which follows will show. Secondly the assumption hides what is going on. If numeracy is believed to be value free there is no analysis of what value position is being adopted and no questioning of the consequences of that position.

Even at the abstract level of pure mathematics (a value laden term if ever there was one), it is clear that mathematics is value-laden. Consider the enormous attempts made to 'prove' that mathematics is based on unassailable foundations and the reluctance to accept the demonstrations that such foundations are impossible. Truth is of course a highly value-laden concept and attempts to show that mathematics is some sort of higher truth are very much concerned with establishing power relationships; hence these are fundamentally political activities.

When we move our interest from pure mathematics to the practical uses of mathematics in the world, the domain of numeracy, it is necessary to recognise that how we use numbers (and other mathematical ideas), why we use some particular numbers rather than others and the language we surround them with are all value-laden, dependent on their cultural contexts and often highly political activities.

In our world, people use mathematics for very specific purposes. Mathematics users try to persuade others to particular viewpoints, they try to communicate certain ideas, they wish to sell us goods and services or they may want us to act in certain ways. These are never value free, politically neutral activities. Here are two brief examples:

When car prices so consistently fit to a pattern of \$14 990, \$17 990, \$19 990, \$29 990, and so on, we can be sure there is a very good reason and it may well be that the reason is not necessarily in our interests as consumers.

When an environmental group publishes figures on the changes in carbon dioxide levels in the atmosphere and predictions of the likely changes in sea levels over the next one hundred years it is clear that they are engaging in political activity and that this is likely to have affected the particular statistics they select for publication.

Consider the example described in the box, *Paying the price for saving*. This item provokes much discussion and plenty of laughter. It shows how a common numerical procedure, rounding down, can have important practical and ethical consequences in everyday life.

## Paying the price for saving

It was reported in the media that a central Queensland shopper spent 45 minutes in the supermarket checkout buying each item individually so he could maximise the benefit of rounding down the prices that the supermarket used. The policy of the supermarket at the time was that each item was rounded down to the nearest 5 cents.

Evidently the customer saved \$2.85 by getting each item rounded down. The supermarket claimed it cost them \$12.27 in additional labour to process the goods.

The supermarket has refused to serve the customer in this way again.

Many critical numeracy questions are relevant to this third example:

Given that the supermarket has a policy of rounding down prices students can estimate how many items the shopper bought if he saved \$2.85. Does it seem reasonable that individually processing this number of items would take 45 minutes?

If processing this number of items cost the supermarket \$12.27 how much is the additional cost for each item? Why is the cost to the supermarket different from the saving by the customer?

How much would it increase the price of groceries by if everyone insisted on having their items processed through the checkout in this way? Is this fair?

If the customer took 45 minutes to save \$2.85 is this an effective way of spending time? If this was a person's wage, how much would they earn each week?

Would you be willing to work for this wage? How does this compare with other wages? How does this wage compare with what the supermarket pays its employees? Is this a good wage?

What if you were unemployed or on a pension? Are there any fairness issues involved?

These three examples suggest that numeracy is a social practice the use of which is never value free. Numeracy is often involved in influencing the power relationships between individuals and social groups.

Critical numeracy encompasses the many ways by which students learn not only to use or access mathematics in the world but at the same time investigate the social practices involved, reflect on the effects on power relationships and seek to understand their consequences for themselves and others.

In this sense, critical numeracy is about critique; it is about helping students develop a healthy scepticism about the use of numbers, graphs, statistics and measurements. However, critical numeracy does not stop there: it is also about empowerment. It involves helping students use mathematics for worthwhile purposes and to assist with the emancipation of themselves and others.

There are four major aspects of critical numeracy:

1. being able to critique or make critical interpretations of mathematical information;
2. being able to unpack, interpret or decode mathematical situations;
3. using mathematics in a self-reflective way;
4. using mathematics to operate more powerfully in the world.

While there is not space in this brief article to elaborate on these aspects, we will conclude with some remarks on the significance of numeracy for empowerment.

## Empowerment

In a critical numeracy approach, empowerment is integral to a student's use of mathematics in the world. This happens in three ways.

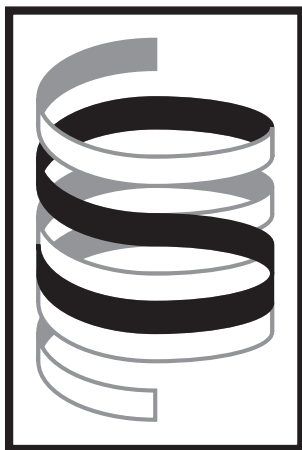
- Students are empowered by an understanding that published mathematics attempts to position them in certain ways. They can critique this positioning and see who might benefit and make clearer decisions about their own interests.
- Students are empowered by their capacity to understand and use mathematics. In this sense critical numeracy is close to traditional mathematics teaching in that it attempts to ensure that students learn the skills and concepts they need to engage with the mathematics they find in the world.
- Students are empowered as creators of mathematics for their own purposes. They are able to select numbers, measurements or shapes to support their arguments and are aware of how to use them effectively in particular social contexts. They are competent and creative in the use of statistics, tables and graphs as ways of illustrating ideas or enlisting support for their viewpoint.

In contrast, current approaches to teaching mathematics are often not empowering. Indeed, many people see themselves as mathematics failures. They will happily report the level at which they were no longer succeeding at mathematics, when it became too hard and when they gave up further study of the subject. Unlike illiteracy, which people make great efforts to hide, innumeracy is socially acceptable. People seem almost proud of their inability to deal with certain aspects of mathematics. How could it be otherwise when so many people leave the education system viewing themselves as mathematics failures?

A focus on empowerment — on critical numeracy — offers a way forward. But the implications of such a focus are that what is taught, how it is taught, how it is structured and sequenced, how achievement is measured, how success is defined and how emotions are engaged will all have to change if learning numeracy and mathematics is to be ultimately empowering.

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# McPizza... the shape of things to come?

Geoff Gillman

Parap Primary School  
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Geoff Gillman has been teaching for over twenty years in both government and Catholic schools, in primary, secondary and special education positions. Most of this time has been served in the Northern Territory between the urban centres of Darwin and Alice Springs. He completed his initial teacher training at Sturt College of Advanced Education in Adelaide and completed one year of service as a contract teacher in Adelaide before venturing to the Territory to gain permanent employment. Between 1996–1998 Geoff worked as a Special Education teacher in Innisfail, a rural community in Alberta, Canada. He is currently teaching Year 6/7 students at Parap Primary School in Darwin. Since working in the NT he has been an active member of the Mathematics Teachers' Association of the Northern Territory (MTANT) and has held a range of executive committee positions.

## Context — Parap Primary School, NT

Parap Primary School is located within three kilometres of the Darwin central business district and is built on the site of the previous Darwin airstrip made famous by the arrival of the Southern Cross in 1919. Currently, the school has a population of around 450 students from Transition to Year Seven. Parap is one of the Northern Territory's oldest schools and last month was provided with a \$2.2 million grant to refurbish the buildings that date back to 1958. The middle and upper primary teaching areas are traditional-style classrooms. However, Room Four in which I teach, has a pleasant aspect looking out into a tropical playground surrounded by palms and huge Beauty Leaf trees.

One of the key objectives developed in the School's Strategic Plan 2002–2004 is to implement the Northern Territory Curriculum Framework. This paper will highlight aspects of this process within the school and how it has been embraced in my own classroom program. I currently teach a Year 6/7 class comprising of 16 Year Seven students and 12 Year Six students. The composition of the class is diverse; two students are working to Individual Education Programs (one of these students has cerebral palsy and is confined to a wheelchair), one student is working to a behaviour management plan and five students have moderate learning difficulties in the area of literacy and numeracy. A resource teacher is employed by the school to provide a support program for developing student literacy outcomes, but no such program is provided for numeracy.

## The emergence of the NT Curriculum Framework

After a two year development and consultation phase, the Northern Territory Government launched the Northern Territory Curriculum Framework (NTCF) earlier this year. The NTCF identifies learning outcomes for all learners T–10 in the Northern Territory. It provides the major elements of curriculum around which schools can develop learning programs that are responsive to local contexts and needs of students, as well as appreciating the diversity of pedagogical approaches used by educators.

The NTCF comprises eight Learning Areas (of which Mathematics is one), EsseNTial Learnings (outcomes that provide the foundation for lifelong

learning), ESL (outcomes and phases of ESL leaning) and Indigenous Languages and Culture (outcomes for developing cultural and Indigenous language programs).

Of particular importance to this paper are the Mathematics and EsseNTial Learnings outcomes. Both these areas of the curriculum are arranged in Key Growth Points (1–3) and Bands (1–5 and Beyond Band 5) which illuminate a developmental continuum. In the Mathematics Learning Area, the outcomes are organised globally into three strands up to Band 3: Spatial Sense, Measurement & Data Sense, and, Number Sense. At Band 4 and beyond the Spatial Sense and Measurement & Data Sense strands reorganise into Space & Measurement and Chance & Data, while Number Sense separates into Number Sense and Algebra.

The process of ‘Working Mathematically’ has been embedded in the four domains of the EsseNTial Learnings outcomes across all Key Growth Points and Bands. The Constructive Learner domain focuses on the elements necessary for learners to become life-long producers and contributors. In this case, learners use their mathematics appropriately and effectively to do so, and justify the strategies they use. The Creative Learner domain contributes to the development of working mathematically in relation to creative problem solving. Components of the Inner Learner domain, particularly reflective thinking and the use of meta-cognitive processes, also contribute to working mathematically. Mathematics also provides ample opportunities to develop the attributes of the Collaborative Learner domain (NTCF v 1.4, p. 295).

In addition, five key overarching mathematical outcomes have been identified as big ideas that interrelate with all of the strands and elements of mathematics (NTCF v 4.1, p. 295–296):

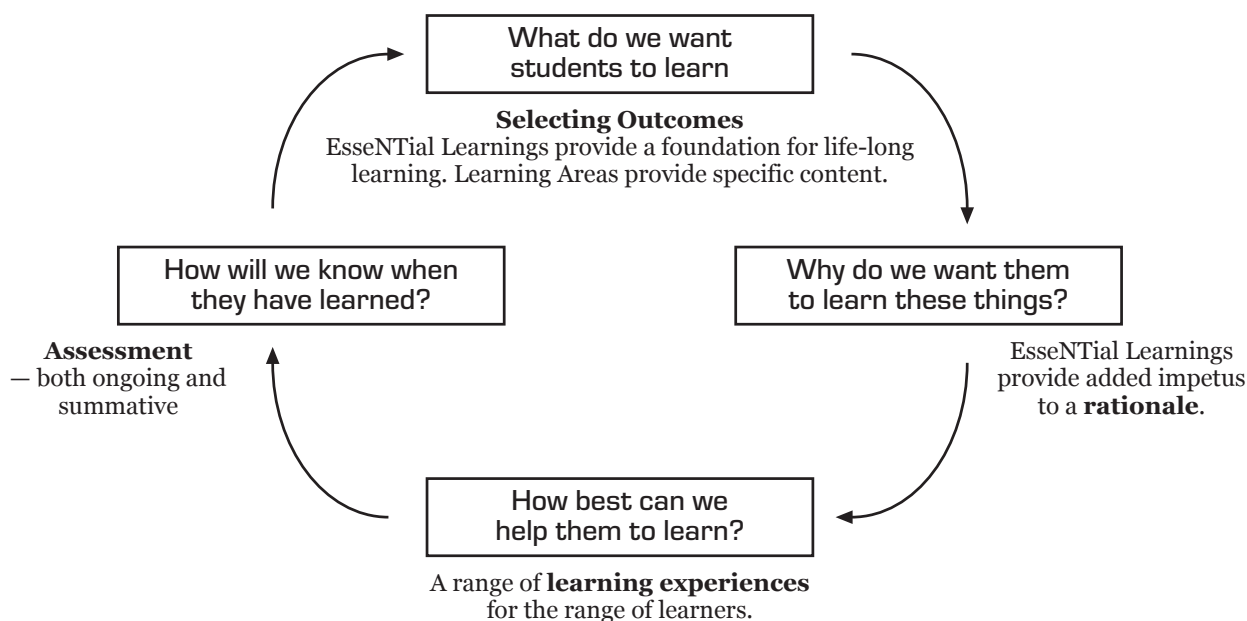
- appropriate and efficient application of skills, concepts and techniques in a range of contexts;
- effective and meaningful communication of mathematical thinking;
- appropriate and varied ways of working through mathematical investigations;
- effective and appropriate use of technologies and other equipment, including the ability to recognise, link and extend multiple representations;
- generalisation – when learners are given a context or problem that they explore and express in their own words, make a generalisation, justify it and apply the generalisation to other contexts.

The five overarching mathematical outcomes are clearly interrelated with each other, as well as with the Mathematics Learning Area and EsseNTial Learnings. These overarching outcomes provide the rationale for teaching, assessing and reporting on learners’ mathematical achievements in a rich process-oriented manner.

## Planning for outcomes – the NTCF model

The NTCF is based on an outcome-focussed approach and accepts that learning progresses along an identifiable developmental continuum. Outcomes describe the observable changes in students' learning. Consequently, outcomes inform classroom programming and are used to make judgements about student progress. Of particular note are four principles of outcomes-focussed learning (NTCF, p. 3):

- Clarity of focus directs attention towards the learning outcomes that are appropriate for the developmental levels of the students. It is critical that the outcomes are made explicit to students, teachers, parents and significant others in the community to enable all partners in education to assist students to achieve the outcomes.
- High expectations provide opportunities for all students to reach the levels of which they are capable and are designed to extend teachers and students expectations of what they will come to know and be able to do.
- Focus on development emphasises the expected sequence of conceptual and cognitive development and acknowledges the range of developmental differences between students.
- Design down-deliver up model for curriculum planning and assessment is underpinned by a student centred approach to learning and teaching. The following diagram identifies 4 questions to direct teachers planning, designing-down from the outcomes.



Expanded opportunities allows for a range of contexts, multiple opportunities and support for students to learn and to demonstrate achievement of outcomes. It recognises that students have different learning needs and all will not necessarily be ready to demonstrate learning outcomes in the same way or at the same time.

## The way forward

A model for analysing teacher change presented to me while attending a professional development course presented by the NTCF development team (Curriculum Services Branch, NTDEET, 2000) suggested that teachers can be identified along a ‘change adoption continuum’. At one end of the continuum is ‘traditional teaching’. I understand this to mean a teacher who programs around content expected to be presented at a given year level for a given subject or topic. At the other end of the continuum is ‘transformational teaching’. I take this to mean a teacher who is programming to outcomes and can take account of student needs and interests both within and across a range of learning areas and growth points/bands within learning areas. In the middle appears ‘transitional teaching’. My own teaching approach is somewhere near the middle of this continuum and is contingent on the learning area I am programming (I feel more comfortable ‘taking risks’ in areas that I have greater content and pedagogical knowledge), my knowledge of the students and resources with which I am familiar and have access to.

Understanding and implementing an outcomes-focussed approach in the classroom has been (and still remains) a challenge to me. However, active participation in the development of the NTCF, talking to supportive colleagues, trying new ideas and questioning ‘traditional’ views of teaching and learning is assisting my own personal learning journey. The remainder of this paper will highlight aspects of my teaching program and my quest to improve numeracy outcomes for students.



Preparing students for success — a range of classroom and playground exercises preceded this Orienteering Trail conducted at a class camp in Litchfield National Park.

## Selecting outcomes — what do I want the students to learn and why?

At the commencement of the 2002 academic year I resolved to program across all curriculum areas using the emerging NTCF. To inform the process of selecting outcomes described in the Mathematics Learning Area and EsseNTial Learnings (that support ‘working mathematically’), I collected baseline data in order to determine the needs of the students. This was achieved in a number of ways:

- Conducting a ‘review paper’ which tested a range of ‘basic’ skills and documenting a class error analysis. I wrote these items to assess skills between Bands 2 and 3 of the NTCF.
- Asking the students to identify their strengths, weaknesses and suggest areas where they feel assistance is required.
- Conducting a practical group activity that would provide evidence to assist identify outcomes for EsseNTial Learnings including cooperative problem-solving utilising a range of mathematical and non-mathematical skills. The particular task chosen for this was an activity called ‘Lunchbox for Cubies’ which required students to construct a ‘lunchbox’ that would hold 12 cubes, and, describe how they solved the problem.
- Reviewing student record folders and reports from previous teachers including previous Multilevel Assessment Program results for Year 6 students.

After this process, which took approximately three weeks, I developed a picture of where my students were broadly positioned along the develop-

mental continuum and what knowledge and skills would need to be programmed. I then developed a Year Overview stating the outcomes that would focus on during the academic year at Bands 3 and 4. Once this was documented, I developed a Term Overview to cater for students consolidating skills at Band 2, developing skills as Band 3 and consolidating skills at Band 3 (skills at Band 4 will be programmed later in the academic year). I also documented two Individual Education Plans (IEPs) in Key Growth Point 3 and Band 1 to cater for the needs of two identified special needs students.

In the Term Overviews, documented in a week-by-week table, I selected key concept areas in at least two strands of the Mathematics Learning Area to be developed each week. With the benefit of an on-line NTCF I was able to efficiently copy and paste related outcomes from each concept area side-by-side in the overview table. This proved to be very helpful when writing my Day Program as it showed the progression in the developmental continuum at a glance and would assist in the selection of appropriate multi-level learning experiences, as well as provide a reference to outcomes for assessing student achievement.

In some instances, student outcomes were identified in the presentation of explicit mathematics lessons. In other cases, outcomes would be identified through cross-curricula units that I planned; e.g. a Studies of Asia unit based on *Asia Counts* materials and Science learning experiences in the topics dealing with outer space and geology of the Earth.

In considering the selection of outcomes, and the development of learning experiences, I continually reflect on the question of 'Why do the students need to learn this?'. This reflection is not a new process for me. In my initial teaching training course at Sturt CAE in the early 1980s this was impressed upon me. Lecturers such as Alan Larkin and Jeff Baxter clearly expressed the view that 'mathematics is everywhere' and 'maths is NOT THAT which is in textbooks!' and was brilliantly backed up by *Donald in Mathmagicland!* This view of mathematics teaching has been incorporated in my teaching in many ways and will be described later in this paper. At this point I will just state that at the forefront of my teaching is the desire to make students aware of what they need to know and be able to do, as well developing an understanding of why it is important to know certain knowledge and processes in mathematics.

## **Selecting student learning activities: How best can I help them learn?**

There are a number of ideas I wish to describe in response to the above question.

### **Employing a range of methodologies**

Given the nature of learning, that is students learn in different ways and at different rates, I implement a range of different learning experiences. For instance, I sometimes group students based around needs (whether they be mathematical or non-mathematical) or allow students to work collaboratively with preferred classmates. On other occasions I may require students to work independently. At times I structure a series of lessons with explicit teaching to whole class or conducting specific needs-based clinics with subsets of the class. At times I provide open-ended, multi-level tasks, on other occasions more individual 'drill and practice' exercises.

I use an activity orientation in presenting mathematics learning experi-



ences to students and I also occasionally use textbooks as students need to be efficient at learning through this medium particularly at the secondary and tertiary levels.

### **Allowing students to express mathematical understandings in many forms**

To cater for the diverse learning styles of students in my classroom, I provide opportunities for students to represent their learning in many ways; e.g. using a range of forms including verbal, concrete, pictorial, symbolic and written words to represent ideas. I accept that students should be encouraged to express their mathematical discoveries and learning in their own natural language, before they are expected to use the more formal language of mathematics consistently. I am usually very explicit in introducing appropriate terminology to students and I insist on students recording definitions of key concepts in mathematics into their journals (exercise book) and ‘glossary of terms’. For example, when describing three-dimensional objects I may ask a question such as, ‘Are there words that mathematicians use to describe features of this object?’ A list of terms is then brainstormed and terms such as vertex, edge and face are explicitly noted and explained.

I also note at this point in time that I strongly encourage and model the use of manipulative support materials and information technology such as electronic calculators. I particularly emphasise this when working with upper primary and junior secondary classes as at times it may be perceived by students as ‘not cool’ to use materials. At all times I have a range of materials which students have ready access to and I ensure that each student has a calculator and knows how and when to use it.

### **Preparing students to succeed with mathematics today and tomorrow**

I aim to provide learning experiences that enable students to successfully use mathematics in school and in the outside world – this is what numeracy is all about! To do this I make outcomes, work requirements and assessment criteria clear to students. This is often done by means of:

- explicit oral statements,
- a review checklist, or in the case of group activities,
- an assessment proforma.

In planning for student learning I carefully analyse tasks to establish what prerequisite knowledge or skills that are required. For example,

- For the McPizza ‘rich task’ described later in this paper I ensured that students had a good understanding of the construction of 3-D objects and representing such objects in both isometric and orthogonal views through explicit instruction and practising drawing such views using isometric and squared dot paper respectively.
- In preparation for taking students to Litchfield National Park for a camp that had a range of outdoor recreation activities such as orienteering I ensured that students could use a magnetic compass to determine directions and were able to measure distances using their own paces.
- In asking students to calculate the circumference and diameter of a water pipe at Manton Dam I conducted a range of practical activities such as MCTP’s ‘How far is it around a circle?’ (Lovitt & Clarke, 1992, p. 209), then measuring the circumference of plates and lids using string which may lead students to the appreciation of the formula for calculating circumference  $C = 2\pi r$ .

- In preparing students for the Multilevel Assessment Program (MAP), a system-wide numeracy test to report student achievement against national benchmarks, I make no apologies for teaching students how to take tests. Students need to become familiar with the type of test items they are likely to encounter in the MAP and other formal test situations. In the lead-up period to the administration of this assessment instrument I provide opportunities for students to practise published sample questions. In this process I provide explicit instruction in how to read, interpret and answer such questions and often this process leads to students responding with other questions such as ‘How do you do...?’ I find this process of examining test items assists students to understand what the test items are trying to find out about their mathematical knowledge and skills.

### Providing relevant, interesting and challenging learning experiences

In order to create a positive attitude towards learning, I plan experiences that I think will not only advance student learning but ones that will be of interest to them. To do this I consider the following strategies useful when working with upper primary students.

Where possible, I relate the mathematics knowledge and skills being developed to the real world. Ways in which I do this include having students complete concepts maps or analysing print materials for the mathematics embedded within them; e.g. when working on the notion of fractions I start by asking students to make a concept map which requires them to list all they can about fractions.

I also use leading questions to stimulate thought, such as, ‘Where do you see fractions?’ and ‘How can fractions help you?’ I also have a collection of print materials such as shopping catalogues, timetables, maps, postage stamps, pages from a telephone directory, Internet time purchase plans, football draw, weather maps and take-away restaurant menus etc. which students can analyse for mathematical content. After completing such an analysis, I ask students to report back what mathematical knowledge and skills are needed to understand such materials.

I work hard to find activities that I believe will capture the interest of students. For example, I make use of the competitiveness of students by developing activities such as the Manton Dam Challenge; a type of maths trail and an orienteering course based on the collection of check point codes and completion of mathematical questions. In the former example, students were requested to secure the answers to a series of tasks while visiting a nature reserve as part of a camp program. I awarded points for completion of tasks and bonus points were awarded for additional ‘challenges’ being met. The competitiveness of the students acted as a motivator for teams of students to successfully engage in the use of mathematics in completing the challenges.

There are also a swag of suitable ‘games’ and ‘puzzles’ that challenge students to do their best. For example, the number guessing game *Celebrity Number* challenges students to guess in as few guesses as possible a ‘celebrity number’ that is a member of a set of numbers represented on a number line. The number sense activity *Find a Path*, from McIntosh and Reys’ resource book, challenges students to find a path through a network to a specified number by conducting a series of operations on a given starting number. Even more challenging for students is when they have the opportu-



Students were prepared for this circle measurement application with hands-on experiences at school before embarking on the field trip to Manton Dam.

nity to create their own *Find a Path* puzzles and give them to their mates to solve. I use these types of activities as a 'warm-up' activity to start a learning episode, to finish a lesson or as a transition activity between lessons 'just for fun'!

Stepping beyond the classroom as a teaching/learning space can also provide excellent opportunities and motivation for students to develop mathematical knowledge, as well as promote positive attitudes and appreciations towards the study of mathematics. Moreover, students have the opportunity to engage in real world, practical applications of mathematics through carefully planned outdoor learning experiences, as recognised in the *Mathematics Curriculum and Teaching Program* (Lovitt & Clarke, 1992, p. 4) a range of features which characterise a quality learning environment.

Some of these features which are evident in well-conceived outdoor activities include:

- students involved physically in the learning process;
- students encouraged to learn together in cooperative small groups;
- is non-threatening and encourages participation of all students; and
- responds to the interests, concerns and personal world of the students.

I have found a bounty of opportunities exist to utilise the outdoors, taking advantage of the pleasant climate in the Northern Territory, to orchestrate learning experiences, not only in mathematics, but also through integration with outcomes stated in other learning areas; e.g. Studies of Society and Environment, Science and Physical Education.

There are two other points that I would like to explain in the provision of interesting learning experiences to students. The significance of students working collaboratively with partners or groups cannot be overlooked. Friendships and peer acceptance is a high priority for many upper primary-aged students. This can be used to good advantage in developing activities in mathematics. I recently planned a series of 'guess and check' practical measurement stations in which students worked cooperatively to complete a range of measurement challenges. Enabling students to work with a partner to complete the stations not only helped with resourcing in this area of the program, but also provided students with valuable opportunities to discuss and share their results with one another.

Lastly, the use of information technology such as electronic calculators and personal computers has provided motivation to engage in mathematics learning. This was particularly highlighted to me in a recent rich task activity in which students found access to a calculator to complete routine operations a great resource. Another recent example was in a mathematics project set as homework during national Literacy and Numeracy Week in which I requested that students research a famous mathematician and present a brief report about the mathematician and their contribution to mathematics. Several students who struggle with mathematics and language were able to successfully locate information about mathematicians through the Internet and produced impressive reports which demonstrated mathematical and non-mathematical outcomes.

## Using rich tasks

A rich task, to my way of thinking, is a learning experience that may extend over several lessons or days that simulates a real life problem-solving experience that is beyond ‘school mathematics’. With the advent of outcome-focussed learning, I see great potential to use rich tasks to promote the achievement of student outcomes not only in the Mathematics Learning



In the McPizza Task students used a range of strategies to design their McPizza box. In this image the student uses a net from a box to assist drawing a net for her own box.

Area but across other Learning Areas and the EsseNTial Learnings. Although I am not greatly experienced in using rich tasks, I have made a commitment to develop rich tasks as part of my program with students engaging in at least one rich task each semester. As my confidence increases with this approach I am sure to make greater use of these tasks because a well-planned rich task:

- provides an opportunity for students to choose from, and to use, a range of mathematical and non-mathematical skills and to use them in an integrated, creative and purposeful fashion;
- gives students the chance to use their knowledge and skills in real or authentic ways, that is, in the same ways that good problem-solvers do in the real/authentic world outside of school (Flewelling & Higginson, 2001, p. 12);
- integrates outcomes from EsseNTial Learnings and a range of Learning Areas other than Mathematics;
- integrates outcomes across strands of the Mathematics Learning Area, e.g. measurement and data sense and spatial sense;
- enables students of varying ability to successfully demonstrate their current knowledge and skills;
- allows students to work at their own pace and get assistance when needed (rich tasks are measured not in seconds or minutes, but in hours and days!);
- enables a variety of strategies to be used to assess student learning; and
- encourages students to engage in the action learning cycle: Plan... Do... Reflect.

What is refreshing about this approach to presenting mathematics learning experiences to students is that the role of the teacher becomes that of a facilitator and mentor. Students, through engaging in the action learning cycle, begin to direct their own learning. This is achieved by exploring ideas and understanding the problem or task presented to them, preparing and implementing a plan, evaluating the success of their plan and if necessary modifying their plans or try new ideas, communicating their learning in either oral or written form.

The subtitle for this paper, ‘McPizza – the shape of things to come?’, is the title of a rich task recently conducted in my classroom. This rich task simulates the actions of a research and development team in the corporate world – the company with the ‘Golden Arches’. The students formed research and development partnerships to design a ‘new taste’ menu item for McDonalds: McPizza. In a memo presented to the research and development teams, the ‘Managing Director’ (teacher) directs the teams to develop an affordable pizza recipe and practical packaging to meet the target market (teenagers and families). The teams were given resources (paper, card, grocery items, etc.) and time (about six hours) to make recommendations in both writing (including drawings, plans and 3-D models) and a two minute video presentation to the Managing Director. In a research and development



The R & D teams were asked to represent their recommendations in both a written report and oral presentation (to be video-taped). The opportunity to express their mathematical [and non-mathematical] thoughts in a variety of ways helped provide valuable evidence of learning outcomes achieved.

team meeting in the ‘board room of the Golden Arches’, teams would make their presentations and be evaluated by their peers on an established criteria.

There were many benefits to students engaged in this rich task including:

- a high level of student motivation to complete the task, especially constructing 3-D models and baking the pizza;
- opportunities to apply knowledge and skills across all strands of the Mathematics Learning Area and other Learning Areas predominantly English and the EsseNTial Learnings (group cooperation skills and problem-solving skills);
- all students contributed to their team reports and completed the task; and
- there were many significant ‘teachable moments’: how do you work out the size of the rectangular piece that forms part of a cylinder’s net? How can I work out the volume of a cylinder? How can I work out the unit cost of ham required on a pizza given a 500 g pack costs \$4.10? etc.

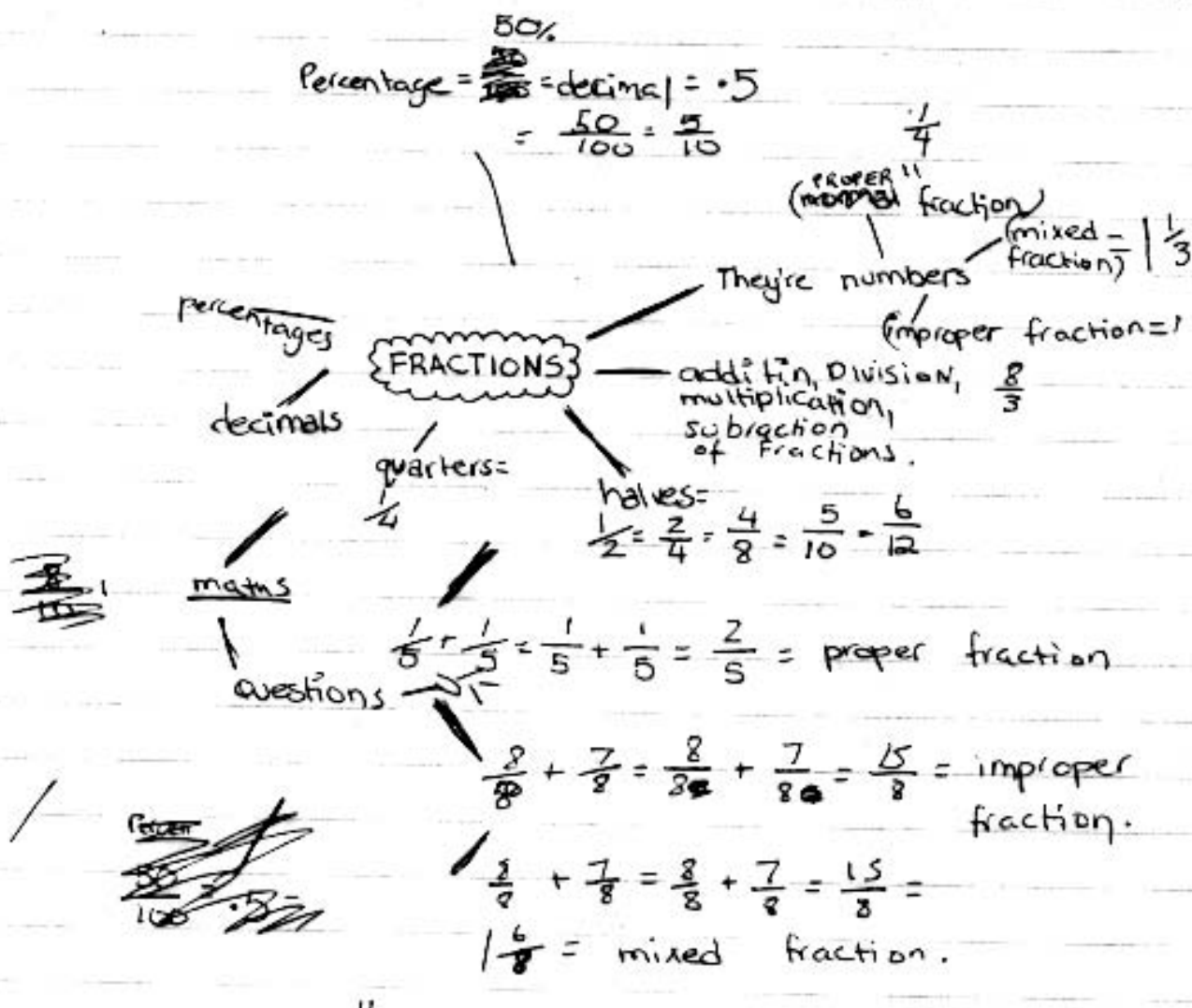
## **Assessment and reporting — how will I know when they have learned?**

In my numeracy program I use a range of formative and summative assessment techniques including:

- learning journals which document lesson notes, explanations, glossary terms, worked examples, solutions to problems etc;
- models, projects and ‘products’ with accompanying assessment criteria / rubrics;
- student self-evaluation sheets;
- anecdotal observations and comments about student performance
- annotated work samples;
- written tests with an error analysis to ascertain what the students have learnt; and
- individual student analysis of multilevel assessment program achievements.

An interesting development in the assessment and reporting of student outcomes in Parap Primary School has been the development of Student Learning Portfolios. Currently, the staff at Parap have agreed in principle to developing Student Learning Portfolios that will contain ‘snapshots of student learning’ which can be shared with parents in student-led or three-way conferences. In the area of numeracy it is anticipated that each student will complete one assessment task each term. The task would be devised and consequently moderated by sub-school teams (e.g. Year 6/7 teachers). The task would be noted on a standard proforma that would describe the task and the outcomes to be assessed. Performance indicators would be developed to describe specific knowledge and skills expected to be demonstrated by students.

The staff at Parap primary School are excited about the prospect of moving away from traditional teacher-parent interviews and written summative reports to more meaningful ways of reporting student outcomes such as three-way conferences in which students set learning goals and student-led conferences which highlight achievements in a range of ways including displaying student learning portfolios, work books, products, photographs, video tapes and actual demonstrations of developed skills.



Pre- or post-instruction concepts maps can be a valuable strategy for assessing student understandings about topics studied. This work sample indicates that the student can successfully use the language of fractions, although there are no explicit links to how fractions might be used to solve problems in 'real life'.

## McPizza... the shape of the future?

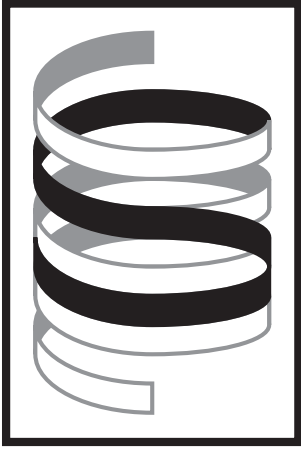
In this paper I have highlighted aspects of the Northern Territory Curriculum Framework and how I have implemented the NTCF within my teaching context to develop student numeracy outcomes. I still have some way to travel along the learning journey to feel entirely satisfied with my transformation to an effective outcomes-focussed approach. However, my recent learning has been significant, as too has been the learning of my 'research and development teams' making and packaging McPizza in Room Four!

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## Acknowledgements

I wish to acknowledge my MTANT colleagues Barry Kepert (Parap Primary School) and Josie Roberts (Numeracy Project Officer, Northern Territory Open Education Centre) for being critical friends during the documentation of this paper. I would also like to acknowledge the students in Room 4 at Parap Primary School who have allowed me to use their work and photographs in this paper.



# Mental munchies — Putting theory into practice

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## What are mental munchies?

- Teacher: What are Mental Munchies?  
7 year-old: Well, you can't use your fingers; you have to use your head.  
Teacher: What goes on in your head?  
7 year-old: Your thinking of course!

**8**5% of calculations done by adults in their daily lives involve mental computation. In comparison, paper-and-pencil calculations and calculators are only involved in 10% and 5% of calculations respectively (Northcote & McIntosh, 1999).

## About the project

One of the basic components of numeracy is mental computation. Unfortunately the classroom reality is that children predominantly use inefficient counting strategies for mental computations and are not explicitly taught mental computation skills, as this is currently not a curriculum requirement. In August 2001, several schools from around the state of Tasmania embarked on a government funded 'Developing Computation' project led by Alistair McIntosh from the University of Tasmania. Alistair McIntosh, Markus Bucher, Shelley Dole and Joy Edmunds formed the research 'team' behind this project. This presentation represents two teachers' experiences of the practical implementation of this project.

## Project requirements

Teachers and classes that took part in the project were from Years 2, 3 and 4. The most important requirement for this project was that teachers were not to teach children 'vertical algorithms'. Initially, this was a source of considerable consternation for most of the teachers participating, as this has traditionally been the fundamental teaching tool for demonstrating the concept of place value. Abandoning vertical algorithms was essential, as the children at the formative phase of the project, were asked to solve addition and subtraction algorithms mentally. Vertical algorithms dictate a rigid set



of rules and strategies that do not allow the freedom to manipulate numbers mentally in the way the project hoped to encourage children to do. Although the project dictated that children calculate addition and subtraction algorithms mentally, written computations were permitted, as long as they were specifically used by the child to record and explain his/her thinking processes.

## Mental facts — Stage One

One of the prerequisites for mental computation is the instant recall of basic facts. Children need to have a thorough knowledge of these ‘mental facts’ before they explore the sub-skills and strategies in Stages Two to Five of the program. Teachers from around the state and from a variety of different schools met on a regular basis to share activities and ideas that could assist the teaching of these ‘mental facts’ to children. The majority of activities were ‘hands on’ and visual, as young children tend to retain and understand information more readily when given a visual base.

### Teaching Sequence

<i>Addition</i>	<i>Subtraction</i>
Doubles	Halves
Tens facts	Tens facts
Count on 0,1,2,3	Count Back 0,1,2,3
Add 10	Subtract 10
Bridge 10 from 8 and 9	Bridge to 10 from 8 and 9
Near doubles	Near doubles

## Using mental facts to solve real problems

In order to cater for the different needs of the children within my Year Two class at Fahan School, I (Kristen) constructed a Mathematics Learning Centre where ‘open ended’ problems were displayed for children to solve. The children were given ‘recording paper’ to explain how they ‘worked out’ the problem on display and resources were available for the children to use if they wished. At the end of every week the children were asked to share their ‘working out’, and this gave them the opportunity to discuss the different strategies they could use to solve the problem. This also allowed the children to discover which strategies were the most practical and efficient. This is an example of an ‘open ended’ problem posed to the children in my class. Twenty two oranges were left on display for the children to refer to if needed. Each child was given a ‘recording book’ with their own copy of the problem and a space for them to record their ‘working out’.


### The Orange Problem

- I. Count the oranges.
- II. How many pieces of orange would there be if you cut each orange in half?
- III. How many would there be if you cut each piece in half again?



There are 22 oranges. Double 2 is four, double 20 is 40. The answer for the first cut of the oranges is 44! Double 4 is 8. Double 40 is 80! Put them together and you've got 88!

88 is the final answer!



Three children preferred to use the oranges as a concrete aid and began counting the oranges in twos. This method worked initially and the children were able to calculate forty four halves from twenty two oranges. However, the children lost count and became confused when calculating the quarters, demonstrating that this strategy did not work as well with large numbers (in this case pieces of orange). The majority of the children in my class were able to use their mental 'double' facts to solve this problem without using the oranges as a visual base to find the solution.

### Real problems have real answers!

After sharing each child's recordings we started cutting up the oranges. The children naturally started talking about halves and quarters exploring the concepts of fractions, shape and division. This was in the context of the child-directed conversation that ensued as we cut up the oranges. The children screamed with glee when we confirmed their answers: forty four halves and eighty eight quarters — yummy Mental Maths! We shared the orange pieces out and the children had lots of fun eating them all up!

This problem is an example of how the 'Mental Facts' in Stage One of the Developing Computation Project can be used in infant classes. When children have a good understanding of basic facts, e.g.:  $2+2=4$ , they quickly generalise:  $20+20=40$ ,  $22+22=44$ . This is clearly shown in the recordings produced by the children in my class. When children have a firm knowledge of the 'Mental

Facts' they are able to use this as a foundation for the strategies they use in many areas of the mathematics curriculum.

### Subskills for adding and subtracting two digit numbers — Stages Two–Five

Once children are able to respond spontaneously to questions related to the basic facts in Stage One, they are ready to explore addition and subtraction of two digit numbers.

In teaching the basic skills in mental computation to my Year 2 class at The Friends' School, I (Gai) have encouraged and celebrated with the children the diversity of strategies that they consistently use. Children need to have the freedom to choose the strategy which best suits their style of calculating. Given a broad experience, together with success and positive



affirmation, students will not only choose the strategy which suits them but they will clearly articulate their thinking providing reasons for choosing that strategy.

For example, when asked to mentally calculate  $45 + 55$  one child may see this as a doubles fact ('I take the 45 up to 50 and the 55 back to 50 and add 50 and 50,' said Max), whereas another student splits the tens, adds the 40 and 50 and makes another ten using their tens fact knowledge from the 5 and 5 (all mentally) 'and that makes 100,' said Andrew.

Other examples of this use of different strategies in subtraction are the responses received for the mental calculating of  $64 - 9$ . All children in my class have come to realise that counting back 9 from 64 is not only an inefficient method but is dangerous, in that miscounting and inaccuracy are very easy to achieve. One student might split the 9 into a 4 and a 5 because the first number is 64, then take away the 4 (thus going back to the nearest multiple of ten) and then take away the 5. Another student would take 10 from 64 and then add 1 on and another may make up 64 in their mind as a 50 and a 14 and take 9 from 14 leaving the 5 to add on to the 50. These are all valid and accurate methods for Year 2 students to be using.

The main point is that no one particular strategy is more appropriate than another. It is what works for the individual that matters! We would be doing our students a great disservice to insist on the use of one method only to calculate! Students will not come to understand these strategies without teaching which is explicit. The strategies have been taught to both of these Year 2 classes using a variety of games and activities, all followed up with sharing sessions and opportunities for individuals to explain their workings out.

Below is a list of the subskills that need to be taught in order for the students develop a deeper understanding of connections within our number system.

### **Stages and subskills for adding and subtracting two digit numbers**

- Splitting a two digit number; e.g.  $37 = 30 + 7$ ,  $50 = 57 - 7$ .
- Adding and subtracting any two digit multiple of ten to a single digit number; e.g.  $50 + 6$ .
- Subtracting units digit from a two digit number; e.g.  $67 - 7$ .
- Subtracting tens digit from a two digit number; e.g.  $67 - 60$ .
- Counting on and back in multiples of ten; e.g. 30, 40, 50..., 37, 47, 57...
- Rounding the two digit number to the nearest ten; e.g.  $57 + ? = 60$ .
- Adding a single digit to any two digit number; e.g.  $25 + 7$ .
- Subtracting any two digit number from the next multiple of ten; e.g.  $60 - 57$ .
- Subtracting a single digit from any two digit number; e.g.  $53 - 7$ .
- Doubling any two digit multiple of ten; e.g.  $60 + 60$ .
- Adding and subtracting two digit multiples of ten; e.g.  $40 + 70$ ,  $90 - 50$ .
- Subtracting any two digit multiple of ten from its double.
- Subtracting any two digit multiple of ten from any multiple of ten.
- Adding a two digit multiple of ten to any two digit number; e.g.  $74 + 40$ .
- Splitting a two digit number into any tens and ones  $37 = 20 + 17$ .
- Subtracting a two digit multiple of ten from any two digit number; e.g.  $74 - 30$ .
- Give the complement to 100 for any two digit number; e.g.  $73 + ? = 100$ .

## When children have strengthened mental facts and strategies how do they solve problems?

Once children have a thorough understanding of basic number facts, Stage One of the program, they can then learn the subskills and strategies in Stages Two – Five. Through learning a variety of strategies and skills the children begin to develop a solid understanding of place value and the number system in general. As a result of this solid foundation, children are able to make choices about the most efficient strategy to use in relation to the problem.

[To demonstrate the effectiveness of allowing young students to choose their own strategy/ies opposed to teaching the traditional vertical algorithm method we presented a short video depicting students in an unrehearsed classroom situation. Students were asked to mentally calculate a number of problems and then explain the strategy used.]

### Effective strategies used by Year 2, 3 and 4 students shown on the video

- $16 + 9 =$  Olivia – Splitting the tens and adding on in 3s  
 $25 + 25 =$  Andrew – Splitting the tens  
 John – Doubles  
 $61 + 19 =$  Callan – Using a tens fact to solve a two digit addition and adding two digit multiples of ten, splitting the tens  
 $15 - 7 =$  Peta and Oliver L. – Near doubles and doubles  
 $21 - 6 =$  Oliver W. – Subtracting units from a two digit number – took away 1 and then 5  
 $22 - 11 =$  John – Doubles  
 $35 - 16 =$  Oliver – an unorthodox method demonstrating understanding of subtraction into negative numbers.  
 ‘You take 10 from 30 this is splitting the tens and that makes 20, then take 6 from 5, that’s minus 1. Take that 1 from the 20 and the answer is 19,’ said Oliver.  
 $45 + 55 =$  Max – rounding up and down to nearest multiple of ten, doubling  
 $53 - 27 =$  Tom – turns a subtraction into an addition, takes each number to nearest multiple of ten

## Parental feedback

Here are some of the written comments received from parents of Year 2 students:

Her maths development has been quite dramatic with simple maths done much faster in her head. An excellent project which has definitely shown results in my daughter.

My daughter's numeracy has developed extremely well, we're very happy.

My daughter is very keen to try maths problems. She thoroughly enjoys it and has certainly advanced dramatically.

My daughter's understanding of mathematical concepts and operations has improved notably this year. She has gained confidence in her ability to complete mathematical problems and appears to have developed a range of strategies to assist her in this process.

## How has this project affected our students?

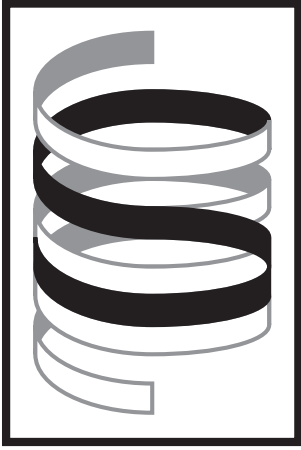
- One of the most positive outcomes from being involved in this project is that the children in our classes are displaying a better understanding of place value.
- The mastering of 'mental facts' has helped the children understand other concepts across the curriculum.
- Parents have, throughout the year, commented on how surprised they have been to see their child calculate numbers mentally in everyday circumstances outside of the school environment.
- Having a large bank of strategies to rely on gives the child the flexibility to choose the most efficient strategy/ies to mentally solve a problem.
- Based on our experience with the project over the past year, we are convinced that the teaching of basic 'mental facts' and strategies dramatically improves children's numeracy.

## More information

For more information about the project please contact Alistair McIntosh at the University of Tasmania.

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# Indigenous Outback Numeracy Project

Sue Hendricks

Sunset State School  
Queensland

Sue Hendricks has been teaching in Education Queensland as a primary teacher since 1989. Over half of this time has been spent in Aboriginal and Torres Strait Islander education and as a result her teaching career has taken her to many far-flung places around the state: Yarrabah State School (Aboriginal Community south-east of Cairns), Malu Kiwai State School (on Boigu Island in the Torres Strait) and Thursday Island State School, just to name a few. The last few years, Sue has been living in Mount Isa, a town in the far north-west of Queensland, where she has been an Education Adviser – Curriculum/ Outcomes Education, then Coordinator of the Mount Isa District Staff College and more recently the Director of the Technology, Mathematics and Science Centre of Excellence at Sunset State School.

Improving Indigenous performance in mathematics is of the highest priority for Australian educational systems. This project, the Indigenous Outback Numeracy Project (INOP), is in the first stage of an anticipated three-year research program, which aims to determine how schools can enhance mathematics teaching so that numeracy outcomes for Indigenous students are improved.

Sunset State School is a state government primary school in Mount Isa, and one of eight Technology, Mathematics and Science Centres of Excellence that have been centrally selected from around Queensland. One of its major roles is to develop programs that will improve numeracy learning outcomes for Indigenous students. To achieve this goal, Sunset State School has formed a partnership with mathematics educators (Prof. Tom Cooper and Dr Annette Baturo) from the Centre for Mathematics and Science Education at Queensland University of Technology (QUT) and the School of Education (Dr Elizabeth Warren) at the Australian Catholic University (ACU). Furthermore, through the involvement on the research team of Ms Eva DeVries, the Queensland Studies Authority (QSA) will use the findings from this project to help determine the new mathematics P–10 syllabus that is due in schools in 2004. This report represents the first year of a three-year program.

The education district of Mount Isa covers a huge land area of northwest Queensland. Most of our rural and remote schools have a high percentage of Aboriginal students. The two schools that have joined Sunset State School in this research project include Dajarra and Boulia State Schools; and they are one and half hours and three hours drive south of Mount Isa respectively.

Sunset State School is a state primary school in Mount Isa with a student enrolment of 340 and 60% of these students are Indigenous. Sunset State School caters for Preschool, Years 1–7 and special needs children through the Special Education Unit. Through its Centre for Excellence, a Director and a Computer Assistant have been employed. In this project, researchers from QUT and ACU have worked collaboratively with 12 teachers at Sunset State School and 5 teachers from two other schools in the Mount Isa region (Dajarra & Boulia State Schools) to investigate the effect of improved teachers' knowledge of content, pedagogy and learning on the effectiveness of Indigenous learning of number, operations and measurement. At Sunset State School, teachers have their own full time teacher aide from 8.30 am until 1.00 pm everyday. Sunset State School was the largest school in Mount

Isa but as the population of the town is dwindling, so too is the size of our school; as a result, each classroom teacher has the luxury of a double teaching space for their class.

## Aims and expected outcomes from the IONP

### Aims

- To identify classroom practices (contexts, problems, materials, activities and language) that improve Indigenous students' learning outcomes in number, operations and measurement.
- To determine teachers' knowledge and beliefs that facilitate the development and implementation of those classroom practices.
- To identify professional development activities that change teachers' knowledge and beliefs to those in the previous aim.
- To develop models that explain how professional development can affect teachers' knowledge, beliefs and classroom practices and improve learning outcomes for Indigenous students in number, operations and measurement.
- To improve Indigenous teacher aides' mathematically-based knowledge and classroom support skills (as an outcome of the first year of our project).

### Outcomes

- Better mathematics teaching, improved teachers' mathematics knowledge and beliefs, and enhanced mathematics learning outcomes for Indigenous students in the Mount Isa region.
- Examples of instructional activities effective in teaching number, operations and measurement to Indigenous students.
- Examples of professional development activities effective in changing teachers' knowledge and beliefs with respect to number, operations, measurement and Indigenous students.

The researcher's major role has been to work collaboratively with the

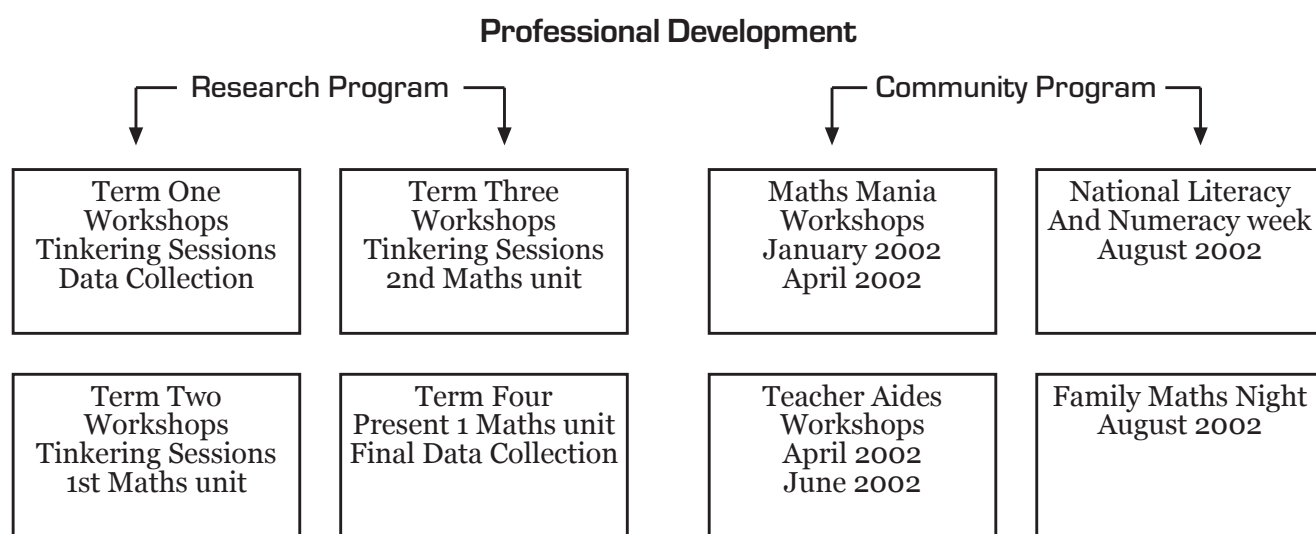


Figure 1

seventeen teachers and their Indigenous students to improve the learning outcomes of students in number, operations and measurement through enhancing teachers' knowledge and classroom practices. Information on new classroom practices has been disseminated through four in-service workshops across 2002 (one in each term); these have been developed to cater to the teachers' needs. In between these workshops, teachers have trialled new classroom activities, reflected on their practices, gathered data on their students and written 2 mathematics units. The researchers have also visited once a term to support teachers in their classrooms with the development of activities and the writing of their mathematics projects. These mathematics projects have been put up on the Learning Place website for other Education Queensland teachers to view (<http://www.learningplace.com.au/communities/thecommunity.asp?orgid=12&suborgid=112&ssid=&pid=&ppid=&uid>).

The researchers have:

- surveyed the teachers re their knowledge and beliefs;
- observed the teachers during the in-service workshops and in their classrooms;
- interviewed teachers re their perceptions of new practices and their students' reactions to new practices.

The teachers have:

- tested their students re-performance on number, operations and measurement using the Diagnostic Mathematical Tasks (DMTs) (Schlesiger, 1993);
- surveyed their students on their beliefs about the importance of mathematics, their interest in mathematics, and their self concept regarding doing mathematics;
- collected artefacts (e.g., teachers plans and programs, students' work and photographs).

## **Classroom practice**

Teachers planned their own mathematics units based on the five-part framework below.

### **Five-part framework**

1. Title
2. Assumptions about mathematics
3. Assumptions about learners
4. Scope and sequence (including outcomes)
5. Learning Activities Engage, Explore, Explain, Elaborate, Evaluate
6. Evaluation and reflection

Photos and teacher comments from one of these units (Year 1) will now be elaborated on.

### **Money Unit — Year 1**

The teachers thought that the children would know more about the concept of money. The children could name purses, wallets, credit cards etc but did not know that people worked for money. Some comments were 'Jesus brings you money,' and 'The tooth fairy brings you money,' or 'You get money out of the machine'. Teachers were surprised with the children's level of knowl-



edge — how little they knew of what money was used for. The children also displayed no initial interest in money and appeared to have little or no concept of change. To offset this the children bought in 50 cents and the class went to the tuckshop to buy a funny face iceblock for 40 cents and they had to get change (Figure 2). The teachers were developing the whole idea of getting change in a real life setting. The children really enjoyed this activity.

In Figure 3, the children are making up their own pattern using play money. The teachers were very impressed with the language that the children were using in their pattern activities ‘straight edges, round, straight edges round’ and ‘circle, 12 sides, circle, 12 sides’.

These purple cards (Figure 4) had food items cut out from junk mail glued on to them with a price. The prices were numerical values that would match to a coin (i.e. 5c, 10c, 20c, 50c, \$1, \$2). The children would ‘buy’ an item and give the teacher aide a coin to match.

One Year 1 teacher made the Sunset Supermarket (Figure 5) as a part of their Money unit. Empty boxes were bought in and price tags were put on them. The teacher got an old cash register and children played shopping activities. Much like the last activity with matching numerical value with the coin.

Another Year 1 teacher made this beachside café out of a refrigerator box (Figure 6). The children spent their art lessons making ice creams with cardboard, cotton wool, hundreds and thousands; and other items like soft drink cans. As with the Sunset Supermarket, the children had to match the numerical value to the coin.



Figure 2



Figure 3



Figure 4



Figure 5



Figure 6

## Other units

The remaining classroom teachers produced other units and these included units on place value, common fractions, decimal fractions, problem solving, addition etc. One of the outstanding similarities that was found with these projects was that all the teachers developed many hands-on, real-life activities that were both motivating for the students (particularly for the Indigenous students) and effective in developing the relevant concepts and processes.

## District / community programs

Other teachers, teacher aides and parents in the Mount Isa District were invited to participate in professional development in mathematics. This was achieved through a variety of events conducted through the year. The first of these was the Maths Mania workshops, which provided teachers and teacher aides with a variety of workshops from which they could choose to attend. Other events included teacher aide workshops, Family Maths Night and the National Literacy and Numeracy Conference.

## Reflections on the Indigenous Outback Numeracy Project

As a result of the research project, the following changes in the school were noted:

- increased teacher professionalism;
- increased teamwork between classes and year levels;
- teachers shared resources and ideas;
- teachers shared children across classes and allocated children to classes based on the number continua;
- teachers valued the experience as they developed an understanding of the sequencing of knowledge concepts;
- it was realised that Teacher Aides needed more knowledge and professional development to successfully participate in classroom activities;
- Year 2 net successes: 51% in 2001, whereas in 2002, 23% of children were caught in the net or needed numeracy intervention;
- teachers were given a lot of support from Administration with non-contact time for planning, marking or developing resources;
- strong partnerships were developed with QUT, ACU, QSA;
- Excellent professional development was provided for the district teachers and teacher aides.

In 2003, the focus will switch from improving teachers' knowledge and beliefs to more detailed study of Indigenous learning of mathematics. We have also received an ARC Linkages grant for 2003 and 2004 to look at the importance of Teacher Aides in Indigenous education in schools in the north west of Queensland. Although we are not experts yet, we are continuing to learn about our children and how they acquire numeracy skills and knowledge.

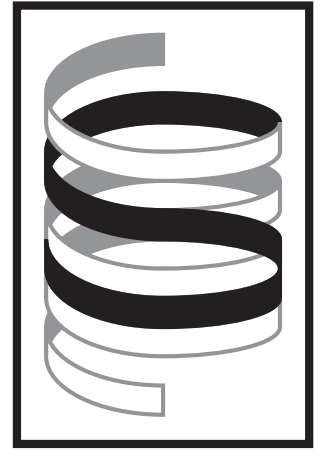
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# Numeracy at Bridgewater School

Kay Hosking

Bridgewater Primary School  
South Australia



‘A basic competence in mathematics’ is the *Macquarie Dictionary*’s definition of ‘numeracy’. Its definition of a numerate person is ‘someone having some knowledge or versed in mathematics.’

In South Australian education, the term ‘numeracy’ has been a hotly debated one. The *South Australian Curriculum Standards and Accountability Framework* (SACSA) states: ‘Numeracy... is the ability to understand, critically respond to, and use mathematics in different social, cultural and work contexts.’

At Bridgewater Primary School, we consider some educational practices and philosophies of the past have isolated and disconnected mathematical learning from other learning areas and the learner. We believe we have reclaimed mathematical learning as a flexible, inclusive, student-centred, relevant experience for ALL Reception to Year 7 learners. How have we achieved this?

Kay Hosking has been a team member of the Bridgewater Primary School for six years. During this time, Kay has been working with junior and middle school students and staff with a focus on student-initiated learning programs at Bridgewater School. Kay currently works in a Year 4/5 classroom in a co-teaching situation. She has been a member of state and nationally-based mathematics and numeracy projects and has conducted workshops for educators around these key areas of learning at Bridgewater School.

## Understanding ourselves as learners

We have embarked on an extensive program to assist the students and adults at our site to understand themselves as learners. Dr George Otero and Susan Chambers-Otero’s paper titled ‘Relational Learning’ states:

Learning in relationship..... requires that the learning start with the learner and not the facts to be learnt. We should create and maintain an environment that invites people to know themselves, one another and the whole. This kind of learning both requires and creates community (Otero and Chambers-Otero, 2000, p. 1)

We began investing much more time and energy in planned opportunities where students could continue to learn more about themselves and others — if you like, in an ongoing Relational Learning program. We provided opportunities to:

- play social games;
- talk and reflect;
- work collaboratively;
- share new learning information in workshops;
- celebrate achievement.

The constructivist view of learning supports and promotes the power of self: to express opinions, confidently share with, and acknowledge others, and so create vibrant, influential learning communities.

The SACSA framework focusses on a constructivist view of the learner as

- building knowledge and understandings on their past, personal experiences;
- constructing their own knowledge;
- developing personal organisational, decision-making and self assessment skills; and
- creating their own contexts for learning.

Individuals, knowing themselves as learners, and knowing what they need to learn are critical issues in this personalisation process.

John A. van de Walle, in his text *Elementary and Middle School Mathematics – Teaching Developmentally*, also emphasises the importance of self and community, shifting from the adult power base to a shared, collaborative view of mathematical classroom environments and thinking. He emphasises

- classrooms as mathematical communities, away from the notion that classrooms are simply a collection of individuals
- moving towards logic and mathematical evidence as verification for learning and away from the idea that the adult has the right answer (the confidence to ask questions, seek support and voice opinions)
- moving towards mathematical reasoning and away from the mere memorisation of information
- towards conjecturing, inventing and problem solving — removing the idea of the one right answer
- connecting mathematical ideas, applications — looking at the ranges of possibilities and not information as isolated mathematical concepts and procedures.

(van de Walle, 1997, p. 7)

This view of the powerful, self-regulating learner is the model of the learner we are working towards at Bridgewater School.

## Personalising numeracy

The SACSA Framework states

...this document is a framework — it does not represent a prescribed body of knowledge or authorise a particular way of going about teaching. Rather, it represents a set of parameters within which educators work to design their own teaching... and learning (DETE, 2001, p. 11).

Our Mathematics program at Bridgewater incorporates the core skills and understandings of

- Number;
- Exploring, Analysing and Modelling Data;
- Measurement;
- Spatial Sense and Geometric Reasoning; and
- Patterning and Algebraic Reasoning

the breadth of which offers students enormous opportunities to shape and relate to, their learning environment. This shaping and relating provides an understanding of numeracy, as a personalised process, where learners can

practise and master mathematical skills and understandings in a wider learning context that they can create.

The 'audit', which shows a wide range of mathematical skills and understandings in mathematics, is one tool that is used by students in this personalised learning environment.

Students assess themselves in areas of their mathematical learning, and make judgements about the extent of their knowledge: they record this information as a 'novice', 'learner', 'advanced learner' and 'user'. To record a skill and understanding as a user is a statement of extensive practice and mastery.

Process	With exchanging	Novice	Learner	Advanced learner	User
Addition +				✓	✓
Subtraction -					✓
Division			✓		✓
Multiplication			✓		
Rounding up/down decimal numbers					✓
Base 10 features		✓			

Topic	Novice	Learner	Advanced learner	User
History of number systems				✓
Systems from other cultures		✓		
Positive, negative numbers		✓		
Factors				✓
Multiples				✓
Squares, triangular numbers		✓		
Square roots				✓
Prime		✓		
Composite numbers		✓		
Percentages				✓
Algebra		✓		
Other growth number patterns		✓		
Quadratic maps				✓

Supporting evidence, which shows this skill used in a variety of learning contexts, is the Bridgewater view of the numerate student.

The students' audits not only provide students with a way of interpreting numeracy, but also show a larger view of the scope of learning possible.

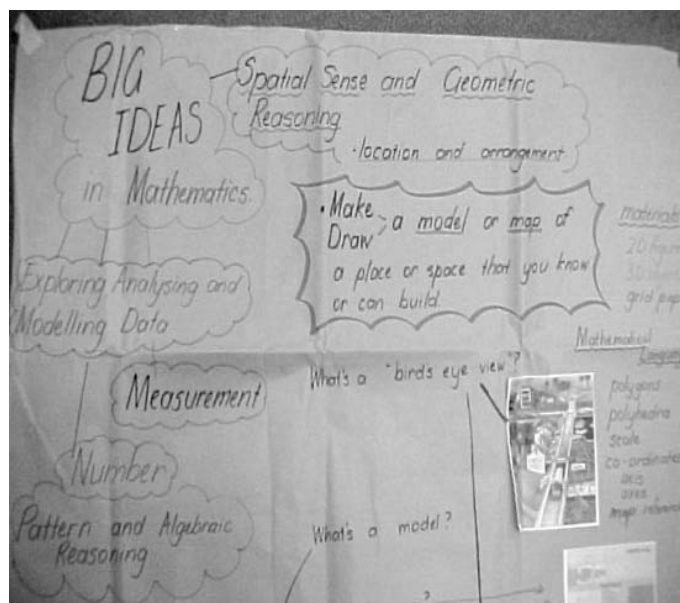
Through these audits, students can identify areas of learning that need to be addressed – they have the information to decide the path of their learning.

## Planning in a 'big picture' way

Connection to old learning in the constructivist sense has already been mentioned as an important consideration for why and (how) we plan and work the way we do. We also know, from current research, that learning needs to BE LARGE. SACS supports the 'big picture' view in the way the Mathematics curriculum has been organised into the five strands of Mathematics.

As an example, Spatial Sense and Geometric Reasoning was the big mathematical picture that was presented at the start of this year. We displayed this work on a large sheet of paper; visually, it showed to students that we were working in this big picture or strand of Mathematics, and that this big picture had wide scope; that is, its presentation emphasised a range of learning opportunities.

The presentation of mathematics in this way also enabled students to understand that particular aspects of mathematics (e.g. maps and models) were an integrated part of the whole Spatial Sense picture. If you like, it was the spot where that learning fitted; maps and models were not floating aimlessly in a mathematical world, but were symbols or attachment to this big picture, with connections to each other. Because the presentation of these mathematical learning opportunities is so visual, parents and visitors can also see the mathematical learning opportunities! It is another way of promoting mathematics and bringing this curriculum out of isolation for all to see and discuss.



Making informed decisions about their learning is important... the BIG PICTURE view supports learners in making informed decisions about their learning because they can see a range of possibilities.

## Sharing new research about learning

New research information created some interesting challenges and revelations about the way we learn. Looking at a range of learning style inventories, for example, enabled students, like the adults, to celebrate their individuality and their strengths. Other 'brain-based' research posed many questions for all learners:

- If some learners need quiet learning times and spaces, how could we accommodate them?
- If learning is best in small groups, where learners have lots of opportunities to talk and discuss — and revisit an hour later — how can we accommodate this?
- If we work best with frequent, small down time breaks how do we make this happen in our learning environment?

All learners at our site have had many opportunities through discussions, workshops and reviews, to share information about latest research and the implications this has for our learning. Decisions about how, when and where we work and play, have all undergone some dramatic changes, driven by the power of new research information at our site. The learners at our site make many choices.

## Making choices

Creating this supportive learning environment, where students can become self regulated learners, making wise choices within their learning environment, is an enormous challenge to organise and manage. We know to make good choices you need

- self knowledge
- information
- structures.

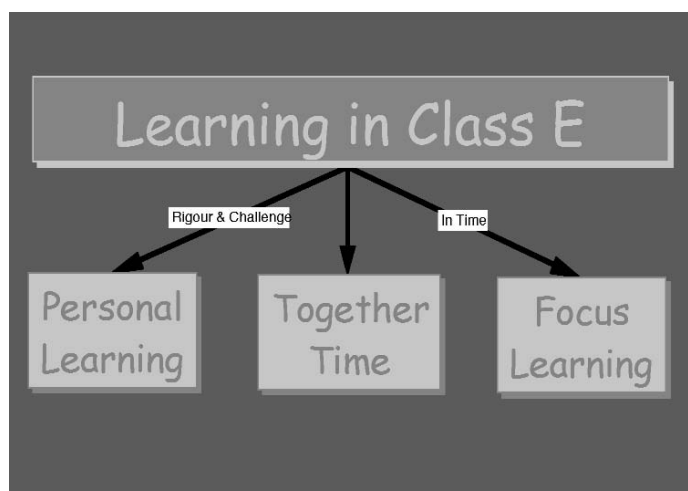
Working with students to build self knowledge and confidence has already been discussed and providing information about the curriculum and latest learning research is an ongoing aspect of our learning program.

Introducing structures for learning time has been successful in creating a user-friendly, choice environment. These structures for organising time are:

- *Together time*, which is time together, as a whole class or smaller groups.

Our class group mathematics time begins with together time of Quick Think Maths sharing students work and reviewing a range of learning opportunities from the BIG PICTURE sheet. Students then move to...

- *Personal learning time*, when students work on mathematical challenges that they have recorded in their timetables. Some students work collaboratively, others by themselves. As students move into their personal



learning time, some have booked in to a...

- *Focus learning time*, which is an explicit teaching session with a very small group. These are generally facilitated by adults, but students do conduct these sessions as well.

Focus learning times:

- have a small number of participants
- are explicit in their message
- are short in duration ( about 10 minutes).

Another together time concludes the mathematics session, which is time for sharing and discussion.

This school model of learning time with personal, focus and together time is supported by current research information and gives students time and opportunity to practise not only mathematical skills and understandings, but also lifelong learning and communication skills as stated throughout the SACS framework. Each day, students' choices for their work and play shows combinations of this model.

## Other mathematical learning possibilities

### Personal Learning Projects (PLPs)

Seeing opportunities for mathematics in a personal learning project, or PLP, is an important feature of our learning program, as students can choose and use their mathematical skills and understandings in different contexts. This is where we see numeracy in action at Bridgewater School. Students work on their PLPs at any time of their day, other than the mathematics sessions, which are timetabled separately.

When Anisa completed her native birds project, she included a technical drawing of a bird house she had designed and constructed. All measurement details were included, along with the completed model.

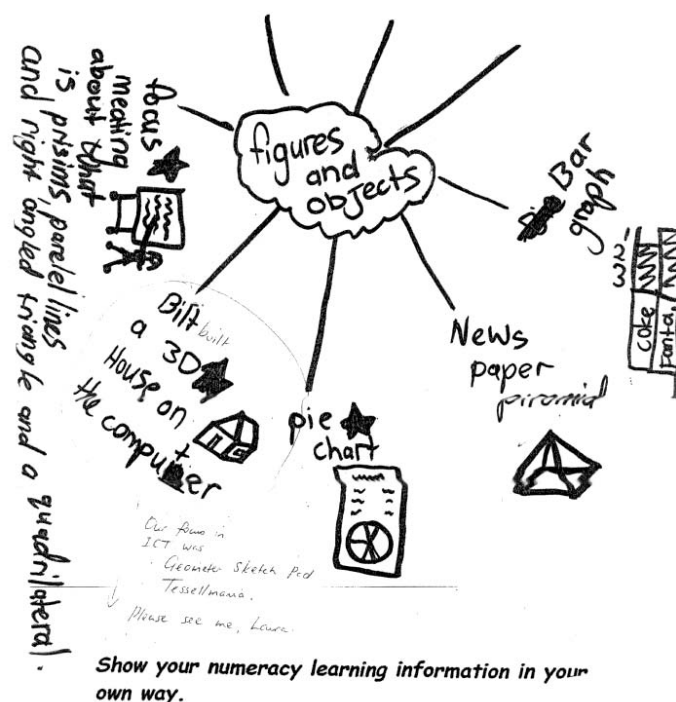
Jacob's PLP was titled 'The Gold Coast'. It included a comprehensive, comparative study of using a car, plane or train to get from Adelaide to his destination. His work included a map, a table of information with costs, time and the convenience factor included!

When students plan a PLP they are asked to show a mathematical component to their work; the big picture view of mathematical learning has helped students to understand the huge range of possibilities available to them and they are now choosing a wider range of options for this mathematical component.

### Numeracy checkouts

These provide students with another opportunity to make choices and record their path of learning. A checkout is a visual way for each student to show what numeracy learning they have engaged in over a number of weeks and it includes:

- the starting point of their learning;



- the new learning;
- useful tools for mathematical learning.

Students have shown this information as web diagrams, flow charts, timelines, graphs, ‘inspiration’ generated — in fact any way that clearly shows where they began, and the learning path. Students are encouraged to present their checkout information in a new way each time.

### **Widening Horizons and Creative Ideas**

These are two other avenues for students to develop their numeracy skills, through informal, choice activities. We describe ‘Widening Horizons’ as the opportunity for adults to share their individual passions and talents with students. Over the year, some of my Widening Horizons groups have been working and playing in a variety of ways. For example

- making your own Mathematics Tool Box with puzzles and useful home made tools (these tasks gave students further opportunities to practise those measuring, making, recording, comparing skills that featured so strongly in their mathematics work around Spatial Sense);
- The Bridgewater News;
- creative dance;
- square dancing.

When I choose a Widening Horizon activity, my challenge is to look for mathematical opportunities within it and to promote discussion with the students around this area.

‘Creative Ideas’ is a weekly afternoon choice for students and adults and anyone can apply to organise and run a group. The application needs to include the following information:

- name and place for activity
- materials and tools needed
- number suggested for the group
- any adult supervision required
- organisers’ names.

Once again, the activities here are as varied and individual as our learning community and my focus is encouraging activities with a numeracy component: cooking, making etc.

In summary, numeracy at Bridgewater means the empowerment of the learner to decide the path of his/ her learning. We have empowered students by nurturing self-confidence and self-knowing, organising structures and providing information that students need to make great learning choices.



A Creative Ideas cooking group

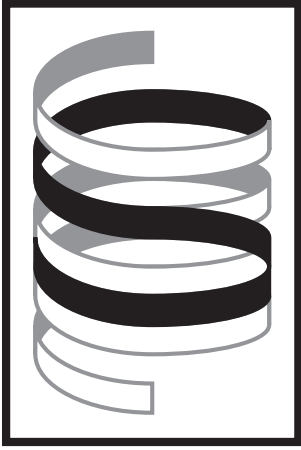
The numerate learner at Bridgewater School has many facets. The learner:

- is a wise chooser of learning opportunities;
- is powerful in creating their own learning environment;
- is a confident, articulate user of mathematical skills and understandings;
- is an active, relational learner, who understands and uses the collective strength of their learning community;
- is a role model of open-mindedness and flexibility.



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# Projects as strategies for the Essential Learnings

Tamara Chen &  
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## Background information of project

Currently, Tasmania's education system is in the process of a massive overhaul, to provide students with a curriculum which is more relevant to their futures. Primary and secondary schools around the state are currently developing the Essential Learnings Framework, which is a part of the national and global move to deal with an overcrowded curriculum. While subject content remains relatively unchanged, the way it is being taught is undergoing a major paradigm shift.

This year, Rokeby High School is participating as a trial school in the Curriculum Consultation Project. As part of the project, we have had to re-examine our middle school procedures, in order to provide students with skills to solve real life problems, to ensure deeper understanding is occurring and to ensure students are engaged in their learning.

When re-examining our current curriculum, we noticed students studying mathematics were becoming more disengaged with their learning. We were continually asked questions, such as, 'Why are we doing this?', 'When will we use this?' and 'What relevance does this have to us?'.

As we are a school committed to teaching for understanding, a group of mathematics teachers discussed a variety of structures to re-engage students with their mathematical studies. We decided that in order to teach for understanding, we needed to provide students with topics that were relevant to their everyday lives. We therefore organised our Year 8 mathematics classes into six units, which were based upon three projects, and three streamed units. The rationale behind the organisation of the six units, was based upon providing the opportunity for students to gain the sound basis of knowledge and prerequisites required for the Tasmanian Certificate of Education (TCE) mathematics subjects in Years 9 and 10, while also providing students with activities which were based on interesting and creative real life situations. The projects also provided the opportunity for students to work in a collaborative, group environment, which provided opportunities for peer teaching and the development of social skills.

Due to time constraints we were unable to negotiate and survey students about the projects that they would like to participate in. However, as a group we choose topics based upon our understanding of our student body and what would interest and motivate them. At the end of the year, we will have the opportunity to survey students on the success of the program, what they

liked/disliked, and other suggested topics. This will provide valuable data for future projects.

## Learning environment

Rokeby School is a small school located on the Eastern Shore, in a housing commission area. Our current enrolment is approximately three hundred students, catering for students in Years 7–10. Our students come from a range of feeder schools, resulting in a wide diversity of students. Our school is divided into two sections: middle school which caters for students in Years 7 and 8 and our senior school, which caters for students in Years 9 and 10. Our aim in the middle school, is to assist students in Year 8 with a smooth transition into our senior school. We accomplish this, by providing one basics teacher per class, who is responsible for teaching English, Studies of Society and Environment (SOSE), Science, and Mathematics. Due to the mixture of clientele, there is a heavy emphasis on social skills in this initial year.

When students move into Year 8, the teaching groups remains the same for English, SOSE, Science, and Health and Physical Education (HPE). However, Mathematics is streamed according to ability. Due to a drop in enrolments this year and our commitment to providing students with more authentic tasks, students in Year 8 were given opportunity to negotiate different mathematically based projects they would like to undertake.

Rokeby High School has established excellence in a number of key curriculum areas and will continue to build on these achievements by extending information and communication technologies (ICT) into areas such as Mathematics and Language and Literature. The Year 8 Mathematics syllabus was developed in response to providing students in Year 8 with a syllabus and associated pedagogic and assessment practices, which would support them to function effectively in the Knowledge Age. The project was also developed in response to providing an example of how ICT can be used to support and contribute to different learning areas, especially in the area of Mathematics.

## Projects undertaken

The projects undertaken were designed to engage students in relevant, interesting and practical mathematical activities, and based upon students' needs, interest and abilities. The following projects were undertaken:

- Car Maths — exploring mathematical concepts related to cars (covering strands Measurement, Chance and Data, Number and Working Mathematically). Activities undertaken include surveying types of cars in order to find the most popular make and colour, activities based on measuring speed, distance, time and fuel economy.
- Consumer Maths — creating and running a restaurant (covering strands Chance and Data, Number, and Working Mathematically). Activities undertaken include surveying students in order to determine what foods they would like to buy, expanding recipes for catering to large groups of people, working out costing of items to make a profit.
- Maths in Sport — designing and implementing sports activities for the school's athletics carnival (covering strands Measurement, Space, Number and Working Mathematically). Activities undertaken include measuring and marking the athletics field, activities relating to speed, distance and time, analysing school results (e.g. from the school's

- athletics carnival), and other sporting results (e.g. football and cricket).
- Leaving Home — exploring mathematical concepts such as budgeting, money matters, buying and renting houses etc. (covering strands Number, Chance and Data, and Working Mathematically). Activities undertaken include virtual shopping online, planning a weekly budget, planning a party, comparison of renting and buying etc.
  - Planning a Holiday — web based (covering strands Measurement, Space, Number and Working Mathematically). Activities undertaken include planning a Tasmanian holiday on the Internet, requiring students to cost a variety of transport methods, accommodation, leisure activities and food.
  - Problem solving and puzzles — (covering strands Number, Space, Working Mathematically). Activities undertaken are based upon specific problem solving strategies, such as drawing a diagram, making a list, acting out, guess and check, finding patterns, eliminating possibilities etc. The activities chosen are based on interesting scenarios.
  - Trigonometry and Algebra — (covering strands, Number, Measurement, Space, and Working Mathematically). This unit of work is a classroom-based unit, to provide students with the knowledge and prerequisites for top course Year 9 and 10 TCE mathematics. Prerequisites for the courses are discussed in depth with students and parents. We found that more students nominated for this course than any other project, which we believe reflects their dedication and motivation to attempt challenging activities.
  - Designing a board game — (covering strands Number, Measurements, Chance and Data, Space and Working Mathematically). The unit of work requires students to investigate what makes a successful board game, designing the board game, physically making the board and marketing and selling the board game.

## **Example of a project and how it supports the Essential Learnings**

See diagram (p. 85).

## **Evaluation of a project (Consumer Maths)**

Enterprise Education as a teaching methodology is held in high regard by practitioners. The project has the advantage as it is ‘real’ or experimental in nature and improves the way students work in teams and how they relate to each other. Students regarded the project as a valid and exciting approach to education. Students commented that real learning happened in the project and that they had fun undertaking supporting activities. They also viewed the project as being relevant to their future working lives.

Based on the premise that we remember 10% of what we hear, 30% of what we see and 100% of what we do, this project provided students with a topic which was not only relevant in nature, but also practical. The project increased students’ self-confidence, improved the way students worked in teams and increased student motivation to participate in activities. The project also provided the opportunity for students to work in a collaborative, group environment, which provided opportunities for peer teaching and the development of social skills.

**Communicating**

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.

**Personal futures**

Has a sense of realistic optimism about shaping preferred futures and confidently articulates own ideas and vision for the present and future

Use what they have learned as the basis for further mathematical learning	Learn how a person can organise and create a business
Add to the variety of situations in which they can use what they have learned	Multimedia software program Running a restaurant
Reflect on their personal use of mathematical ideas, and the use of others	Designing a web page
Communicate their mathematical ideas to others	Portfolio assessment pieces Web Pages

Is a self directed and self modifying learner who understands how to create, set and manage meaningful short and long term goals for life, leisure and work	Brainstorming how to set up and organise a restaurant
Has the capabilities to plan and organise strategically, both individually and with a group, to achieve and critically reflect on personal and term goals	Developing concepts maps to demonstrate individual and team goals
Is able to monitor own goals, celebrate successes and modify strategies if they are not moving towards success	Evaluating and self-assessing activities by developing a web page

**Rokeby Restaurant**

**Year Level: Grade 8**

**Subject: Mathematics**

**Length of unit: 12 weeks**

Understands how to pose and define a problem, clarify the issues involved and selects and monitors the most effective processes to use	Brainstorming ideas of how to successfully organise and run a restaurant Constructing lists about long and short term goals
Understands how to decide information needs and collects, organises and evaluates data	Surveying students Tabulating results in the form of a spreadsheet and graphs

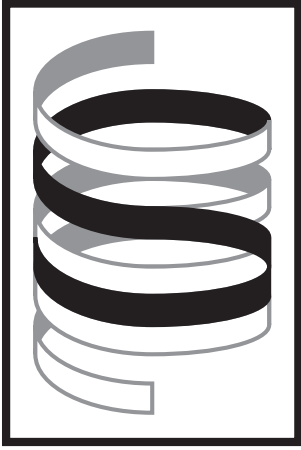
Demonstrates a command of information skills and strategies to locate and use effectively print, non print and/all electronic resources to solve problems, conduct research and pursue personal interests	Using the virtual online supermarket to gather information Use multimedia (Measuring Up) to conduct research and solve problems
Apply evaluative criteria to the selection, interpretation, analysis, reorganisation and synthesis of information from a variety of sources and formats	Using spreadsheets and publishing software to organise data and to present written work
Use appropriate technologies to create written, visual, oral and multimedia products to communicate ideas, information or conclusions to others	Developing a web page to evaluate activities undertaken during the unit Designing posters using publishing software to communicate ideas and information

**Thinking**

A student who is an inquiring thinker

**Communicating**

Being information literate



# Catering for diversity — 'This is Maths and it's fun!'

Ruth Court & Sally Gill

Kingston Primary School  
Tasmania

Sally Gill and Ruth Court are both upper primary school teachers at Kingston Primary School in Hobart. Their interest in maths was further stimulated/ developed when an opportunity arose to work with Doug Williams as part of a professional development program called *Changing Places*. This was over a three-year time frame. In this program the focus was to improve literacy and numeracy outcomes for Indigenous students using the *Maths 300* website as a teacher resource. Sally and Ruth have found it an invaluable opportunity to explore the 'working mathematically' strand with hands on, engaging and authentic learning experiences. Both teachers have a strong information and communication technology (ICT) backgrounds and use this to further broaden their students' learning opportunities.

Louise finds learning a struggle and maths is not her favourite subject; consequently her attitude has been fairly negative. She epitomises the students we are trying to 'switch on'. We can motivate the high flyers but if we can challenge all students in interesting and relevant ways, we are well on the way to achieving our goal of helping them become numerate.

## What is happening in Tasmania?

This year the Department of Education (DoE) in Tasmania has conducted a numeracy consultation process to identify needs and to make recommendations for the provision of numeracy professional development (PD) to form a state numeracy plan.

The DoE has undergone a curriculum review and from that the Essential Learnings (ELs) framework (Figure 1) has evolved. Included in this are the 5 curriculum organisers, which are Communication, Social Responsibility, Personal Futures, and World Futures, which are all interconnected by Thinking. This has exciting implications for numeracy as we delve into ways to engage students in exploring opportunities to develop understandings of these 'big ideas'.

Many classrooms have an element of disengaged, disenfranchised students who feel alienated towards the current curriculum. They see it as having no relevance to their lives and this is an increasing challenge to teachers to motivate and stimulate their students and to find out what they truly know and understand. The ELs framework encourages higher-order thinking and empowers students to take control of their own learning.

## Changing places

This is a professional development program which focusses on improving literacy and numeracy outcomes for Indigenous students. It is in its fourth year and involves over 60 primary school teachers state wide. In our own school, three staff members have regularly attended PD opportunities with two Aboriginal parents. Our meetings are off campus (in various parts of the state) and usually are of two or three days duration. At these meetings we have time allocated to numeracy (usually Doug Williams and Rosemary

Callingham) and literacy (usually Pat Smith from RMIT). During this time, Doug has introduced us to the Maths 300 website (<http://www.curriculum.edu.au/maths300>) which is an invaluable planning resource. In the numeracy area we have been focussing on the Working Mathematically (see Figure 2) strand. It has given us the opportunity to deepen our mathematical understanding as we trial authentic learning tasks with our students. The collegial support which emanates from this PD opportunity is invaluable as we can trial and re-assess our teaching practice, as well as helping Indigenous students with their learning. However, it is clearly evident that rich learning tasks such as these have benefited all our students.

**Working Mathematically:  
The Process**

© Maths300, Curriculum Corporation

**When mathematicians become interested in a problem they:**

- Play with the problem to collect & organise data about it.
- Discuss & record notes and diagrams.
- Seek & see patterns or connections in the organised data.
- Make & test hypotheses based on the patterns or connections.
- Look in their strategy toolbox for problem solving strategies which could help.
- Look in their skill toolbox for mathematical skills which could help.
- Check their answer and think about what else they can learn from it.
- Publish their results.

**Questions which help mathematicians learn more are:**

- Can I check this another way?
- What happens if ...?
- How many solutions are there?
- How will I know when I have found them all?

**When mathematicians have a problem they:**

- Read & understand the problem.
- Plan a strategy to start the problem.
- Carry out their plan.
- Check the result.

**Values**

We are guided by this set of core values:

- Connectedness
- Resilience
- Achievement
- Creativity
- Integrity
- Responsibility
- Equity

**Purposes**

We share the purposes of ensuring our children and students are:

- Learning to relate, participate and care
  - Learning to live full, healthy lives
- Learning to create purposeful futures
  - Learning to act ethically
  - Learning to learn
  - Learning to think, know and understand

**ESSENTIAL LEARNINGS**

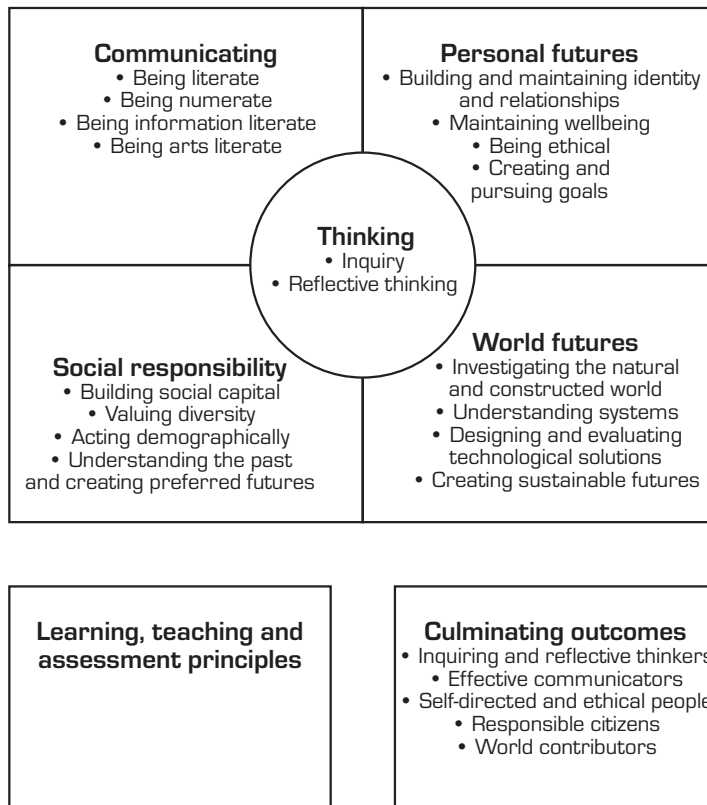


Figure 1. Essential Learnings framework overview.

**A mathematician's strategy toolbox includes:**

- Do I know a similar problem?
- Guess, check and improve
- Try a simpler problem
- Write an equation
- Make a list or table
- Work backwards
- Act it out
- Draw a picture or graph
- Make a model
- Look for a pattern
- Try all possibilities

If trying one way doesn't work they just start again another way.

Figure 2

## Design Brief: Four Cube Houses

© Maths300, Curriculum Corporation

### Memo to Architects

Congratulations!

Our company has won a contract to supply modular houses made of four cubes to a new housing estate. The construction rules are:

- all cubes are the same size.
- all cubes touch face to face (not like in our logo).
- there are no 'cantilevered' structures.
- all the houses must be different, i.e.: cannot be transformed into each other by a simple rotation around a vertical axis.

With your work partner your task is:

- Design as many four cube houses as possible.
- Draw each house on isometric dotted paper.
- Work out the construction cost of each design using these figures:
  - \$10 000 for each square unit of land covered.
  - \$4000 for each square unit of external wall.
  - \$6000 for each square unit of roof.
- Choose two designs and prepare an advertising brochure that:
  - Shows each design in isometric drawing or photograph.
  - Shows each design in its front, left, back, right & top views using square dotted paper.
  - Includes scale drawings of the estate.
  - Includes a few brief statements promoting the good things about the designs you have chosen.

Your office teams may also want to:

- Build a 3D model of the estate.
- Prepare a joint presentation to the developer promoting the features of the model.
- Prepare a full page newspaper advertisement and/or an advertising video to promote Cubist Homes and the new estate to the public.

Thanks for your help team.

## Four cube houses

We have trialled a selection of Maths 300 lessons and have chosen one to demonstrate an authentic learning unit. It demonstrates the real-life learning that can take place in the classroom. 'Four Cube Houses' is an exciting unit of work that highly motivated students and helped them to take control of their own learning. (The 'Four Cube Houses' lesson was developed from the Four Cube Houses task which is from the Task Centre Home Base at [www.blackdouglas.com.au/taskcentre](http://www.blackdouglas.com.au/taskcentre)).

### Tuning in

Initially students were presented with a stimulus sheet (Figure 3).

Students worked in groups of three to try and find out how many different combinations of cubes could be used. After much trial and error, making sure not to have two or more of any one house, it was agreed that there were 15 different combinations.

After much discussion the students wanted to know how we could tell the combinations apart. For instance one shape had four cubes stacked on top of one another and another lay flat on the table but was really the same shape. They decided to name each shape to help identification. One student took pictures of the shapes and then made them into cards using Publisher.

Other students thought we could build models of the houses. Ideas as to what could be used to make the cubes and what size were shared. Students wanted to make nets of the cubes so our next challenge was to decide how many nets would we need and how would we go about making them. Given that we had 23 students in the class we would need to make about 3 each to make all the shapes into houses. Right from the beginning students were making important decisions while working numerately.

Figure 3



## Further exploration

The 60 cubes were being constructed during free time and gradually a collection was made. Children making the cubes felt that they were too light and it would be difficult to maintain their shape, so some weighted material was needed. Polystyrene shapes, wool and shredded paper were put inside the cubes to give them strength.

At the same time, students worked on the stimulus sheet activities, drawing plans of their shapes on isometric dot paper (Figure 4). This was a really interesting activity as it showed the levels of the students' spatial awareness; I learnt a lot about my students' spatial knowledge. Those having difficulty were helped by other students or sought my help. One or two had real difficulty but on the whole with a bit of practice most coped.

Then the students used the square dot paper (Figure 5), which was provided on the Maths300 site, to show each design in its front, left, back, right and top views.

Using the stimulus sheet they then worked out the cost for each house. They had to show their working out on a piece of paper which was attached to the recording sheet. The groups then recorded their results in the form of a graph, using *Excel* and later transferred it to *Word* (Figure 6).

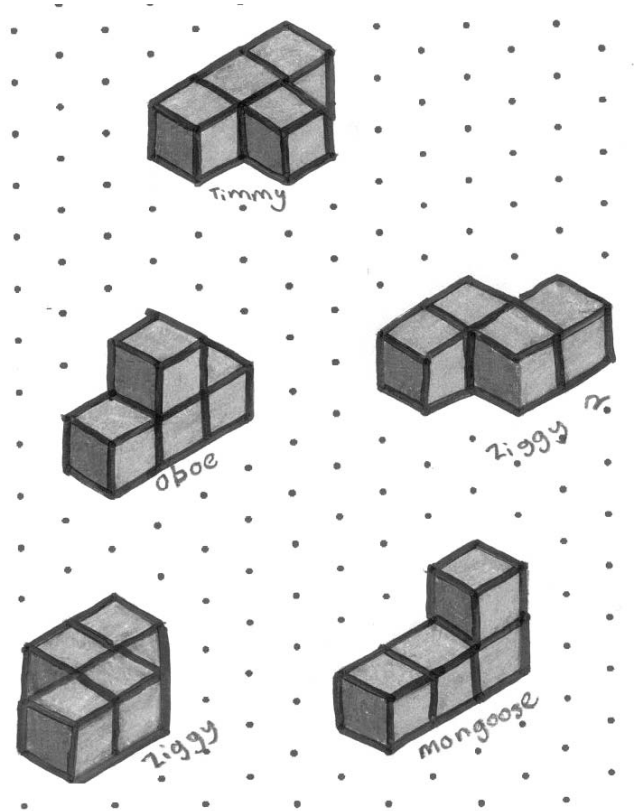


Figure 4

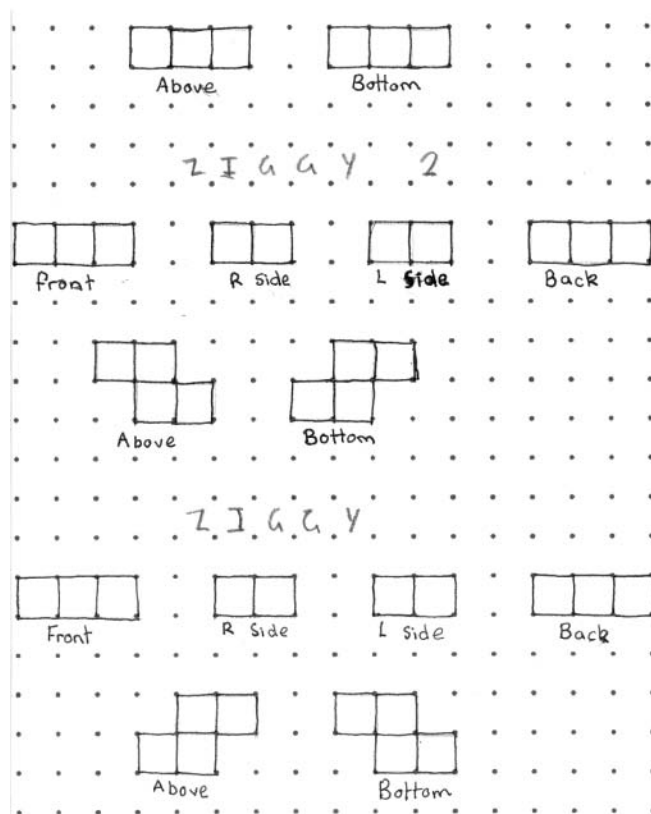


Figure 5

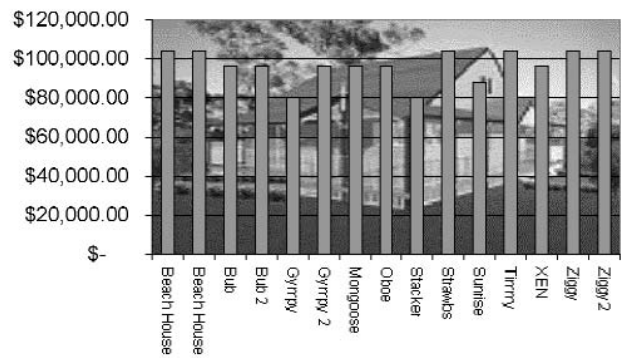


Figure 6



Figure 7




Figure 8

# View From Heaven

<b>Valley Bay</b>
34 Gillian Drive
Sandstone house with colour bond roof
House size: 144m <sup>2</sup> Land size :1 hectare
Price: \$149,999
Bay Kit Homes Casey Hodges Phone: 03 62918342

**T**his lovely family home has all the room you need. This home is enjoyable for children too with its spacious playroom. This home has two verandahs with spectacular views. One verandah has a shade area but the other one has sun, sun, and sun. This two-storey luxury home has four bedrooms that all include walk in robes. The main bedroom includes a reasonably sized en-suite. This home has a garage and



carport out the front and around the back there is an enormous pool and modern gardens with a garden shed. Is this the house for you?  
Cost: \$149,999  
(Includes house and land package)  
Phone: 03 62918342

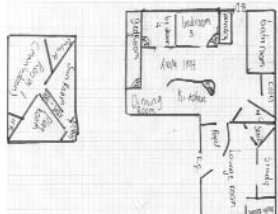


Figure 9

## Taking ownership

I planned to use the activities from the stimulus sheet but I had not anticipated the students' response to the unit. Some students came up and asked for some paper with squares on it. I asked them what they wanted it for and they said, 'We want to make plans of our houses'. I then produced some graph paper and stated that it was there if anyone else wanted to use it, but it was not a set task. Every single student proceeded to draw a plan of his or her house. They were given no instruction. The results were interesting, as some students drew perfect plans, while others had no idea how to represent the inside of a house. However some interesting discussion arose from this as we were able to talk about what real architects do and the things one needs to plan for. One student's father was a builder so she brought in some 'real' plans. We also looked on a website for kit homes to see some house plans.

Discussion then arose suggesting that if these were real houses how long should each side be to get a decent-sized house. We investigated the possibilities. Some said 4 metres, some 5, 6, 7 and 8. We then had to test them, so students went out with trundle wheels to test their hypotheses and decided on the optimum length of the side of their cubes. After much testing most children decided on 6 metres. From here we worked out the area and perimeters of all the houses. We visited a local subdivision right next to our school and measured out our houses to see how they would look on a real block (Figure 7).

The students then set about building their own houses and eventually they were placed on a new subdivision called Cubist Court (Figure 8). Considerable discussion about how to divide the subdivision up and how to number the houses followed. Some students brought their home knowledge into the discussion by saying that they lived in a court and the numbers went consecutively. Tasmania has just introduced 50 km limits on suburban streets, so a sign had to be made to comply with this new law.

## Linking literacy and numeracy

I then asked the students to write advertisements for their houses. However, before we could do that, we had to do more research. We had a number of Real Estate guides in the classroom, so the students were able to look at the cost of land in new subdivisions, discovering that the costs varied depending on the suburb. They decided to look at land prices in Kingston where they live. Most of them decided on a land price and added their house price to it. A couple of houses were on 1 or 5 hectare blocks so they had to work out an appropriate price.

There were no set guidelines for their advertisements, however one or two students decided to copy the models of the advertisements in the Real Estate guides. This is not what I had planned but the students were taking charge of their own learning. To make their advertisements, they scanned their plans from the graph paper and photographed their houses. The advertisements were then created using *Publisher* (Figure 9).

While this was taking place, a group of 6 students were making a website to promote their kit homes. When they had prepared their plan I gave them some guidance as to how they could put it into practice by showing them the basic skills of inserting photos, linking pages, centring, colouring backgrounds etc. Initially they were only going to use the houses and write about themselves but the momentum grew and they decided that everyone should be included on the website. They asked each child to write a little bit about themselves as builders or architects and also to include information about their buildings. Once they developed their IT skills, they were able to work independently, working on individual pages and then linking them. When it was finished, each student was given a copy of the website (on CD) as most of them had access to a computer at home. It was a very powerful way of publishing their work. The website can be viewed at the following web address:

[www.discover.tased.edu.au/ec/teachers/GoodPrac/KingstonP/Kit%20Homes](http://www.discover.tased.edu.au/ec/teachers/GoodPrac/KingstonP/Kit%20Homes)

This site has also been included as a Classroom Contribution to the Four Cube Houses lesson on Maths300. The students were delighted to be able to share their work in this way.

We stopped the unit at this point, as it was almost the end of Term 1. However, the students kept making suggestions about what we could do next which included looking at house designs, heating for houses etc.

The students learnt a lot as well as enjoying the experience. 'This is Maths and it's fun!' At the same time I learnt so much about how students learn and what they can learn when they are motivated and can take ownership and control of their own learning.

## **So what?**

(as Kath Murdoch challenges us)

There is no doubt that this activity enabled the students to achieve success at all levels of ability. It led to a positive attitude to learning by giving students confidence to be risk-takers. They were able to see themselves as having a need to learn and understand and make sense of their world. They were prepared to say, 'I don't know', ask questions, make demands of the teacher and to suggest the direction their learning should take. They were taking control because they had a reason and a desire to find out, not just to please the teacher but to make the link between learning and real life.

It also provided authentic opportunities for the teacher to assess students' understanding, to listen to their thinking, to ask them questions to try and ascertain their level of understanding.

This learning activity was one that truly catered for a diverse range of students' abilities, engaging them in exciting and challenging numeracy learning.

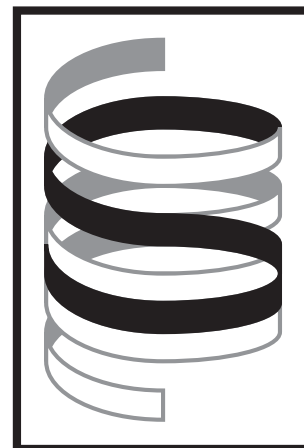
## **Acknowledgement**

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# Supporting all learners — Effective strategies for working with ESL students

Vicki Rubino

Catholic Education  
South Australia



## Introduction

A major focus in the development of my teaching practice over the last few years has been to explore and develop effective strategies for supporting English as Second Language (ESL) students while ensuring equity for all students within my classroom.

I have been involved in a range of numeracy projects with Catholic Education South Australia over the past few years both as a facilitator and a participant. These projects have enabled me to undertake research into the different pathways students take in their learning and to explore a range of strategies that successfully support the diverse range of students within my class. The Numeracy Projects model is based on action research whereby teachers work with numeracy consultants exploring mathematics, reviewing current research literature and mapping students thinking through work sample analysis and classroom observations.

My participation and work undertaken in these projects has enabled me to deepen my understanding of how different students learn, further develop my own knowledge of mathematics, build onto my knowledge of designing tasks that support specific needs of students as well as develop my understanding of features of a supportive learning environment.

This presentation will focus on students' growth and development of the mathematical ideas in measurement as well as the various strategies I implemented to support individual students' growth in the learning of mathematics.

## Background of school/class

I currently teach a Reception /Year 1 class in a small Catholic school in a low socio-economic community, which comprises 87% ESL students. The students are predominately from a Vietnamese background while others are from Chinese, Cambodian, Filipino and Indonesian backgrounds.

There are twenty-six children in the class, which includes eleven Reception and fifteen Year 1 students. Nineteen of these students are from Vietnamese backgrounds, three students from Chinese backgrounds, one student from a Filipino background, one student from an Malayan background and two students from English speaking backgrounds. For all of the ESL background students their first language is the main language spoken at home.

Vicki Rubino has had sixteen years' teaching experience in Victorian and South Australian schools. She has participated in various Catholic Education SA numeracy projects as a key research teacher and as a member of the Catholic Education Early Years Numeracy Team. She presently works in a R/1 classroom and works in collaboration with the numeracy team researching and trialling a numeracy observation assessment for early intervention in Catholic schools.

## Getting started

Early in the year I plan for and set up structures in my classroom to support student learning in mathematics. My expectation is that learning will occur as students engage with mathematics tasks. A way of achieving this is through setting rules in place that are specific to mathematics sessions. These rules are negotiated with students so that they have ownership of them and are revisited during the year as the needs arise. These rules also provide strategies for students to be able to attempt to solve their own problems while waiting to see me so as to ensure minimum disruption as I am interacting with other students in the class.

I ensure equity in my classroom by keeping a record of students I have seen and the areas of mathematics I have worked in with them. When planning a unit of work in mathematics I brainstorm the mathematical ideas to be explored as well as a range of materials that could support the development of those mathematical ideas and any other equipment or tools that will support students in their investigations. For example, in the linear measurement tasks described in this article I provided students with a range of non-standard units (e.g. flipblocks), standard units (e.g. rulers and tape measures with metric units of measurement), as well as non-uniform units (e.g. shells) and uniform units (e.g. centicubes).

I also ensure that there are a variety of materials available for students to choose from. This is an important feature of classroom organisation as it allows students to work within a set task at their own level of understanding and encourages active rather than passive learning.

Once the task is set the students in my class are encouraged to decide how to go about the task and how to record their understandings because if they

are to become independent thinkers they need to learn to make independent choices. This also allows them to make connections in their learning. All students' attempts with tasks and choice of recording are valued and built upon. While the students are working on the tasks, I collect information on their learning through observations and discussions with individual students. Worksample analysis during and after the sessions about their thinking informs my planning for future directions to support individual student's needs.



Figure 1. Different classroom materials.

## Student growth in linear measurement

The following worksamples highlight growth of one student's understanding of mathematical ideas in linear measurement and are not presented in sequential order. Also included are examples of different pathways other students have taken when working on the same tasks to demonstrate a range of mathematical thinking and methods of recording.

Quyen is a Year 1 student from a Vietnamese background and the main



Figure 2

language spoken at home is Vietnamese. Early in the year Quyen was a quiet student in mathematics sessions and often found it difficult to express her thinking, as she did not have the necessary language to do so. Strategies I implemented to support Quyen in her learning included providing Quyen with a partner to work with, allowing her to use her first language to clarify her own thinking, providing English models of mathematical language through displays, questioning her in context and providing opportunities for Quyen to work with other students more proficient in their use of the English language. Over the year I have observed Quyen interact more confidently with others, use mathematical language in context more regularly and begin to ask questions to clarify her thinking.

This early work sample from Quyen (Figure 3) shows that she was able to order and compare the lengths of three strips. She was questioned about the order of the strips and she explained that the first strip was 'big', the next one was 'half' and the other one was 'little'. Quyen was using her own language to describe differences between the strips. This discussion was an opportune time to verbally model comparative language (longest, shortest, longer etc) in context. I then asked her, 'How do you know that this one is longer?' She placed the strips next to each other and said, 'This one is more big' as she pointed to the longest strip. I then asked her if there was another way that she could prove her order. She seemed unsure about this and I realised that it was probably the language that I was using that caused her uncertainty. So I then asked, 'Could you use any of these to help you show which is the longest/shortest strip?' as I indicated the materials which were available to her. She then chose non-standard units (counters) to match and measure the strips and used number to describe her measurements. In observing Quyen, she left gaps and overlaps between the units. This informed me about Quyen's need for further experiences in measurement to begin to develop an understanding about the need for accuracy so that she can make fair comparisons between the objects she is measuring.

In this next task students were asked to find out which ants took the longest and shortest paths to the cupcake and then to find out how much longer the longest path was in comparison to the shortest path (Catholic Education SA).

Quyen chose uniform units (triangles) to measure the paths and used number to describe her measurements. In observing Quyen she measured more accurately by placing the units end to end without leaving gaps and overlaps. She attempted to make comparisons between the paths and used language including 'longest' and 'fastest' to describe differences between them. Although she measured all three paths she only included measurements in her recording for Paths A and C. She was asked how much longer Path C was in comparison to Path A and replied '12'. She showed difficulty in understanding the question and I realised that this type of questioning was new to her and that she required

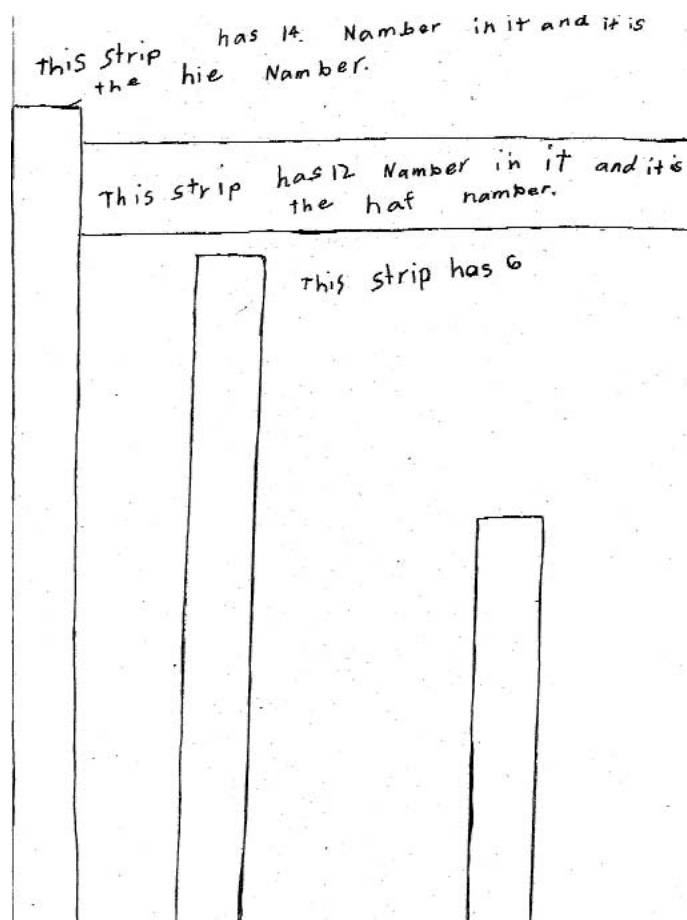


Figure 3. Quyen's early work sample.

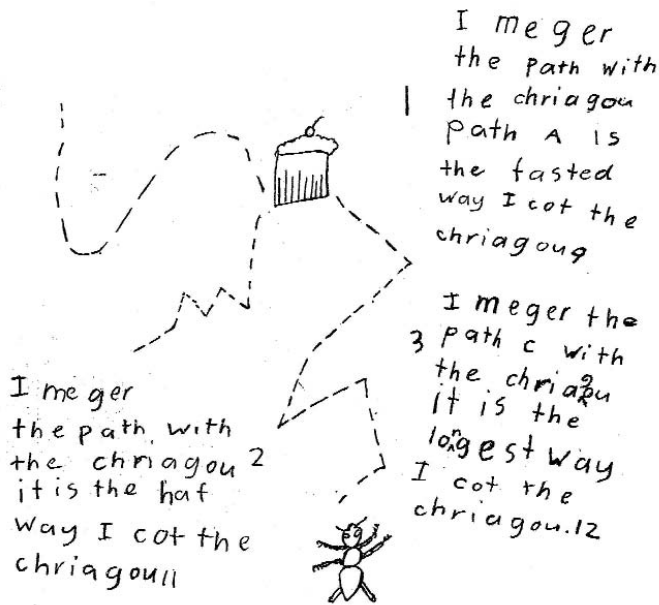


Figure 4. Quyen's explorations of fractions.

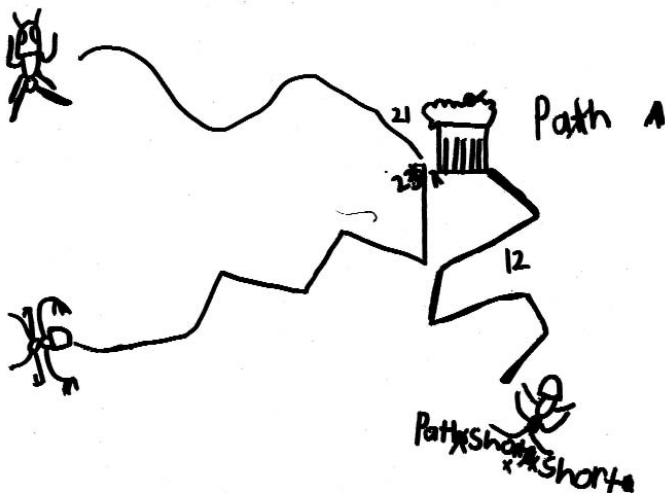


Figure 5. Chanice's worksample using non-uniform units.

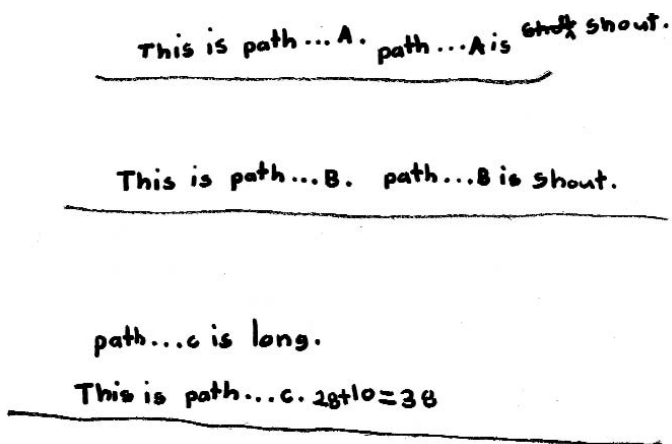


Figure 6. My Hanh's comparison of lengths.

further time to reflect on her thinking in order to make sense of this.

To support Quyen I decided that she required further experiences with tasks involving the comparison of her measurements and related questioning in order to allow her to begin to recognise the importance of using measurements to make comparisons as well as comparing objects measured.

I was also aware that Quyen was using the term 'half' to describe objects of length, which were between other objects. To begin to address this I planned tasks in which Quyen explored fractions and the relationship between pieces in fraction kits alongside measurement investigations.

Another student, Chanice, selected non uniform units (counters, matchsticks and centicubes) to measure the paths but does not show this information in her recording. She used number to describe her measurements but did not make any comparisons between the lengths. She was questioned about the longest and shortest paths and explained that 'Path B is the longest because it is a bigger number'. From my observations of Chanice, it was evident that she required further experiences in measurement with a focus on using uniform units to enable her to begin to develop an understanding of the importance of using uniform units in order for her to be able to compare lengths.

My Hanh used a referent (string) to match and measure the paths. She then measured the lengths of string using a tape measure. She compared the longest and shortest lengths and calculated the difference between them. In observing her she used her fingers to count on from 28 to 38 and recorded this as an addition algorithm.

These three worksamples clearly show the different pathways students took as they worked with the task. Providing students with open-ended tasks allows them to enter at their own level of understanding as well as allowing for a range of strategies to be implemented.

The students in my class are also provided with opportunities to share their ideas and strategies as they work in small groups. These opportunities allow them to build onto their prior knowledge, understandings and thinking as they make connections and make meaning in their learning. Working in groups also allows students to explore different strategies



used and provides opportunities for them to begin to discuss and develop an understanding of the relationships between them. The structure of groupings was important in supporting students' learning. Mixed ability groupings ensure that students are provided with a range of mathematical thinking models as well as being exposed to a wide variety of recording methods. Individual students' specific needs also need to be considered with groupings. For example I found that Chanice was quiet and rarely engaged in group discussions. I felt that this might have been overwhelming for her so I planned for Chanice to work with a partner she was comfortable with and someone she could converse with in her first language if she felt the need to in order to clarify her thinking. After a period of time and as her confidence was developing she then began to work in a small group. I observed that she was interacting more frequently and more confidently with other students in her group.

In this task students were provided with two different sized pictures of fish and were asked to find out which picture would use the most border tape to frame, and how much more border tape the bigger one would need compared to the smaller one (Catholic Education SA).

Quyen placed the smaller picture on top of the larger one (Figure 7) and used comparative language (small and big) to describe the differences in size. She measured the perimeters of the pictures showing an understanding of the attribute she was required to measure for this task but did not compare her measurements. It is important to recognise that in collecting information about student learning, a range of worksamples and observations in different contexts is required before making judgements about student learning. For example in earlier worksamples Quyen always used uniform units and it could be assumed that she had an understanding about the importance of this in measurement. She used different units (centicubes and counters) to measure and therefore would not have been able to make a fair comparison between the objects she was measuring in this task and through questioning it was evident that she did not have a clear understanding of this. Quyen required further experiences to explore the idea of uniform units in measurement.

John chose non-uniform units (cuisenaire rods) to measure the perimeters of the pictures. He calculated the difference between them using a 'counting on' strategy. Although he showed a good understanding of what was required to solve the problem provided, he was unaware of the need to use uniform units to compare the perimeters. Further planning to explore this idea was required for John. It

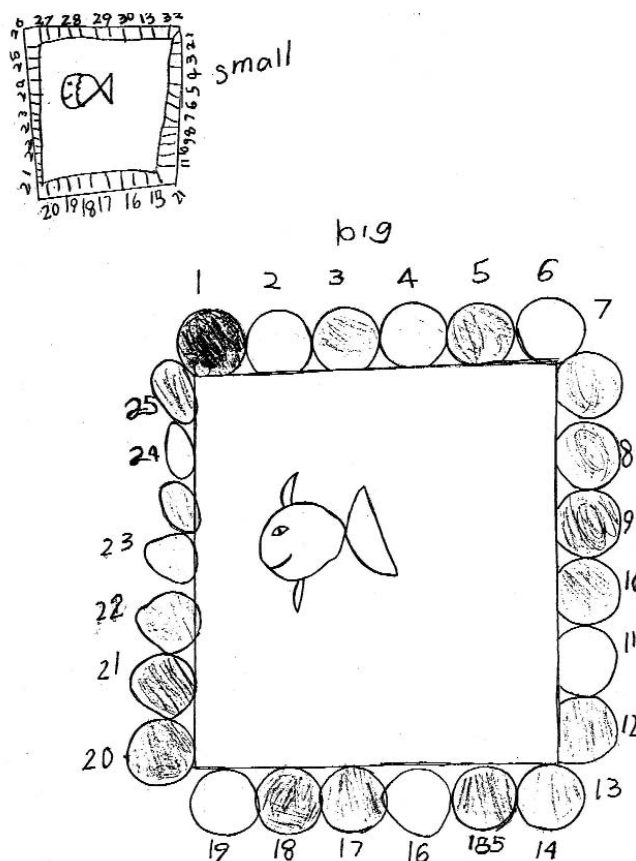


Figure 7. Quyen's comparison of size.



Figure 8. John measuring the perimeter of pictures.

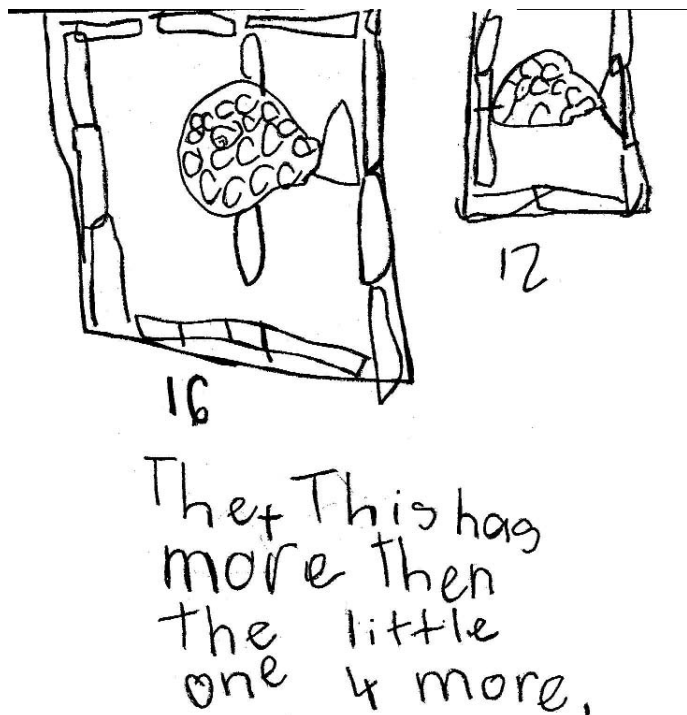


Figure 9. John's work sample.



Figure 10. My Hanh measuring the perimeters.

would also be fair to add at this point that providing further experiences does not always necessarily mean that the student will then have the understanding. Repeating materials and tasks over time allows students to become more familiar with them so that they can more meaningfully engage with the demands of the task and continually build onto their experiences to construct knowledge. It is also necessary to provide students with adequate time as they reflect on and build onto their prior knowledge.

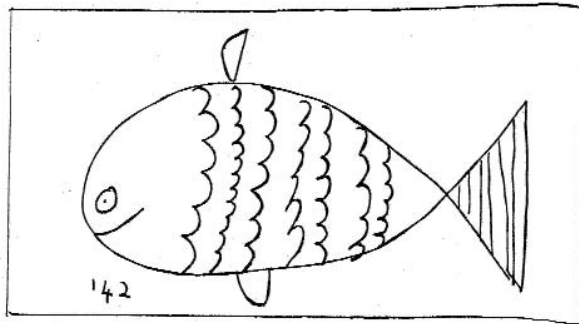
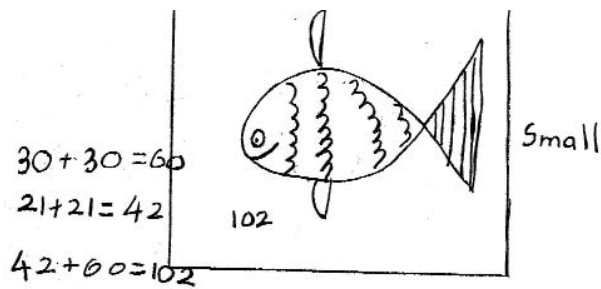
My Hanh chose to use a measuring tape to measure the picture borders. She measured the length of each side of the pictures and chose to use a calculator to support her in making her calculations as she was dealing with larger numbers. She recognised the need to add the measurements of the sides to calculate the total measurements of the perimeters and the need to subtract the smaller measurement from the larger measurement to calculate the difference. Through questioning I also discovered that although My Hanh used standard units to measure with she was unable to name them. So further tasks were planned to enable her to develop her understanding of standard units.

Within my classroom I have four tasks operating simultaneously and students are provided with opportunities to engage in mathematical as well as contextual tasks. Exploring mathematical ideas from different strands allows students to integrate these and make connections. The next two worksamples (Figures 11 and 12) are examples of this.

Quyen chose to use measurement to compare two shapes. She used a rotogram (a tool she was familiar with) to measure and

compare the angles. She shows the tool in her recording as well as the angles in the shapes. She numbered the sides of each shape and used centicubes to measure the lengths of the sides to make further comparisons. Quyen was measuring more accurately and she placed units more consistently end to end without leaving gaps or overlaps.

The worksample in Figure 13 shows Quyen using measurement to compare the perimeters of shapes and calculating the difference between them. She described the attribute using her own language 'around the shape' and through questioning and discussion the mathematical language 'perimeter' was modelled to her. She chose to use a calculator to add the lengths of the sides to calculate the perimeter showing her understanding of selecting the appropriate process to do this. Through questioning Quyen explained that the distance around the shapes was a difference between the shapes and a similarity was that both shapes had the same number of symmetry lines. She was aware of symmetry lines as she was exploring the



$42 + 42 = 84$  big  
 $29 + 29 + 58$      $142 - 102 = 40$   
 $84 + 58 = 142$

Figure 11. My Hanh's work sample.

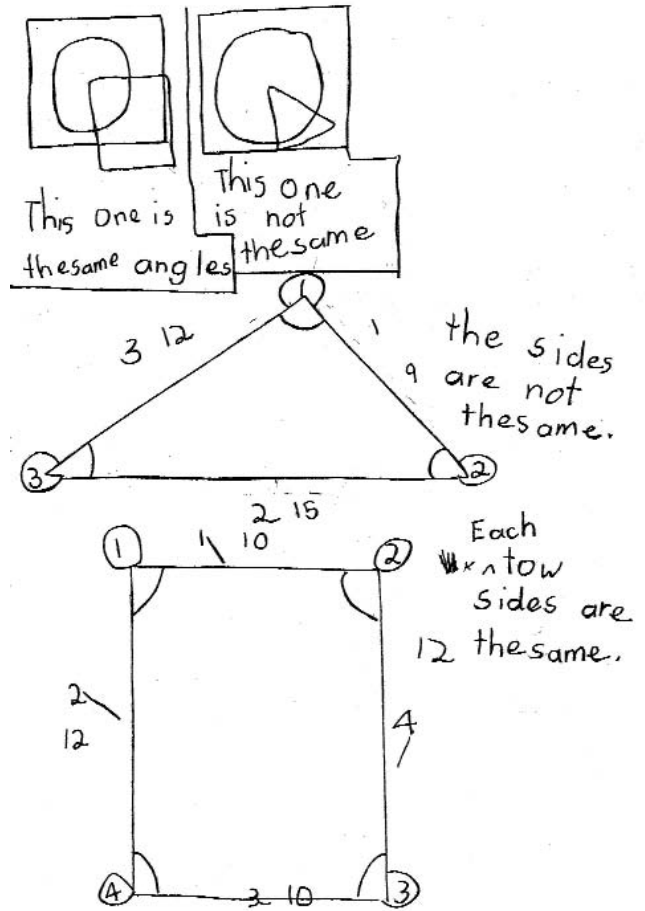


Figure 12. Quyên's measurement using the rotogram.

mathematical ideas of symmetry alongside this work.

Analysis both of these worksamples investigating 2D shapes clearly showed the choices and decisions Quyên made about how she would attempt the task as well as her transfer of knowledge between different areas of mathematics.

## Conclusions

From my experience, to develop quality programs that enhance effective learning, two factors are significant, which involve the development of two broad aspects of teacher knowledge. Firstly, the development of their own mathematical knowledge and understandings and secondly the knowledge of how students construct understanding and the different pathways students may take in their learning.

The role of a teacher involves facilitating student learning and development throughout the learning experience by analysing each student's thinking and work, modelling behaviour and

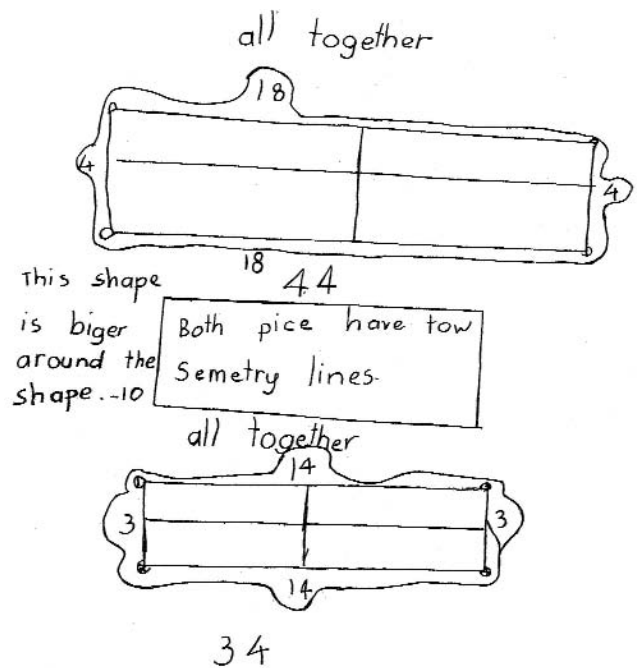


Figure 13.

language, providing appropriate resources, and instilling a challenging framework. This contributes to establishing continuity of learning.

Classroom organisation is crucial to creating an effective learning environment. It is imperative that all students have their own materials to work with to enable them to take control of their learning with tasks designed to direct and challenge their thinking. As students explore mathematical ideas and create their own meaning they begin to integrate new knowledge into existing knowledge.

Assessment is ongoing and provides useful information which influences future planning and programming. Observations of students' thinking and strategies, learning behaviour, interactions, communication skills, knowledge and use of mathematical language are used in planning future directions for individual students. Analysis of student worksamples alongside observations ensures informed decision making for future planning and programming.

My goals in teaching include students understanding what they are doing and why they are doing it. Students need to see a purpose in what they are doing to enable them to fully engage with the process of learning. Students also need to feel positive about themselves as learners and therefore it is important to value all their attempts and to celebrate all students' achievements. If students feel good about themselves as learners this in turn creates positive attitudes to the learning of mathematics.

My involvement and participation in various numeracy projects over the years has contributed to developing a classroom environment that supports all students' learning as well as developing my own knowledge of mathematics. My continued participation in the Early Years Assessment Numeracy Project is enabling me to continue to build onto my practices and further develop my skills and understandings in supporting and facilitating effective learning in my classroom.

## Acknowledgement

I would like to acknowledge that the linear measurement tasks labelled (Catholic Education SA) which the students engaged in were designed by Trish O'Toole and Nicola Godwin as part of the Early Numeracy Observation Assessment Strategy for Catholic Education South Australia, and trialled in my classroom. The analysis of all tasks was supported by the linear measurement growth points outlined in the Catholic SA document *Planning For Students Mathematical Thinking: Measurement R-8*.

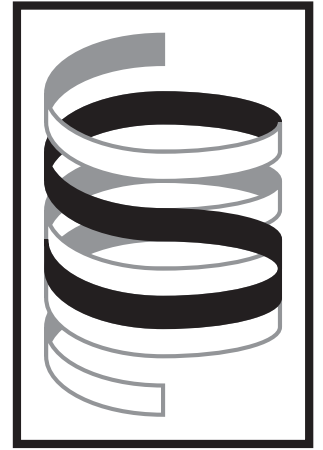
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# Connecting numeracy across the curriculum

Jan McCarthy

Tennant Creek High School  
Northern Territory



This paper will address the topic connecting numeracy across the curriculum from the viewpoint of a secondary school Mathematics teacher from the outback. There are three main messages that I wish to address through this paper, namely

- who owns the curriculum?
- my beliefs in the need for taking an environmental scan;
- what are we doing for our new recruits?

These three issues are addressed through my experience of conducting a Commonwealth funded literacy and numeracy project at Tennant Creek High School. First let me set the scene with an introduction to the town environment, a description of the teaching setting, my class and the project.

## Setting the scene

My home is equidistant from the East and West Coasts, 500 km north of Alice Springs approximately 1000 km south of Darwin and in my new role as project officer, I travel the length and breadth of a region slightly bigger than Victoria. Tennant Creek boasts of its title as the ‘Golden Heart of the Northern Territory’. This reflects our proud history of gold mining after Australia’s last great gold rush of 1932. We are also the ‘hub’ of the Barkly Tablelands, famous for its pastoral industry, pioneering drovers and the latter day rodeo rider.

With the demise of gold mining and the decline in world metal prices, tourism became our new vehicle for growth. Just take a drive through outback Queensland, plan a stop over in Tennant Creek and you will be sure to get your kicks on Route 66.

The latest boost to our economy is the Alice to Darwin railway. The most tangible evidence of their generosity was an invitation for the whole town to attend a sausage sizzle celebrating the laying of the first tracks out of town. While avoiding the queue for BARBEQUE snag and sauce, I was very taken with the track laying process; a very satisfying numeracy moment, and so the morning was not a total loss. It really amazes me how many opportunities we have for these moments in our own Dodge City.

There is permanent water outside town, scenic views, and history at every turn along the way. With all this is the joy and privilege of working with the caretakers of the oldest culture in our land.

Jan McCarthy — whose first love was mathematics and whose early sights in life were set on becoming the next Sophie Germain — joined the staff of the infamous Wiley Park Girls High after finishing her teacher training. While her initial reaction was a desire to resign within her first week, she was dissuaded from doing so, but still sought other challenges, which eventually brought her to settle in Tennant Creek in the Northern Territory. The landscape, climate and people were unlike anything else in her experience, but made it a place that she immediately felt at home.

Statistically speaking, the 1996 census paints the picture of a small town with a population of less than 3856. The mean personal income was less than \$308 per week, the median age was 28 and full home ownership was less than 15.9%. At this time, there were 779 Indigenous language speakers, 2 244 English only speakers and 146 speakers of other languages. Even though Tennant Creek has taken a few blows in recent years, the 1996 figures are still a good indication of what is happening today. Tennant Creek is therefore a remote community with a small town population and a low socio-economic base.

## **Setting the education scene**

There is only one high school and one primary school in town. It is a sad fact that both schools experience regular turnover of staff. This can have a disruptive effect on the school programs and I must admit that at times I feel we are standing still when we need to orientate and induct new staff on such a regular basis.

The high school caters for students from Year 7 to 12. We provide a diverse curriculum for the junior school as well as offering a wide choice of Stage 1 and 2 courses at Years 11 and 12. Many of our students participate in VET courses with a growing number now enrolled in pre-VET.

More than 50% of our students are Indigenous. A large proportion of this population needs to board in town at the hostel, as there is no formal provision of secondary education in their communities. Students can travel between four and nine hundred kilometres to attend school each term. Not only do they have to adjust to the town life, the workings of a secondary school and many different teaching styles, but many suffer terribly with home sickness.

The school has firm partnerships with the feeder communities and the house parents at the hostel. The School Council and Aboriginal Student Support and Parent Awareness (ASSPA) committees are very supportive and active, as is the Student Representative Council (SRC) and Aboriginal and Islander Tertiary Aspiration Program (AITAP). There is a very strong relationship between the school and the employers in town as well as the many training organisations, educational institutions and Indigenous agencies.

## **Professional development**

So far the picture has been rosy; I can anticipate an increase in the number of applications for employment if not an increase in tourist numbers. There is one major factor that impacts on the teaching and learning in our school and that is lack of access to professional development. In a town the size of Tennant Creek and in the remote region of the Barkly, there is limited access to professional development for educators. All courses, seminars or conferences are held in the two major centres of Darwin and Alice Springs. Travel is extremely costly and this is compounded by the fact that there are no relief teachers in town to replace staff when they are out of the school.

Professional development is a hot topic especially for the high school teachers. In some subject areas there is only one staff member and with no access to professional discussions, it is a huge task for the teacher to keep abreast of the changing trends and technical developments in their subject area. There is some support however with DEET offering professional devel-

opment for literacy, numeracy, ESL and the new Curriculum Framework Implementation. Project officers visit schools to work with groups of teachers or individuals. This requires officers to travel a great deal and the tyranny of distance impacts on the amount of support one school can access. When working for an acceptance of the fact that numeracy is every teacher's responsibility, we have a long way to go or a new approach to delivery in order to spread the message.

## **The mathematics curriculum — then and now**

When I started teaching, mathematics lessons involved the Jones and Couchman textbook and all the exercises that were in between the covers. Assessment practice was limited to setting topic tests, term tests and end of year tests. Students' final grades were calculated using test scores, marks for homework and an arbitrary mark for attendance and participation. Students did not question why they had to do what they did (or more to the point it was not encouraged), or why you were doing what you were doing. Thankfully the same cannot be said today. Curriculum delivery is far more flexible, more exciting and more challenging professionally.

Nowadays, I try to start from where the students are and build something real and relevant for them. I decided to take a huge leap of faith and actually ask the students what they thought was missing from the lessons or what needed to stay in my repertoire. The responses were thought provoking to say the least. These ones following were high on everybody's agenda.

Why did I ask?

Entertain me!

I want to go outside now!

Can't we go to the computer room?

Why do you have to be different Miss?

When are we ever going to use this?

Maths is photocopies, blackboard work & textbooks.

This is Maths not English.

I like working with my friend.

I don't like working with them.

I don't get it!

And of course, the perennial favourite,

I want to go to the toilet!

These statements really were laying down the gauntlet, and as I am not one keen to back away from a challenge, thanked heaven for Fay, the Teacher Assistant, and set about business. We needed something outdoors, involving technology, that would foster working in teams, something that supported and extended the students literacy skill development, would make them aware of other cultures around them and would keep them amused. Hopefully I could show them the relevance as we went along and that we could share those 'aha' moments when they got it.

Fay and I worked hard over many a coffee at the legendary Memorial Club and devised the project that would fulfil all the students' needs.

## The new curriculum

We called our brain child ‘Where in the world is Spinifex Longifolius?’

You have to admit a catchy title will grab them every time. Let’s face it, who would want to participate in a project called ‘map reading’. Our planning took into account the Key learning areas of Mathematics and Studies of Society and Environment.

We included the cross curricula perspectives of Learning Technologies and the Indigenous Studies Curriculum Policy. We addressed the literacy needs of our students using the ESL outcomes as well as a focus on the EsseNTial Learnings that underpin the Northern Territory Curriculum Framework.

The project in a nutshell was:

### **‘Where in the world is Spinifex Longifolius?’**

The desired outcomes for the project were:

1. Students will identify the position of and best route to locations of local bush medicines.

The project involved learning to navigate with a hand-held Global Positioning System (GPS) and then using the information from the unit to produce both formal and informal (mud) maps.

2. Using appropriate hardware and software they will produce an information package that will communicate the results to different audiences.

This was suitably vague so as to give the students the opportunity to produce a package that they were comfortable with. Some of the options would be to produce a web-based presentation, a pictorial presentation, a highly literate or formal presentation and some students would produce an audio commentary

3. The package will include charts, scale maps, diagrams, transcripts, photographs and video footage.

This was an underhanded attempt at producing a package that could be a potential money-spinner for the faculty.



The time to begin arrives. I am ready, Fay is ready, the Indigenous women willing to help us are ready, the money is in the bank and the resources are in the room. What a surprise — the other Year 10 Maths teacher goes out on stress; overnight the class doubles. Just like Bob the Builder, ‘Can we fix it? YES we can!’ All it will take is a little, (a lot) of re-jigging.

The class number grows to twenty-five, ten male, fifteen female, eight Indigenous and 17 non-Indigenous students. This group was made up of rodeo riders, speedway drivers, party animals, committed studious types (both the talented and the hard worker) and the drop-ins (nobody in Year 10 ever dropped OUT, they would only drop IN from time to time).

Lesson One is to be prepared for major upheavals. Not only absent teachers but also making sure to address the needs of the poor attendee, interruptions like sports day, sport trips away, server downtime, unexpected changes to the daily timetable and the list goes on. One solution was simple for us, one teacher assistant was invaluable, and two were worth their weight in gold.

## Who owns the curriculum anyway?

To the staff, it seemed all very well and proper for the Mathematics teacher and the assistant teacher to plan and prepare for the Mathematics lessons. Little did I know that I should seek permission to use curriculum from the other learning areas.

- ‘Latitude and longitude belong to Studies of Society and Environment. It is placed in Year 8, your students have completed that section, why do it again?’
- ‘Year 10 doesn’t have access to the software that will produce eye-catching multimedia presentations. That software is only available for the IT teachers Stage 1 and 2 classes.’ The same was said for hardware, scanners, cameras and the video editing machine — we ended up buying our own!
- ‘There are protocols and procedures for involving the Language Centre, why would Maths want to access these resources any way?’
- ‘Do you think that a Maths teacher is able to support, model or scaffold the literacy development of our ESL students? Shouldn’t you have asked the ESL support teacher for help first?’
- ‘We are very happy for you to take care of the Mathematics outcomes for the class and please help yourself to the EsseNTial Learnings.’

So in other words: ‘Get back in your box!’ It is only that I had been teaching in the school for a long time that I could talk down the critics and go ahead with my plan. A new teacher may not be so lucky.

After these conversations with staff members, I really wanted to know ‘Who owns the curriculum anyway?’ It would seem that in the secondary school setting we are all very protective of our own domain. In a way I suppose that as we regard ourselves as specialist teachers it is understandable although not entirely defensible, to feel under threat when other subject areas borrow our content.

There are discussions still to be had about the responsibility for numeracy especially in the secondary school. From my experience, it is a strong belief that it is the sole responsibility of the Mathematics teacher for creating numerate students.

I shall finish this point with a classic quote from a secondary 'Tech' Studies teacher, 'All the Commonwealth numeracy and literacy money goes to the Maths and English faculties. I am tired of money being linked to numeracy and literacy, as the rest of us don't get a look in!'

How do you reply without sounding facetious or even downright rude?

## The environmental audit

There is a need to take an environmental scan, which is a good military strategy to ensure a successful campaign. In the educational setting, I mean it to be an audit of skills, knowledge, interests and experiences of all those involved in the teaching and learning process as well as gathering resources both concrete and human.

Good teaching practice means finding out what the students know, making plans to take them on from there, making the links, modelling the processes and devising methods for making a real assessment of their abilities. If you were to ask my students they would add that good teaching should also entertain them. Teachers need to know their students, know their interests and know how they function within the town. This is one of the beauties of living in a small town. All their knowledge and experience value adds to the learning and teaching process.

In this class, there were students where a GPS was not a foreign object. Their dad installed a unit in the fishing boat so he could navigate his way around the best Barramundi fishing grounds in the Gulf of Carpentaria. Some of the students belonged to the cadets and had extensive practice with map referencing and orientation. The students from communities contributed their local knowledge and there were many opportunities for language exchanges, (some I know were a little dubious but at least they were communicating).

Usually the way I work is to take a situation or issue that I find interesting and would like to explore. After a test run on the students to gauge their interest I then work out the links for the numeracy outcomes and I plan for the best way to present the content. When it is something that I feel confident about the enthusiasm for the topic is shared with the students and sometimes it rubs off. After all these years, students I have taught can still tell you my stories of Pythagoras and his secret society. They will also explain why Trigonometry is so useful and who could forget the three-act one-woman show about the history of measurement?

I suppose the environmental scan can be summed up as:

When you know where you are coming from  
 When you think you are on the right track  
 When you feel confident that the students will come on board  
 Relax and have fun.

## Handling the new recruits

My definition of a new recruit is not only someone new to teaching fresh from University but includes all teachers new to a system, a school or a region. It is a given in Northern Territory secondary schools that there will not necessarily be a Mathematics teacher taking a Mathematics class or in others instructing in their specialty subject. In a relatively recent position vacant advertisement was the following classic example: 'School X requires teacher for Year 10 English and Year 10 Mathematics classes'.

To promote the message that numeracy is everybody's responsibility, new teachers need to be encouraged and prepared to make the links between the numeracy components of their subject area and the required mathematical outcomes.

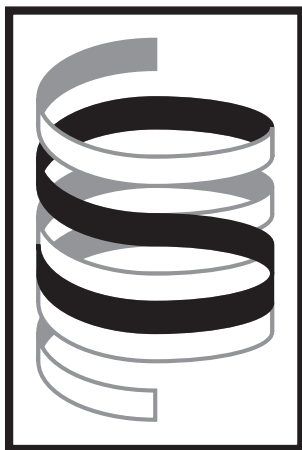
When the stress of teaching overwhelmed my Year 10 counterpart, he was replaced with an energetic, keen and trusting highly qualified art teacher. She drove three thousand kilometres to join our staff unaware of the requirement for her to teach Mathematics to Year 10 and 11. After removing the distributor cap from the car's engine to stop her running away and giving her a strong drink to calm her nerves, we sat down to discuss the situation. She was convinced that she had no skills to teach mathematics and she also feared that, as she could not do mathematics at school, how would she be able to teach our kids?

We started with what she liked and knew. After a little while she had a great unit of work prepared on 'graffiti' that made all the links to the space and the measurement strand as well as good links to critical literacy. Not only did she engage the students but the work generated a lot of discussion with parents as to what their kids were up to and how this related to mathematics, as they knew it.

It has been said that if you stumble across the right person in a school, you manage to survive. If we are to promote numeracy as a cross curriculum element and to have teachers believe that they are capable of creating the numeracy links in their teaching then it is very clear that we need to get better at supporting teachers from the start.

This is a huge challenge for institutions, education systems and individual schools to come to terms with. If we want numeracy to be everyone's responsibility then they need to deal with the many implications that have arisen. For example, how could a revision of staffing formulae promote better support for new staff, how could systems provide equitable funding for the many diverse educational settings around the country as well as how could there be better provision of appropriate professional development for all staff?

Long time teachers love the phrase, 'We have always done it that way'. Perhaps someone should tell them that 'the times they are a-changing'.



# Quality experiences equal quality numeracy

Liz Irwin

Hilder Road State School  
Queensland

Liz Irwin is a Deputy Principal/Teacher at Hilder Road State School in Brisbane, Queensland. She works in Years 1–4 classrooms teaching Mathematics. Liz is an experienced early childhood teacher with a passion for introducing children to a love of mathematics for life. She introduced a hands-on, developmental place value program into the school three years ago. Consequently, with the support of the students, staff and parents, Hilder Road State School recently won a state award for this numeracy work in National Literacy and Numeracy Week 2002. Particular interests are patterning, place value and problem solving, as well as creating experiences where children are guided to construct their own mathematical knowledge.

Students with a passionate desire to be numerate! Children finding maths exciting, puzzling and mysterious! Playing with it in their minds, engaging with it, feeling and thinking about it! Acting like ‘real mathematicians’! This is part of the numeracy vision I have for children at our school. But how does one person’s passionate view become transformed into an ongoing whole-school journey – particularly in light of Queensland’s systemic requirements focussing on literacy?

Numeracy permeates life. It can be defined independent of any key learning area. While numeracy is not part of mathematics as a discipline, mathematics needs to be taught for its own sake, and as part of wider investigations. ‘The idea that mathematics is beautiful, it’s important, and that you fail sometimes... needs to be conveyed to young people.’ (Jan Thomas in *The Australian*, October 28–29, 2000).

Creating a hunger for knowledge, and a ‘fire in the belly’ enthusiasm for mathematics, are challenges for any teacher. I had previously worked as an Education Adviser (Numeracy) introducing the Diagnostic Net, and studied mathematics education for a post-graduate qualification. On returning to a multi-age classroom (Years 1, 2 and 3) I was able to experiment and develop productive pedagogies through providing quality numeracy experiences. On becoming a Deputy Principal in a new school, I was faced with the challenge of meshing a passionate vision about the teaching and learning of mathematics with a staff focussed on other systemic priorities.

Many researchers agree that professional development for teachers needs to focus on a process of reflection, mentoring and coaching, combined with meaningful workshops. At Hilder Road I was a 0.5 Deputy Principal, which meant I also worked 0.5 of my week in classrooms, relieving teachers for non-contact time. I appealed to the teachers I was working with to allow me the pleasure of ‘doing maths’ with the children – predominantly Years 1, 2 and 3.

Armed with my constructivist notions on Base Ten, I worked with children each week, using anecdotal notes to record observations about the students. Teachers were on non-contact time in this period and initially some left the room. Eventually they stayed at their desks, semi-observing what the class was doing. In time, we often stayed back at lunchtime and discussed the observations made and the processes used.

Because of the continuing interest, I ran several workshops for teachers on teaching place value, continuing to mentor the process during non-

contact time. The aim continually was to create a ‘Mathematical Discourse Community’, encouraging children to share what they were doing and thinking in a variety of ways, discussing and puzzling over mathematical issues and ideas together. Because numeracy involves abilities that include interpreting, applying and communicating, the priority was not in having a ‘quiet’ classroom of children focussed on their relationship with a textbook (heaven forbid!). Rather, the focus was on creating and maintaining a classroom of learners discussing, playing and reflecting on ideas together. This involved the provision of relevant and meaningful contexts to help children make connections between school maths and real-life maths.

Children learn through personal experience with mathematical ideas. It is important, then, to acknowledge prior learnings so children are able to make connections and links. This program focussed on engaging children in their work through acknowledging their need to make sense of the world with concrete materials. It was also important not to assume that the provision of such materials would allow children automatically to ‘see’ the maths involved. ‘Concrete materials do not necessarily a mathematician make’. The need for a teacher with background knowledge of the ‘big picture’, working as a facilitator, guide, observer and challenger, was ever-important. Most importantly, there was a need for teachers to understand that with Base Ten, everyone uses materials involving all three representations: oral, written and symbolic.

Eventually the stage of recording symbolically is reached, but even then there is much discussion and mental play with ideas. Children are often given the impression by well-meaning teachers that the higher the year level, the less likely it is that students need concrete representations. My challenge to those teachers is that students need such materials — not merely procedural learning of the abstract — to help build mental representations and conceptual knowledge.

Having a reflection time at the end of each session ensures that children are able to share their learnings, understandings, discoveries and puzzles, and develop and use metacognitive skills to talk and reflect about their learning together.

During all sessions, persistence, risk-taking and acceptance of errors as part of learning were continually encouraged and reinforced. One of the most effective ways of doing this was through the use of a puppet, Peter Possum, who modelled an enthusiasm for learning, a keenness to persist in spite of making errors, and a passion for everything numerate! He would even go on ‘holidays’ and bring back photos of discoveries in the real world: patterns on the beach, water ripples in the resort pool... Peter has become a school icon and now wears the school uniform and badge. His tail quivers with excitement at any new mathematical discovery! Learners require feedback that values each one of them, and Peter has contributed greatly to providing an ‘objective’ opinion that anyone can delight in mathematical discoveries, that differences and variety in answers are anticipated and expected, and that mathematics is something to be enjoyed.

By facilitating the provision of quality mathematical experiences, such as Base Ten, we also address teachers’ age-old problem of catering for students with different levels of understanding and different rates of development. ‘Students aren’t made to match how the teacher teaches.’ (Munro, 1996). We focussed on catering for different learners by linking to prior learning, promoting visual strategies (e.g. mental computations with 99 board), emphasising students’ recording their own findings in ways meaningful to them, leading to a more formal ‘mathematical’ presentation. Group work,

paired work and triads catered for mixed-ability groups, with the composition of the groups constantly changing depending on members' experience and needs. The planning for such groups was based on observations of what children were doing or thinking, thus catering to or challenging different levels of need.

Base Ten work is a really good example of open-ended experiences, where all children are happy to work at their own level without fear of failure or loss of self-esteem. Jameson needs practice with becoming familiar with two digit numbers and is still coping with add on 1 and add on 2 strategies, using paddle-pop sticks. Meanwhile Tom can work happily beside him with MAB, becoming familiar with four digit numbers, and recording regrouping with three digit numbers. We continued to assess and report these experiences using anecdotal notes, being one of only a few schools to use such evidence at moderation with other schools. The evidence we collected about individual children's mathematical thinking was rich, valid and extremely reliable, and gave us much data to map children's progress on the Number Continuum – Year 2 Diagnostic Net much more, in fact, than the proliferation of 'ticked tests' we saw at moderation.

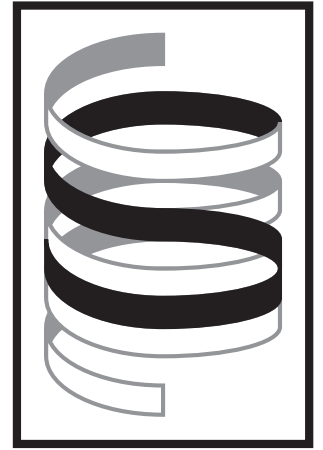
The success of the 'ripple effect' of improving pedagogical practice continues today, with new teachers being introduced to these practices and experiences through a similar approach. The upper school has also begun a 'rippled' mathematical journey, with an intensive mentoring and workshop approach being implemented in Term 4, with two 'critical friends' focussing on Working Mathematically. Other staff have completed workshops focusing on Productive Pedagogies and Mathematics. The whole school has decided to write a Numeracy Strategy and Implementation Plan this year to formalise much work that has already begun, and to provide a shared vision for all members of our school community for the future. In doing so we acknowledge our need to have time to develop a common language and understanding about mathematics, to get the 'big picture', and to reflect together on challenges to our common practice.

Quality experiences equal quality numeracy? Yes, but the equation is heavily underscored by a strong framework of teaching for deep understanding and deep knowledge. 'Teachers with a deep knowledge of teaching are better teachers.' (Thomas, 2000). However, they often need someone to share the journey. The 'ripple in the pond' effect on changing beliefs and practice does work. It is imperative that administrators accept the challenge of being heavily involved in a quality numeracy curriculum and become just as passionate about joining the trip! Bon numerate voyage!

# Promoting deep understanding

Tracey Muir

Bracknell Primary School  
Tasmania



**T**he teaching of numeracy necessitates the employment of a varied approach which encourages students to think and work mathematically. My involvement with the Thinking and Working Mathematical Project has seen me incorporate many key principles into my classroom which enhances children's learning and leads to a deeper understanding of the concepts covered. This project is a collaborative one, involving the Prospect cluster of schools in and around the Launceston area, and is facilitated by Professor Alistair McIntosh from the University of Tasmania.

## Project principles

I use a constructivist approach in all aspects of my classroom teaching. With particular regard to numeracy I consider the following principles to be the basis behind all experiences:

- communicating;
- making connections;
- problem-solving and investigating;
- creating positive attitudes and feelings;
- using concrete aids and technologies;
- promoting metacognitive thinking;
- encouraging reflection and using authentic assessment.

## Communicating

Students in my class are encouraged to communicate what they are thinking/doing in a variety of ways. The provision of a collaborative working environment, coupled with ample opportunities to work in small groups had led to students being confident with sharing their responses and valuing the input of others. Key questions such as 'How did you work it out?' and 'Is there another way of doing it?' leads students to examine their thinking and realise there are different strategies and ways of

Tracey Muir is a Grade 4/5/6 teacher at Bracknell Primary School in Tasmania. She graduated from the University of Tasmania in 1987 with a B.Ed and since then has completed a Graduate Certificate in Leadership and a Master of Education Degree. She also works 0.2 as a Resource Teacher in the Thinking and Working Mathematical Project and lectures the Bachelor of Teaching students in Mathematics at the University of Tasmania, Launceston.



solving problems. Students record when necessary and appropriate; the recording should be purposeful and not merely the filling in of a worksheet.

In response to, 'How would you work out  $57 + 39$ ?' students volunteered the following responses:

'I worked it out by using a graph, but I used a picture in my head before drawing this one. I knew that 50 and 30 were 80 and that  $7 + 9$  was 16 and then I added them together.'

'I worked out that  $7+9$  was 16 and then added  $50 + 30$ , then added the 10 and the 6 to get 95.'

Comments such as this give the teacher a good insight into what the students are thinking and what mental strategies they are using to solve problems.

## Making connections

Another feature of my classroom practice is to encourage students to make connections in their learning. This is accomplished through presenting material in a variety of ways, linking different strands and integrating maths into other areas of the curriculum where appropriate. The importance of this aspect was highlighted by one student's response to the question, 'What are seven lots of three?' The student responded, 'I don't know, I'm only up to my three times table.' This indicates that the child has not made the connection between the processes, probably due to the traditional approach of teaching tables, starting from one and moving to twelve. Students need to be encouraged to build new knowledge from old and to employ strategies to help them work out the answers. Using real-life contexts and meaningful experiences also help to facilitate these connections.

A recent example in our classroom involved the construction of a Coolgardie safe as part of Science Week. The students had to work together to design and build the 'safe' and then judge its effectiveness at keeping food cool for a week. The design and construction saw the implementation of many numeracy skills, including estimation, measuring with informal and formal units, working out costs, and using area and perimeter.

In a recent unit of work on exploring two-dimensional shapes, children were involved in a variety of experiences which began by focussing on their prior knowledge, engaging them in motivating tasks and extending their understanding further. Students brainstormed

lists of shapes, used geoboards to make shapes, investigated triangles using toothpicks, found shapes in the environment and photographed and documented shapes found in buildings. They found this to be a very stimulating experience and the individual outcomes achieved indicated that by the end of the unit, most students had a deeper understanding of 2-D shapes.





## Problem solving and investigating

Students regularly take part in problem-solving and investigating challenges. Particular problem-solving strategies are explicitly taught and discussions are generated which highlight effective strategies. Students are now confident with using ‘guess and check’, drawing a table or diagram, working backwards and using logical reasoning.

Some topics to encourage extended investigations include:

- People say you are as tall as your armspan. Investigate.
- Do people with bigger hands have larger angles between their fingers?
- How would you fold an A4 piece of paper to make a container to hold the most popcorn?

Open-ended investigations such as these encourage all children to contribute at their own level and draw their own conclusions, enabling all students to experience success. Chance and data activities also provide excellent opportunities for both investigating and working collaboratively. Students recently worked on a challenge about ‘Which game is fair?’, a topic generated by the upcoming local show. A number of side-show games were discussed and predictions made about which one would be the best investment for our pocket money.

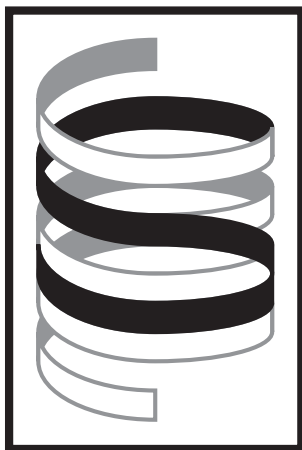
## Positive attitudes and feelings

Significant attention is paid to developing positive attitudes and feelings, engaging all students and valuing their contributions. Student work is displayed and shared throughout the school and community. Students regularly share their numeracy work at school assemblies, ranging from a placemat activity showing their understanding of fractions, to Escher-inspired tessellations to 3D models they have constructed.

Promoting deeper understanding comes through employing a pedagogy which incorporates the principles of Thinking and Working Mathematically. Paying attention to what students are telling us, promoting examination of their own thinking and encouraging reflection leads to children taking on a greater responsibility for their own learning. Using authentic assessment tasks and tools, such as thinkboards, rubrics and learning logs helps to keep the teacher informed of students development and enables the implementation of a program which meets all individuals needs.

Tasmanian education is currently undergoing an exciting change with the implementation of *Essential Learnings*, a framework which is designed to engage learners more deeply in their learning and to develop higher-order thinking. I like to think that the students involved the Thinking and Working Mathematical Project have already had a head start in this area, and that their confidence and achievements will continue to grow as teachers incorporate this new curriculum into their practice.

For more information on the Thinking and Working Mathematically Project, visit the website: <http://discover.tased.edu.au/numeracy> or e-mail: [tracey.muir@education.tas.gov.au](mailto:tracey.muir@education.tas.gov.au).



# Motivation and enjoyment through numeracy across the curriculum

Peter Mobey

Gold Creek School  
Australian Capital Territory

Peter Mobey is a Year 7 home-room teacher in the middle school at Gold Creek School — a K–10 school across two sites in Gungahlin in Canberra’s north.

Having graduated with Honours in 2001 from the University of Tasmania’s Bachelor of Teaching program, Peter has tried some very successful, innovative techniques, which incorporate numeracy across a wide range of Key Learning Areas. For this reason, Peter was selected to join the *Middle Years Numeracy Research (MYN) Project*, a two year project conducted by the University of Canberra and the ACT Department of Education. Peter brings many real life numeracy experiences to teaching, most notably the daily application of number skills mastered while keeping accounts for the NSW railways. It was during this time that he also learnt the importance of gradient, graphing and equivalence, as well as working with a practical application of systems. His first degree in Fine Arts has assisted in the mastery of weights, space, pattern, symmetry and the practical application of formulas.

The stories that follow highlight the importance of motivation in effective numeracy teaching and highlight my philosophy that ‘We are all teachers of numeracy — all of the time’.

## Spiro’s story

It was during my first week of teaching that I encountered Spiro from Grade 8 for the first time. It was in the Library. Spiro was sizing himself up against another male student. I stepped over to intervene.

‘Hi! Anything I can help sort out?’

‘No. No. Everything is just fine Mr... errrr... [looking at my name badge] Mobey.’

‘Oh, that’s good. Very pleased to hear it.’

‘Hey, Mr Mobey? How long have you had that beard?’

‘This one? Since 1988.’

‘Why don’t you shave it off?’

‘Well it gives me at least five minutes extra every morning.’

‘Ha! 5 minutes; that’s nothing!’

‘Well, you work it out then: if it saves me five minutes a day, how much time do I save each year?’

Tony turned to his mates and walked away: ‘Hey give us hand to work this out.’

Shortly afterwards Spiro and the rest of his class left the library. I did not see him until I was on duty the following Monday. I walked up to Spiro and his mates. ‘So — did you work out that problem?’

‘Yeah! Yeah! We did!’

‘What was the answer then?’

‘Err. It was... It was... thirty hours somethin’.’

‘Great! Well done. Was it more than you expected?’

‘Err... Yeah.’

Although I had never met Spiro before our chance encounter in the library, I am certain that I was able to use the situation to stimulate some quality numeracy learning. Furthermore this story demonstrates how powerful motivation can be in encouraging even the most reluctant student to use whatever numeracy they have.

Now, Spiro is no ‘A’ grade student, his homeroom teacher has a tough

time getting any mathematics work out of Spiro or his mates — yet they were able to go away and use their skills to solve the problem.

I am sure this story will strike a chord with many other teachers. In my classroom I can identify several students who are similar to Spiro in many ways. They have one thing in common with a number of students in every classroom, in every school: they have very successfully learnt the necessary skills to spend plenty of time in the corridor, be relocated to another class, or sent to the Deputy principal.

To put it simply, they have learnt avoidance strategies because they can see no relevance or importance in what they are being asked to do in Mathematics as well as most of the other key learning areas.

## Answering the challenge

Despite our freedom to timetable to suit our class needs, the tradition in the middle school at Gold Creek has been to teach 3 or 4 hours of mathematics a week as discrete lessons with content streamed according to ability.

Accordingly, in the first days of the school year I conducted diagnostic testing in mathematics to gauge students' abilities in areas such as ordering of numbers, fractions, times tables and symmetry. Results were distributed over a wide range from a high of 90% to a cluster of students well below 50%. I was sure that the higher ability students would be OK, but I was really worried the lower ability students: how could I possibly provide a positive experience for these students? I toyed with several ideas: maybe a rich task or rotations during maths lessons.

The answer came through an unexpected avenue. Faced with students' blank expressions and a lack of interaction when I was trying to get across the effectiveness of poetry as a way of communicating our ideas as part of our integrated unit on communication, I deviated from my planning and issued 'a challenge' to the students: 'In pairs create a 3-D poem'. The effect was spectacular! Immediately an excited discussion broke out about how we defined three dimensions and 'Couldn't we just use the straws to create the letters?' 'Wouldn't that be three-dimensional because it has depth?'

Over the next week there were many, many discussions that centred around numeracy in small groups and as a whole class. We discussed weight and balance, the appropriate size of a grandstand on a paper football field. We even argued over the best way to count out twenty straws.

Perhaps the most pleasing result was from two students who had both scored well below 50% in the diagnostic test. Although I had been warned that these students were unlikely to complete much work all year, because the task was different and exciting, they embraced the challenge with gusto. They decided to create a 'Zig-Zag' poem, the construction of which required very careful mathematical planning indeed.

Due to the way the boys decided to construct the poem, they needed to decide how many sections the poem and title would be divided into. Then they measured and cut each section accurately into eight equal parts, ready for mounting onto the backing section which required careful mathematical planning itself. I am quite sure if I had asked these students to divide a piece of paper into eight equal parts they would have complained very loudly indeed or even refused point blank! However, here they were calculating, measuring and cutting with the greatest of care.

In the face of such success, as well as a pervading air of negativity the



Figure 1. Zig-zag poem.

moment mathematics was mentioned, I resolved to augment everyday mathematics lessons in favour of an integrated, hands on approach employing numeracy across the curriculum. This approach continued to be highly successful throughout first term, as I issued the students with more challenges including, sending a message across the school courts and creating a communication board game. Each of these tasks required significant numeracy skills to complete successfully.

## Building on success

Second term was a time to distil some of the practices I had been carrying out intuitively — although I would have done this informally as part of my reflective practice. I had decided at the initial meeting of the Middle Years Numeracy Research Project to observe and note the numeracy moments and numeracy potentials in technology (design, make and appraise) hosted activities within the integrated studies units.

My thinking was that through the identification, highlighting and discussion of numeracy moments provided during hands-on activities, will prove valuable to those considering the enhancement of numeracy through an relevant, exciting, integrated curriculum in a middle school/lower secondary setting.

As our unit for second term was ‘The Mystery of History’, I decided that a suitable and stimulating activity would be to construct models of buildings in the ancient world. I began the process by outlining the model building project to the students. We then moved on to form groups and scan through a range of books to find drawings, photos or plans that would assist in creating our models.

While the students were for the most part engaged, they quickly became negative when I asked, ‘What about scale. Does anyone have an idea of the sort of scale we should use?’ One student said loudly, ‘I don’t know! All that stuff is too hard. Ben is good at all that stuff.’ Although Ben is perceived as being good at mathematics, in my opinion his strengths lie in textbook exercises rather than practical applications. Ben just looked bewildered.

A large number of the students chorused their agreement. As it was nearly time for the afternoon bell, I decided not to take the opportunity to discuss ‘scale’ but wrapped up the lesson — we would deal with the problem next time. Before the next model making lesson I decided that many of the students were simply not ready to deal with the formal use of scale and settled upon asking for a sketch and brief outline as part of the planing process. This decision proved to be correct with many students struggling to translate the two-dimensional drawings into 3-D models. In particular, there was James. Despite protestations from the rest of his group, he insisted that every second tower on a Roman Fort should be set back. The negotiations over this issue and whether pop sticks or matchsticks would create the most accurate model went on over several weeks. Although I was unable to convince James that the towers needed to be made of matchsticks and positioned in a straight row, the other group members eventually succeeded. Despite finding James’ stubbornness frustrating, the positive outcome I observed was the increased use of numerate language that the students were able to employ in order to convince their team mate.



Figure 2. Modelling historical buildings.

## A turn in the right direction

As I alluded to earlier, students began the year with very poor attitudes to mathematics, especially algorithms. The successful turn around in these attitudes where tasks are engaging, relevant and exciting was easy to see when I presented the students with several calculations as part of the ‘Round Australia Rally’.

The numeracy demands of the rally activities included:

- the choice and use of the four operations;
- understanding of scale;
- use and understanding of the points of a compass;
- calculation of distances using tables and maps;
- maintenance of a budget (manual and *Excel* spreadsheet);
- calculation of registration and insurance costs;
- calculation of fuel consumption and total fuel costs.

After ‘purchasing’ their car (I supplied a number of *Open Road*’s with vehicle costs as well as a selection of 4×4 trading magazines and the current *Trading Post* to facilitate this task), students were required to calculate registration, insurance and, when the rally began, fuel costs. These were all complex calculations. To register their car, students needed to select an appropriate base registration cost or transfer fee before calculating stamp duty at 3 cents in the dollar and adding the figures to obtain the total cost. The insurance required a similar calculation with the additional complicating factor of calculating GST!

The cost of fuel was the calculation which students found the hardest. After their first (largely unsuccessful) attempts, I devised a ‘fuel cost calculator’ – students were then more successful in performing this calculation on the whole. However as the students successfully calculated the costs for their first stage, a look of horror invariably spread across their faces. One student even called out, ‘Mr Mobey – is this right? It can’t be right. We’re broke!’ What they had failed to recognise was that they were calculating costs in cents not dollars! I asked, ‘What have we calculated the fuel cost in?’. The answer coupled with a quick discussion around place value saw a sea of relieved faces.

The exciting thing about this part of the rally was that each and every student was prepared to have a go – even after experiencing initial difficulties. This continued with many students determinedly attempting the calculations even though they needed to be talked through the calculations for three, four and even five stages. By this time the vast majority of the class were able to do the calculation with a minimum of fuss.

I was also fascinated and encouraged by the attitude of a group of girls to the calculation of the rally distance between Melbourne and Albury. Students were required to highlight their route from Melbourne to Albury via Geelong, Ballarat, Bendigo and Shepparton on the road map provided. To successfully complete this task, I had considered that students needed to either locate the distances between the centres on their road map or use a ready reckoner table I had provided in order to find the distances, before adding to find the total distance.

The majority of students chose to use the table. However, they simply located the direct distance between Melbourne and Albury. When I questioned the accuracy of this method by pointing out they had calculated the distance along the Hume Highway, several students became confused. They did not seem to understand that they could add several distances together to get a correct answer until I gave them permission to do so.

However, one table group of four girls displayed numerate behaviour I had not expected as a solution to the problem. Using string they used the scale provided on the map to estimate the total distance for the route travelled. This method proved to be more accurate (to within 30 kilometres) than many of the other students who used what I had considered to be the ‘correct method’.

This example not only demonstrates a fantastic ‘have a go’ attitude but highlights the benefits of giving all students ready access to equipment and manipulatives in the classroom. In my classroom I have many items always on hand which students are encouraged to use to help solve problems, they include:

- plastic counters
- dice
- play money
- paddle pop and match sticks
- number mats
- calculators
- set square
- protractors
- and, of course, string.

By now, I hope you have an image of a buzzing, active classroom where the numeracy opportunities are drawn out whenever possible. Of course it is not always easy pursuing numeracy throughout the curriculum. Not only can it look very messy, but the numeracy is not always obvious; it takes time and reflective practice to plan and unpack the numeracy potentials. However, the more I pursue this style of teaching the more I become convinced that not only is an integrated approach appropriate for teaching and reinforcing numeracy – it is highly relevant, and even more importantly, students find it exciting and are prepared to have a real go!

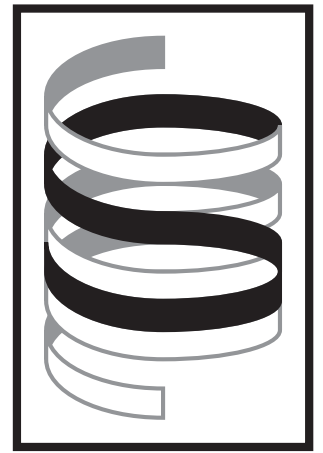


Figure 3. Students playing games.

# Early Years Numeracy Interview — An assessment tool for P–4

Heather Norbury

Boronia Heights Primary School  
Victoria



We all know that every child in our class brings with them a wide range of skills, understandings and experiences in mathematics. How can we find out what children know and what skills they use to solve everyday mathematical problems?

The *Early Years Numeracy Interview* used in Victorian schools is a powerful tool for assessing students' numeracy development during the first five years of schooling. The Interview is conducted in a one-to-one situation by the class teacher and preferably at the start of the school year. It involves using hands-on materials and the child's responses can be recorded either electronically or with pen and paper.

Information gathered during the interview allows teachers to develop a profile of student numeracy development in nine aspects of mathematics: counting, place value, addition and subtraction, multiplication and division, time, length, mass, properties of shape and shape visualisation. Evidence from the Interview allows teachers to plan focussed teaching sessions for all children in their class and to cater for individual differences.

## History

The *Early Numeracy Research Project* (ENRP) was conducted in Victoria from 1999–2001. As part of this project a need was identified for the development of a comprehensive assessment tool for early numeracy. Through the ENRP a framework of growth in numeracy learning was developed, using available research on young children's mathematics learning.

The framework provided a means of tracking students' learning through significant points of growth in number, measurement and space, organised into the domains of Counting, Place value, Strategies for addition and subtraction, Strategies for multiplication and division, Time, Length, Mass, Properties of shape, and Visualisation and orientation. The points of growth identified through the ENRP were used as the basis for the stages of mathematical growth in the Early Years Numeracy Program (EYNP) now being introduced into all Victorian government primary schools.

This framework was then used to create appropriate hands-on assessment tasks where students could demonstrate their mathematical understanding and strategies used for solving increasingly complex tasks. These tasks have been presented to more than 11 000 students during the ENRP in the form of a one-to-one interview.

Heather Norbury has trained and worked as a primary teacher since the 1970s. She has always had an interest in mathematics and has developed this interest throughout her teaching career. Heather is currently a Leading Teacher at Boronia Heights Primary School in the outer eastern area of Melbourne. She is a full time Prep teacher as well as Mathematics Coordinator for P–6.

Heather recently trained as an Early Years Numeracy Trainer for the Eastern Metropolitan Region in Victoria and she is involved in conducting Numeracy Network Meetings for school-based Numeracy Coordinators. She has also presented at curriculum days and conferences on the development of whole school mathematics plans, the numeracy block, and whole school moderation in mathematics. Heather has also been involved in research projects of the Australian Council for Educational Research in the area of mathematics.

## Value of the numeracy interview

The Early Numeracy Interview is a powerful tool for assessing students numeracy development from Year Prep to Year 4. Information obtained during the interview allows teachers to:

- develop an individual student profile of each students' numeracy development in number, measurement and space;
- inform focussed teaching of students.

It is recommended that the classroom teacher conduct the interview on a one-to-one basis as the teacher's observations of a child's mathematical skills and understandings and the strategies used are invaluable.

## Stages of mathematical growth in the early years

Stages in number, measurement and space have been outlined to illustrate the probable mathematical growth of students in the early years of schooling. However, these are not discrete, sequential stages of mathematics development as, at any time, students may demonstrate a range of skills and understandings depending on the mathematics in which they are engaged.

The stages of mathematical growth:

- reflect the findings of relevant research in mathematics education from both Australia and overseas;
- allow mathematical profiles of individuals and groups to be developed
- form the basis of planning and focussed teaching for teachers;
- allow teachers to identify and describe student improvement;
- enable teachers to identify students who may benefit from additional assistance in mathematics;
- have sufficient scope to describe the knowledge and understanding of most students in the first five years of schooling.

Within each mathematical strand, stages are described by points of growth.

## Links to the Curriculum and Standards Framework

The *Curriculum and Standards Framework: Mathematics*, Victoria in Levels 1–3 provide the broad stages of mathematical growth for Prep to Year 4 in the strands of Number, Measurement, Chance and Data, and Reasoning and Strategies. In the EYNP the points of growth in Number, Measurement and Space are closely aligned to the *Curriculum and Standards Framework* (CSF).

## Links between stages of mathematical growth and the Numeracy Interview

Tasks in the numeracy interview are linked to the points of mathematical growth. Student responses from the interview can be tracked against these points of growth to develop a profile of mathematical skills and understandings in the sections of the interview conducted. The student profile provides a guide in establishing a mathematical focus for teaching.



## About the interview

The interview includes oral questions that invite students to respond verbally or to demonstrate their level of understanding using a variety of materials and equipment. For example:

### Section E: Time

Equipment

- children's own hand-drawn clocks
- moveable yellow clock
- yellow June calendar card
- digital clock showing 12:51
- excerpt from TV guide
- blank digital and analogue clock faces

Prior to the interview, ask children to simply 'draw a clock'. If they draw a digital clock, ask them to then draw an analogue one. They bring these clocks to the interview.

#### 38. My Clock

*Depending upon the kinds of information shown in the child's drawing of a clock, ask questions like:*

Tell me about your clock.

What are clocks for?

What are the numbers on your clock? (If relevant)

How do the numbers work?

What time does your clock show?

Tell me what you do at this time.

#### 39. Telling the Time

Tell me what time these clocks show? (Use the yellow clock face.)

- a) 2:00
- b) 9:30
- c) 2:20

#### 40. The Days and the Months

- a) Tell me the days of the week (*or 'some days' if the child hesitates*).
- b) Tell me the months of the year (*or 'some days' if the child hesitates*).

#### 41. Calendar Tasks

*Show the child the yellow calendar card for June.*

- a) Find the 18th of June.
- b) Tell me what day of the week that is.
- c) Show me the last day in June.
- d) Tell me what month comes after June.
- e) What day of the week will the 1st of July be?

#### 42. Duration Tasks

*Show the child the green page with the diagram of the digital clock showing 12:51.*

- a) You put a pizza in the oven when the clock shows 12:51. You take the pizza out after 13 minutes. What is the time then?  
If the child answers '13:04', ask the next question.
- b) Is there another name for that time?

## Equipment

The equipment and cards needed for the interview tasks are listed at the start of each section of the interview.

Some materials need to be prepared before the interview commences with instructions listed at the start of each section. The interview will be easier to conduct if all materials are arranged on a separate table in the order in which they will be used. Interview kits are available from several educational supplies companies and the same interview kit is used at all year levels, as students from any year level may progress to different stages of mathematical growth depending on the extent of their skills and understandings in each section of the interview. It is not uncommon for students to show deep understandings in one mathematical strand but need additional assistance in another strand.

## Preparation

Before conducting the interview, teachers need to be familiar with the tasks, the equipment, the wording to be used, appropriate starting points for their students, the possible responses students might give and the different pathways that can be taken after each task. Teachers also need to be familiar with the scoring process and it can be very useful to observe a colleague conducting the interview before starting with one's own students.

A comfortable environment is needed to allow both the student and teacher to focus on the tasks, without any distractions. All student responses are recorded on the Early Numeracy Record Sheet or on the teacher's laptop using the electronic version of the interview.

Some tasks require detail about a student's response, such as the number counted to, the strategy used, or an explanation of a student's thinking. It is recommended that teachers record as much as possible of students' responses to gain a deeper understanding of their mathematical thinking.

### Section F: Length Measurement

Equipment:

- 25cm skewer
- 30cm piece of string
- 20cm plastic drinking straw
- 8 large (5cm) paper clips
- 30cm ruler (marked in cms and half cms)
- Long strips of straightened streamers around 180cm each
- Several streamers, exactly 93cms long
- Subtle marks on the table indicating lengths of 75cms and 125cms
- Pen within reach of child

## Determining starting points

It is recommended that the interview be conducted with all students at the start of the year. Students in their first year of school will need to commence with Task 1 as well as the 'First Year Detour'. Students from Years 1–4 should begin with a task just below the student's current performance level to ensure initial success. Ongoing monitoring and assessment would determine this performance level. If difficulties are experienced with the task chosen, the teacher should move back to the previous task.

## Conducting the interview

The aim of the interview is to determine the most sophisticated strategies a student chooses to use in each of the mathematical areas assessed. The entire interview takes about 45 minutes to conduct and students should be assured that the interview time is a time for the teacher to find out more about how they think while they are doing mathematical tasks. It is important for the teacher to use the exact words in the interview when introducing each task as this ensures consistency in collecting the data. It is also important for the teacher to allow time for the child to think about the question and provide a response. The teacher can also observe non-verbal responses, such as using fingers to count.

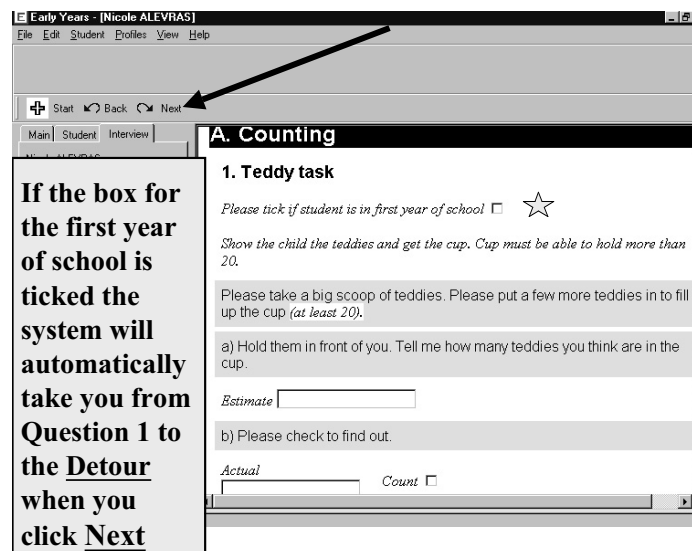
The full interview involves sixty tasks, some with sub-tasks, and the pathway through these tasks is determined by the students' responses. When a student has difficulty with a task, the teacher either moves into a detour to elaborate more clearly the student's level of understanding or proceeds to the next section of the interview.

At the start of each year, teachers from Years 1–4 commence the interview from where the student finished each section the previous year. It may be necessary to start one task before to ensure initial success.

## Analysing the interview responses

The information recorded during the interview can be used to determine the points of growth a student is currently demonstrating. Achievement of some points of growth will be indicated by success in just one or two tasks, but achievement in others will require successful demonstration across more tasks. This applies particularly in the Strategies for addition and subtraction and Strategies for multiplication and division.

Interpretation of student responses, and which points of growth they demonstrate, can form the focus of meetings of professional learning teams to develop a shared understanding of the strategies students are using.



**Higher order strategies are listed in bold type**  
**You must select only one strategy used by a student**

	<i>Tick strategy used Select only one</i>
<i>Known fact or fact family (e.g. 5+3=8)</i>	<input type="checkbox"/>
<i>Count back all, in head (e.g. 7, 6, 5 or 8, 7, 6, 5)</i>	<input type="checkbox"/>
<i>Count back all, with fingers used to keep track (e.g. 7, 6, 5 or 8, 7, 6, 5)</i>	<input type="checkbox"/>
<b><i>Other preferred strategy:</i></b>	<input type="checkbox"/>
<i>Modelling all (Shows 8 fingers, then takes away 3)</i>	<input type="checkbox"/>
<i>Other non-preferred strategy:</i>	<input type="checkbox"/>
<i>If incorrect answer, ask part (b) below</i>	

## Electronic version of the Numeracy Interview

At the beginning of 2002, all Prep to Year 4 teachers in Victorian primary government schools received a copy of the electronic version of the interview, which could be loaded onto their laptops. The electronic version combined the interview and record sheet into one and teachers were able to record students responses directly onto their laptops. The electronic version automatically navigated the interview for the teacher and determined the

**Individual Student Profiles list the highest point of growth for each area assessed by the interview and list the indicative CSF levels**

pathways to be taken during the interview. This version also determined which points of growth had been achieved by the students and aligned them with the *Curriculum and Standards Framework – Mathematics*, as well as producing individual and group profiles of students skills and understandings.

An important thing to remember is that the numeracy interview is only one form of assessment. Teacher observations, anecdotal records, self and peer assessment, and monitoring and assessment data collected during mathematics sessions, including that related to other mathematical areas, can be used to support and expand the interview-based profiles.

However the Early Numeracy Interview is an extremely valuable tool for determining what skills and understandings students have at the start of each year. It also enables teachers to provide focussed teaching for all their students and move them forward in their mathematical learning.

**Group Profiles show all points of growth for each area assessed by the interview-in this case Number**

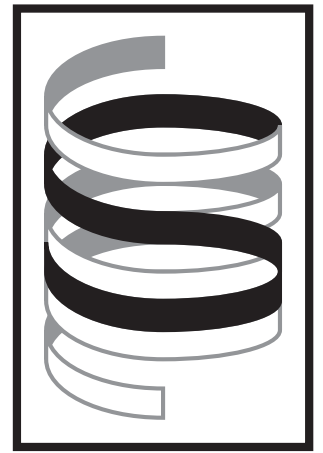
**Group Profile displaying the whole class**

All information in this paper has been based on information in the Early Numeracy Interview Booklet, produced by the Learning and Teaching Innovation Division, for the Department of Education & Training in Victoria.

# Supporting numeracy through student-initiated curriculum

Peggy O'Connor  
& Tara Hall

Hackham West Primary School  
South Australia



## Background

We work at Hackham West Primary School which is situated approximately twenty-five kilometres south of Adelaide. The school has 430 students, 18 classes and a junior primary special school class. The school is Category 2 on the Index of Disadvantage. Hackham West School was selected to be part of the *High Performing Literacy and Numeracy Schools Project* and the *High Performing Numeracy Schools Project* (joint SAPPA / DECS / DEST). We were also a 2002 winner of a National Numeracy Award.

Our class consists of fifty-nine Year 3/4/5 students and the students reflect the same diversities as shown in our school population. We have:

- six children from Non English Speaking Backgrounds (NESB)
- two Aboriginal / Torres Strait Islanders
- eleven on Negotiated Education Plans (NEPs)
- twelve on Special Support programs

We work as a collaborative team, with the children free to work in any learning area across our unit: children make choices about how and with whom they work (this is fostering interdependence skills) and children access resources as required, with negotiation where appropriate. Children have access to a pod of computers which are connected to the Internet. We have regular parent support, five hours of Student Support Officers' support (SSOs) per week, and two hours of Special Team support per week.

## Our beliefs

As educators we found that we shared common beliefs about how children learn. These beliefs about learning are based on constructivism which underpins our *South Australian Curriculum Standards and Accountability Framework* (SACSA), and which assumes that children are the learners and the constructors of the learning. There are four major beliefs which come under this umbrella and have impacted on our teaching practices, namely:

- all children can learn, but not on the day in the same way;
- there is a strong emphasis on teaching in time NOT teaching in case;
- we value an experience and activity-oriented curriculum over an instrumental curriculum, so that in our work, it is about '(t)eaching from

Peggy O'Connor is a Teaching and Learning Coordinator at Hackham West School, working on numeracy and student-initiated curriculum. She also has 0.8 responsibility for a 3/4/5 class of 55 children, which she shares with Tara Hall. Peggy has many years experience in a diverse range of schools, teaching across Years R-7. In addition, she facilitates a series of workshops at Flinders University for undergraduate teacher education students. Tara Hall is in her third year of contract teaching at Hackham West. She co-teaches with Peggy O'Connor. The focus of her practice is on student-initiated curriculum, learning through the Essential Learnings and student empowerment. Tara has taught in a diverse range of country and city schools, teaching across Years R-7. Included in both Peggy's and Tara's teaching and learning roles are mathematical and numeracy professional development across South Australia.

- learning over learning from teaching' (from Cal Durrant and Bill Green);
- numeracy is the ability and confidence to choose and use mathematical skills and understandings to solve problems in our everyday life. (This definition of numeracy is the one we use in the classroom. It fits in with the SACSA frameworks' understanding of numeracy, and with our belief that numeracy is part of all learning areas and empowers children to be numerate people who can participate successfully in daily life now and as adults.)

The major challenges that these beliefs posed for us in our teaching were:

- meeting individual needs of children if they were to learn at different times and to learn different things;
- how to include SACSA, the mathematics content and the Essential Learnings in our curriculum;
- how to have inclusive, individual assessment strategies which would inform all children of their future learning; and
- to ensure children see the relevance and purpose of mathematics and how they and others use it constantly in their daily lives.

## Student initiated learning

In order to meet children's needs there were three important issues for us to consider, three pieces of information that the children needed to successfully work individually: as constructors of knowledge, learners need opportunities to consider and frame

- what they already know;
- what they need / want to know (the possible knowings);
- how will they come to know (their preferred way of building knowledge).

We developed teaching / learning practices which we feel address these issues and allow for the best possible learning outcomes for all children. These constitute Student Initiated Learning, with all children developing their own individual learning plans. Included in this paper are examples of how we developed support material for the children and how the children develop their own learning plans in all strands of mathematics and all other areas of learning.

The process of Student Initiated Learning in Mathematics involves supporting students to identify 'what they already know' to enable them to build on their prior knowledge in order to set learning goals. At the beginning of each year we do a group brainstorm with the children for each of the strands of Mathematics. This may begin with questions such as,

- What are all the things we need to learn about in measurement?
- What can we measure in this room?
- What can we measure about these things? How can we measure?
- What tools can we use?

Children will offer ideas from their learning experiences and then we fill in the gaps they have missed due to not experiencing all aspects of each strand. This is followed by the use of audit tasks in each of the strands (e.g. Measurement). An audit task for Measurement may be:

- Choose an object and measure it in as many ways as you can
- or
- Choose two objects and measure them in as many ways as you can and then compare them.

number systems	choosing and using in the four number operations	place value
history of number		patterns in number
factors	addition subtraction	square numbers / square roots
common multiples	multiplication division	rectangular numbers triangular numbers
fractions	<b>NUMBER</b>	prime numbers composite numbers
percentage decimals ratio	mental computation thinking mathematically	problem solving word problems
theories/investigations in number		

**Mathematics Learning Plan  
Number**

Name \_\_\_\_\_

Term \_\_\_\_\_

INVESTIGATION TOPIC:

1. What do you know about \_\_\_\_\_?
2. What do you need to learn (SACSA)?
3. Essential learnings
4. How will you learn these skills?  
(What type of investigations / activities will you do?)

**Unit of work review – Mathematics**

Name \_\_\_\_\_

Term \_\_\_\_\_

I have completed a unit of work in \_\_\_\_\_

I have learnt

- 
- 
- 
- 
- 

I used the mathematics

- 
- 
- 
- 

I developed my skills and understandings in the Essential Learnings in  
**COMMUNICATION**

- 
- 
- 

**THINKING**

- 
- 
- 

**IDENTITY**

- 
- 

**INTERDEPENDENCE**

- 
- 

**FUTURES**

- 
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Students refer to the SACSA framework to plan their learning and they use the wide range of resources to work out the best possible way to implement and build on these learnings and understandings. The students assess and monitor their learning by using a range of strategies including reviews and learning conferences with an adult.

We did need certain factors to be present for this to be successful and so we spend some time at the beginning of the year to ensure that these factors are present. Specifically, there is a need for children:

- to develop independence so that they do not need to ask
  - to use the computer
  - to go to the library
  - to go to the photocopier etc.:
 if these are part of the learning plan then you just use them;
- to acquire knowledge: there is no one way to learn – record – assess. We are all different in our needs with these and what works for you may not work for me;
- to learn that it is okay to make mistakes, and to try again (and again) – we learn from our mistakes;
- to learn to relate their learning to their lives;
- to learn that there are many sources of help for learning in the room – not just the teacher: friends, adults, dictionaries, computers, etc.;
- to learn that it is not okay to do pages and pages of things we know – if you know it, then you are not learning, so consider how you can use that skill to learn something new or use the knowledge in a new situation.

## Outcomes of student initiated learning

As a result of our work in this area we have received immeasurable positive feedback from our students and their parents about students' learning success and their engagement in learning. Student Initiated Learning has proven to be a successful learning experience for all children in our class. Data from various tests such as Waddington – Spelling and Number, Torch Reading Comprehensions, Mathematics Social Audit and Basic Skills Test have shown dramatic growths in all children's learning. Many of our children were underachievers and also extreme behaviour problems. The Student Initiated Learning has meant great changes here also, for as the children become achievers on their own learning plans, the extreme behaviours have diminished, which in turn has led to greater learning outcomes for all, because of the decrease in overall interruptions and disruptions in class.

We asked some of our children to share their thoughts about this kind of learning.

Having your own learning plan is good because you get to choose what you want to work on and you learn what you need to not what someone else does. I think the decisions we make are good because the teachers are not the only people deciding it's the children as well. I waste less time because you get to choose what you work on and when. We have lots of different work so we don't get bored. I think it's a great investigation for all children and all schools should have a go. Learning this way makes me feel more confident because I'm in a level I can cope with. I like it this way.

*Natalia, Year 4*



I think that when I learn with learning plans I can expand my knowledge because I can choose what I want and need to learn and not what others might need to learn.

I waste less time with learning plans so I can fit more learning in my time. With learning plans I am telling teachers what I already know and I can move on with my learning. In the class we share out the decisions with our learning so we are always learning and we don't repeat what some students might already know lots about.

We figure out how we learn best and this helps us make learning more enjoyable and this makes us learn better and learn more.

This learning will help us in our futures lifes (sic) and jobs being our apprenticeship (sic) in democracy.

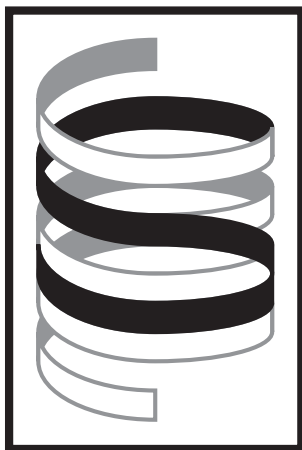
*John, Year 5*

Learning is better when you get to choose what you need to know about all the different strategies. You sometimes share your work with other children and teachers. It is also better when you get to do your own work because not only is it what you need to learn but it is usually fun. You don't need to do what your friends are doing. When I work this way it makes me feel confident and helps me see who I am.

*Mariam, Year 3*

Learning with different strategies is great for your brain and confidence. You don't have or need to learn what your partner needs to learn it's what you need to learn. You don't waste time by learning things you already know. I enjoy this because you get to choose what you want to learn. By learning it this way, it makes it more interesting and enjoyable. This way of learning makes me more confident and proud of the work I do. I choose what I work on and I like it this way.

*Lila, Year 5*



# Beneath the surface — Understanding the mathematics in children's minds

Penny Lane

New South Wales Department of Education and Training

Penny Lane is a Mathematics Consultant with the NSW Department of Education and Training.

After graduating as an Early Childhood Teacher from Hobart Teachers' College in 1970, Penny taught in Hobart, then tutored at the Nursery School Teachers' College in Sydney. She later moved to the ACT where she gained her Bachelor of Education, taught classes from Kindergarten to Year 6 and held the position of Deputy Principal in two schools.

Penny has always had a particular interest in teaching mathematics and has a long record of innovative practice, which is documented in her two books on mathematics teaching, *What's Your Problem?* (1990) and *It All Adds Up!* (1998), published under her former name, Penny Skinner.

The major focus of Penny's current position as the St George District Mathematics Consultant is working in Kindergarten to Year 8 classrooms with teachers and students, principally to implement the *Count Me In Too* and *Counting On* programs.

Let me begin by introducing you to Kylie, a former eleven-year-old student of mine who viewed school as largely a social setting. Kylie's mind was almost entirely occupied by her fascination with boys, rock stars, film stars, television celebrities and fashion. Imagine her at the beginning of the school year sitting in class with her glittery purple pen in hand, responding to the question, 'What is mathematics?'

This is what Kylie wrote: 'Maths is something to do with sublicating and adding'.

Kylie was a disengaged student for whom mathematics existed as a procedural stratosphere outside her mind. Her participation in mathematics lessons until then had been a matter of exchanging procedural responses for predictable, closed questions, both orally and in writing. She carried a muddle of scantily understood facts, procedures and loose connections on the periphery of her mind.

Kylie is not alone. There are many students simply sublicating and adding, answering predictable answers unthinkingly.

## Pathways into children's minds

We must go beyond surface communication, beyond predicability, to find out how our students are thinking. Until we find pathways into children's minds, we cannot support them to build robust mathematics concepts and connections. I identify four possible pathways into children's minds:

- posing problems;
- devising and discussing solution strategies;
- investigating and reporting; and
- making estimates.

I shall look at each pathway in turn.

## Posing problems

When children pose problems, they draw on their knowledge, their understanding of everyday language and mathematics language, their partially formed ideas and their curiosity to reveal their thinking.

Even the youngest students can pose problems. Here is an oral problem posed by one young student:

Last night I hugged my two teddies. Dad hugged Mum, and Mum hugged me. How many hugs were there?

Not all problems involve numbers.

My mum has the flu. My sister has the chicken pox. Which one is sicker?

Children begin by using numbers with which they are comfortable, and branch out into using numbers that fascinate them. Many young children enjoy exploring decade and hundreds numbers. Angela wrote the following page of problems; her answers are shown in brackets.

There were 100 unicorn 100 flyed away how many were left? (0)  
 There were 800 fairies 100 flyed away how many were left? (700)  
 There were 900 people at the opra house 800 went away how many were left? (100)

Here are two other student's problems:

Theres 100 ducks in the Pond then another three ducks came to the Pond.  
 How many left? (300)

and:

There were 100 PeoPle and 10 PeoPle were watching TV. How many alltogether = 10010?

Through their problems, students reveal to their teachers their sound understandings, limited understandings and misunderstandings. The following shopping problem reveals a lot more about the student's understanding of change than if she were simply asked to solve a problem an adult had posed.

I went to the shops. I took 5\$ with me. I spent 1\$. How many do I have left? (4\$) I went to the chemist. I spent 3\$. How many do I have left? (1\$) I went to the pet shop. I spent my \$ and I got 2\$ change. I went to Katie's. I bought a 2\$ dress and I got 5\$ change. I spent my 5\$ on a skirt and I got no change. The end.

When children pose problems, they also demonstrate their accurate use, limited use and misuse of language.

When a Year 1 teacher wanted to assess her students' understanding of sharing, she asked them to write 'sharing problems'. Sarah wrote:

I had 6 chips then I had 6 more how many altogether (12) my 2 friends helped me eat my chips how many did each of us eat chips (4 4 4)

Note how Sarah recorded her answer to her second question; she did not understand that the '4' only had to be written once.

James wrote:

I had 14 bulldogs with sharing one friend hes called Nicholas I let him hold 7 and I hold 7 he was scared of them but would I worry about him then I hold 8 and he hold 6 What's the answer

Children pose problems to express their new understandings and challenge their peers.

There were 12 people at my party. My mum only made 6 cupcakes. And she only bought 6 Tim Tams. What could I do?  
Can you make a triangle out of two short pencils and a long one?

Sometimes students pose problems to extend their knowledge and understanding.

If you cut off the top of a square pyramid you get a shape with 6 faces. Is it a shape with a name?  
Is 0 an even number?  
Can 0 be a multiple?  
Can 0 be a factor?  
Is 0 a factor of 0?  
Can \_ be a factor?  
Does 2 have twice as many multiples as 4?  
What is gradient?  
What does 70% gradient mean?

Sometimes students pose problems for investigation that arise from their observations of mathematical phenomena and their curiosity about mathematical patterns and relationships.

Do different kinds of caterpillars travel at different speeds?  
Do longer caterpillars travel faster?  
Do all car keys have to turn the same number of degrees to start the car?  
Do even numbers have more factors than odd numbers?  
What would happen if you squared a number and a half like 4?

## Devising and discussing solution strategies

We must allow and expect our students to devise, explain and discuss their own ways of solving problems, from simple problems requiring one-step calculations to more complex problems involving data collection and analysis. When we elicit children's solution strategies, we find a richness in their thinking and a wealth of clever strategies. Here we are digging deep into their minds and we strike gold.

For twenty years I have taught mathematics to students from Kindergarten to Year 6 without teaching standard algorithmic procedures. When students are expected to learn to use standard written algorithms, there is no place for teaching them procedurally. We can lead students to generate standard or close-to-standard algorithms by posing problems such as, 'Can you create a written right-to-left strategy for adding pairs of four-digit numbers?' The focus when considering written algorithms should not be on mastering the mechanics, but rather on generating possibilities, exploring how they work and reflecting on how useful they might be.

Students encumbered by thoroughly practised written computation procedures can be challenged to devise visual and mental solution strategies to problems for which they would typically respond procedurally. For example, when squaring 4 in response to the student's problem posed above, a visual strategy could be creating an array.

## Investigating and reporting

Children's written mathematics must not be pages of unrelated number sentences, algorithms, measurements, diagrams and graphs whose purpose is skills practice. Their pages should instead record their investigations of mathematics topics and problems. Their recordings can include number sentences, their own computation strategies and standard written algorithms when these are useful tools to explore number patterns and relationships and to express their observations and ideas.

## Estimation

The final pathway is estimation. I am suggesting a fresh approach to estimation, using it as a tool to teach a range of mathematics concepts. Children can estimate the number of items in a collection, answers to computations and the full range of measurements. Students should not be asked to record their estimates and can change their estimates at any time; for example, when estimating the number in a collection, they can change their estimates up until the last item is counted. This ensures estimation is non-threatening and all students participate willingly.

For entrenched procedural students, estimation is a path to recovery of their initiative in dealing with numbers. The questions are unpredictable, and students cannot resort to procedures to find answers; instead they have to draw on their own thinking to produce and explain estimates. For example, when very briefly shown eight cards, each with a number in the low twenties recorded on it, students are asked to estimate the total of the numbers; or when very briefly shown a card with '1.5' written on it several times, they are asked to estimate the total if all the numbers were added; or very briefly shown a card with several bicycles pictured (and their hands go up to say how many bicycles they think there were), they are asked how many wheels there were — and what if the bicycles were cars?

Children's estimates reveal a lot about how they are thinking. Through estimating, they demonstrate and build understandings of the magnitude of numbers, of number relationships and of measurements.

## Conclusion

The four pathways into children's minds are also the most effective pathways to further learning. Students posing problems, devising and discussing their own solution strategies, investigating and reporting, and making estimates these should be the key elements of school mathematics programs.

Let me return to Kylie. At the end of the year which began with her viewing maths as 'something to do with sublicating and adding', she wrote me an unsolicited report which looked like this.

Kylie was still the same student who loved celebrities and fashion, but please note what is at the top of her list and how many ticks she gave it.

Maths 100%	√√√√√√√√	Legs 99%
Art 100%	√√√	Figure 101%
Dance/drama 100%	√√√√√√	Dress 98%
Over all teaching 100%		
Keep it up Penny		



# Outcomes From INISSS (Improving Numeracy for Indigenous Students in Secondary Schools)

Greg Allen

Tasmanian Education Department

Greg Allen has 29 years experience in Tasmanian schools of all kinds: city and country, high schools (7–10) and colleges (senior secondary). He is currently Mathematics Coordinator at Deloraine High School, located in the northern part of the state. He is also a moderator of senior secondary mathematics courses and has a major interest in incorporating technology into the teaching of mathematics.

The INISSS program was initiated by Vicky Nicholson from the Aboriginal Education Unit of the Tasmanian Department of Education. Vicky was advised and supported by Rosemary Callingham, Ian Smith and Doug Williams and others. The impetus for the program came from the observation that Indigenous students performed below other students in statewide numeracy testing and that this gap increased in secondary school. While many of the factors causing this problem were outside the control of mathematics teachers, one factor was not: the pedagogy used in the classroom.

Once the program had started, it was soon realised that the changes that were envisaged should benefit all poorly performing students. Although the program was initially based on the Curriculum Corporation's Task Centre Material and the Maths300 website, any practical, hands-on investigations could be used.

The results of the INISSS program may be considered in two parts

- changes in pedagogy, and
- implications for professional development.

## Changes in pedagogy

The major changes that came out of the program were:

- incorporate/allow the use of, physical manipulatives in class. Some possible materials could be blocks, plastic disks or cardboard cutouts. Many students have not yet reached a 'theoretical' stage of development and they have no starting point in a 'theoretical' environment. Almost everyone reverts to a concrete approach when they are confronted by a completely new situation. The materials may also be of assistance in the teaching process.
- in order to involve students in a mathematical dialogue, use more open-ended tasks/investigations. The question  $5 + 6 = ?$ , is a closed task since the student either does or does not know the answer. There is little basis for a dialogue. However, the question  $? + ? = 11$  opens up the possibility for the student to try a response. Students will also begin to question the meaning of the task ('Are you including decimals?', 'Are you including negative numbers?'). It also allows for the extension question 'How do we know when we have all

- of the solutions?'. Reduce the amount of time devoted to 'textbook' work and try some open-ended/investigative tasks.
- c) allow opportunities for descriptive 'reporting'. Students often feel that writing in mathematics is simply for the purpose of summarising the steps of a calculation. They need to be encouraged to develop observational skills and also qualitative discussion techniques.
  - d) encourage the use of different approaches to problem solving. Students should come to realise that there are many ways of dealing with an investigative task not just by using an authorised method. This helps students to work independently and to rely more on their own ideas. It also encourages students to follow investigative pathways of their own devising not just depending on the teacher to provide the task.
  - e) do not 'sanitise' the task. Textbooks tend to have material which contains just enough information to answer the question in a particular way. Students need to learn to make decisions about what data they will need in order to work through the investigation in the manner of their choice.
  - f) affirm the importance of cooperative learning and student discussion. This allows all students to become involved to some degree. It also means that questions can be directed to groups, rather than individuals, as many students find questioning to be an intimidating process. It is often the case that the discussion that the students engage in is the most important part of the activity.
  - g) incorporate the open-ended investigations seamlessly into the teaching environment. These activities should not be seen as 'fill-ins' on a Friday afternoon, but as worthwhile mathematical tasks. One model which seemed to work well involved using an initial investigation which established the need for some new 'understanding'. Introduce this new work, referring back to the investigation and then follow up by giving a new investigative task which utilises the recently acquired skills.
  - h) try some different approaches to assessment. Assessment should be an integral part of the teaching program. If students are working collaboratively then the assessment should occur in a collaborative situation. This means that students may be learning from each other while the assessment is taking place. Assessment rubrics were devised which enabled responses to be categorised, depending on the understanding that was shown. Responses which require an explanation gave a good indication of how much a student understood.

## Implications for professional development

Many of the outcomes that emerged from the INISSS program had already been considered by mathematics teachers as being needed, but they had not been incorporated into the mainstream of mathematics teaching. The manner in which professional development is provided should be considered carefully, especially when the aim is to produce a change in the attitudes and pedagogy of mathematics teachers. To achieve this type of change requires:

- a) the recognition that it is a long term process. Professional development that aims to produce large scale change can only hope to be successful when carried out over an extended period of time. The first

INISSS group has been operating for five years, although there has been some change in the staff that represented each of the schools. Time is needed to allow teachers to become familiar with the materials and approaches being advocated, but also to allow the other teachers and students at the school to become comfortable with the new approach.

- b) that the teachers (and also the students) need to be involved in the overall process. Feedback on activities, and the problems that are encountered, is important but teachers must also be involved in choosing the direction that the program is taking: they must have some ownership.
- c) that the program is adequately resourced. The resources should be able to cover the payment of relief, visiting speakers and the dissemination of materials.
- d) that teachers are actively involved by the program (not just as listeners). Teachers need to be given some training and then be required to implement some specific tasks when they return to school. The outcomes from this trial process form the basis of discussion at the next meeting.
- e) that the process is carried out in a non-judgmental fashion. In order to obtain realistic feedback, teachers must be able to admit to having problems without feeling that they are being judged. Even experienced teachers may have difficulty when trialling some new material and new approaches.

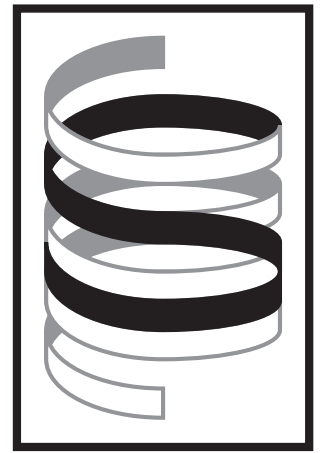
While the adoption of these ideas can not be considered as a cast-iron guarantee for success, they may provide a basis for pedagogical change that will be beneficial to the students.



# Counting on parents' support — A vast, untapped resource

Alice Lockrey

Port Macquarie District Schools  
New South Wales



It is always interesting to ask parents what they think mathematics is. Invariably their responses include phrases such as 'learning to do sums' and 'knowing your tables'. Parents are surprised when told that mathematics is actually a study of patterns and relationships. Parents already have a wealth of understandings about patterns and relationships, and with a little direction they begin to see even sums and tables in a new light. Immediately they become thinkers and explorers of ideas beyond the basic facts that constituted their pre-existing perception of the subject called Mathematics.

## The Counting on Parent Support Project

This paper describes a project at Willawarrin, a small rural school in the Port Macquarie District, New South Wales. The project has:

- created authentic partnerships between home and school;
- empowered parents to help their children within the home environment;
- had a positive effect on student achievement in mathematics at school;
- raised teachers' expectations around what parents are able to do; and
- established a model for use in other school communities, including the development of a training resource.

A ten-minute video *Counting On Parent Support* was produced by Willawarrin School community as a record of the project with funding provided by the Priority Schools Funding Program.

Teachers at Willawarrin Primary School began implementing the *Count Me In Too* program in 1999 with children in their first years of schooling. The implementation resulted in a shift in classroom practice from students writing lots of answers on paper to students engaged in discussions, games and small group activities. Parents were excited by both the program and the progress that their young children were making.

Previously, parents and care-givers had played a very limited role in the implementation of mathematics at Willawarrin school. To encourage parents to become more active in their children's mathematical learning, an information day was run early in 2000 by the district mathematics consultant. The key theme of this day could be described as 'letting parents in on the secrets'. One of the aims of the day was to link parent awareness of the achievements of their younger children to some understandings about how students learn.

Alice Lockrey is the mathematics consultant in government schools in the Port Macquarie District in New South Wales. One of her key roles is professional development and support for teachers to implement the *Count Me In Too* project. Alice has a background of twenty-two years of primary teaching in a variety of school settings. She has a special interest in working with the wider school community, including parent groups, Aboriginal tutors and teachers' aides.

Growing up on a farm, Alice developed a keen awareness of the practical applications of mathematics and an interest in the way adults used numeracy to inform decisions and make judgements. Her childhood mathematical experiences have combined with formal education and training to provide a rich basis for current work with school communities. Alice works with parents to identify everyday mathematical applications and then empower them to model their skills and understandings for their children. By recognising and valuing the high degree of numeracy within the home environment, parents have become excited about the significant role they play in supporting their children's learning.

## The Mathematics Information Day

Genuine learning occurs when sense is made of a situation and thinking is reorganised. Parents know and effectively use mathematical ideas constantly in the course of their daily lives. During the information session, parents were asked to consider the mathematics that occurs in their own environments and the opportunities that exist for them to model what they know and can do for their children. They were asked, 'Do your children know what you know?' Some examples used were:

- Children are usually taught to cook by a family member. Much teaching exists around how to stir the cake etc, but are children asked to set the oven at 220 degrees when the numbers on the dial are in multiples of 50?
- How far is it from Willawarrin to Kempsey? Do your children know that?
- Videos have the duration of the movie written on the cover. Is there enough time to watch the movie before Dad wants to watch the football?

Immediately the need for talking and listening in mathematics, beginning with the child's use of everyday language, became apparent.

Asking parents to mentally solve a problem, e.g.  $79 + 34$ , and share how they worked it out enabled them to recognise the range of strategies used when solving problems. Parents became aware that the focus of mathematics teaching was not on teaching written algorithms but on supporting students to develop their own increasingly sophisticated strategies in order to solve problems. The importance of recognising the strategy currently being used by the child was emphasised. This change in emphasis was illustrated by a parent who began her reply with, 'I did it the wrong way'. While she mentally calculated  $(70 + 30) + (9+4)$  to solve the problem, she had thought that constructing a mental image of a vertical algorithm was the expected thing to do. Parents in the video footage constantly restated the empowerment of discovering that various strategies could be employed successfully, that there was 'no right way' so long as the answer was correct.

## The Parents as Maths Tutors Program

The participation of a teacher from the school in the mathematics information day was critical. An effective Parents as Reading Tutors program was already running in the school, and after the initial mathematics information day parents asked about the possibility of running a Parents as Maths Tutors program to support their adolescent children who were experiencing problems in mathematics. It was the nature of this program and the facilitator training, which parents received, that made all the difference.

The teacher assessed a group of identified students from Years 5 and 6 and established benchmarks for each of them against the Learning Framework in Number. She then selected from educational resources, board games that addressed the learning needs of these students. She made them up into packs including dice, counters, and instructions on how to play the game. These game packs formed the basic kit for the Parents as Maths Tutors program.

On the Parents' Training Day, parents were taken through the Count Me In Too Learning Framework in Number and then trained in strategies for using the games kit. The main focus of the tutors' training day was the devel-

opment of effective questioning techniques and parents were given a list of questions to facilitate this process. The parents played the games in small groups and took turns at being the parent leader, and practising their questioning and support techniques. The teacher made frequent interjections asking parents to consider a good question, which they could ask at that point in the game. Parents in the video refer back to this day and the importance of questioning in the process of student learning. One parent refers to his favourite question, 'How did you work that out?'

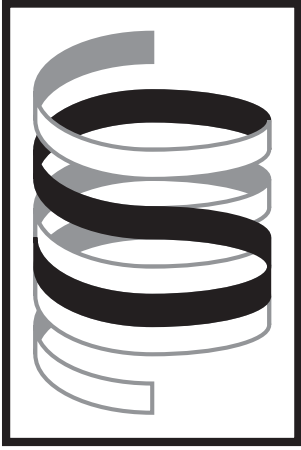
The tutoring program ran for ten weeks. Students were withdrawn from class and worked in pairs with parents in the library. Each student had a personalised folder, which contained a record of the games they played and their response to them. Parents completed this student record folder after each session, thus providing continuity in the tutoring process. Students and parents loved participating in these sessions.

### **Evidence of success: the Willawarrin video**

In the Willawarrin video, parents comment on the important things that they learned and the different approaches they now use when working with their own children at home.

Learning how to ask the right question has empowered the parents and they are now able to support their children in everyday mathematical contexts. The Willawarrin video also depicts parents' reflection on their own schooling and the changes that have occurred in their thinking about mathematics. The parents' enhanced awareness of numeracy which has been facilitated through their participation in this project, is making a wonderful difference to their children's confidence and learning.

The video has been shown to other school communities. As a result they have requested support in developing similar programs for their own school. On the video one of the parents acknowledges that programs such as this 'raise the learning culture of the whole school'.



# Improving classroom practice — Gateways and barriers

Christine O'Halloran

Catholic Education Office  
Tasmania

Christine O'Halloran is a Numeracy Support Consultant with the Catholic Education Office, Hobart. She is based at three systemic primary schools and works on site with teachers to enhance their classroom practice. Christine's role also involves her assisting teachers in upgrading curriculum and policy documents and resources in line with current 'best practice'.

Christine's particular interest in mathematics teaching developed when she was selected to participate in a DEET/University of Tasmania Mathematics Teaching Project in 1993. From 1997 to 2001, Christine was a primary school principal and her school was chosen for a University of Tasmania study in the teaching and learning of mental computation. In 2002 she embarked on further study, this time focussing on the classroom needs of behaviourally and emotionally disturbed students.

**T**he Catholic Education Office is located in Hobart, and oversees thirty-seven primary, secondary and senior secondary schools in the Diocese of Hobart, that is, all of Tasmania. These schools and colleges are situated all over the state and meet the educational and spiritual needs of diverse population groups: rural, suburban, isolated and city. The schools and colleges have site-based management.

My role, since the middle of June this year, is that of Numeracy Support Consultant in three single stream Catholic primary schools catering for Prep to grade 6. The role is a new one for the Catholic Education Office in that I do not operate from 'Central Office', but rather am stationed in each of the three schools on a schedule each week.

## Gateways to improving classroom practice

One gateway is the fact that primary school teachers acknowledge that they are less confident in teaching mathematics as compared for example with literacy-based learning areas. Teachers can well describe in some detail the overview of literacy in their school, but readily acknowledge that there are gaps in their understanding when it comes to numeracy. Therefore they are open to help and do respond to assistance because they are professionals and want to do better, even if sometimes they are looking for the 'quick fix'.

Another gateway specific to me is that I am in the three schools regularly and have an overview of what is going on in mathematics/numeracy across the school.

## Barriers to improving classroom practice

Barriers include time, and the lack of it, the genuine fear that some teachers have that their ignorance might be exposed, and the fact that teachers will often expect their students to be risk-takers but are cautious about taking risks themselves.

## Establishing a mathematics/ numeracy culture

To establish a mathematics/numeracy culture in a school demands a keen understanding of all the viewpoints held by all the stakeholders. It also demands an outcome that is owned by the stakeholders. But however much time is available, the highest priority is to affirm in teachers that the effectiveness of their teaching in their classroom is the single most important factor that will influence students' learning. It is critical that teachers grasp this fundamental fact, reaffirmed by research, that despite feeling that media and parental analysis of their work sometimes undermine their worth, they play a key role in the classroom.

### Strategies

When I first arrived at each school, I wrote to each teacher explaining what I perceived my role to be, indicating when I would be at each school and inviting each person to 'catch up' with me on site about any issue with which they needed advice or assistance.

I have found it important to have a 'barometer' in each school to refer to, particularly in planning professional learning sessions. This person assists me to pace the sessions so that other planned and unplanned activities in the school during my absences do not impact on the mathematics/numeracy focus. For example, it is not desirable to present sessions at times when teachers are engaged in preparing for special school events such as the annual school concert.

Another approach I used was aimed at focussing attention of teachers on the current status and future possibilities in numeracy learning in their schools. Teachers are given statements to which they are asked to respond in confidence in writing (single words or phrases) without any comment:

Mathematics/numeracy in my classroom is...  
 Mathematics/numeracy at School X is ...  
 Mathematics/numeracy at School X could be...

This strategy frees up teachers to write what they really think about the statements, not what they might or might not say in an open staff meeting. Without exception in the three schools, participants have identified concerns about lack of collaboration between teachers on important issues such as planning and resources, as well as the paucity of resources (such as manipulatives). The responses were collated and distributed to teachers at a second session. I have found that this process assisted teachers to have shared understanding of beliefs and perceptions held by their (unnamed) colleagues. They also informed my decision-making regarding professional learning needs of the teachers.

Concurrently, an audit of all mathematics/ numeracy resources (human and physical) was conducted and published. While this vindicated the teachers' perceptions about resources, it did provide both a planning platform for future purchasing and gave teachers the opportunity to know exactly what was held in the school and could be borrowed. Interestingly, not one school identified any human resources to assist in the teaching of numeracy!

## **Professional learning sessions**

Initially we explored the issues of the nature of numeracy and what it means to be a numerate student. This was followed by treatments of number sense, problem solving strategies, use of manipulatives, mental computation strategies and work stations. During these sessions, emphasis has been placed on doing the activities, that is, on being engaged learners and so that the teachers will have confidence to try them in the classroom.

Each professional learning session is made as ‘user friendly’ as possible, with time for interaction with the presenter and collaborative activities. The modelling of collaborative strategies at these sessions creates opportunities for teachers to model them in their own classrooms.

Another strategy to assist with professional learning is the ‘ten minute study group’, embracing topics such as Open-Ended Questions, Collaborative Planning and Higher Order Thinking.

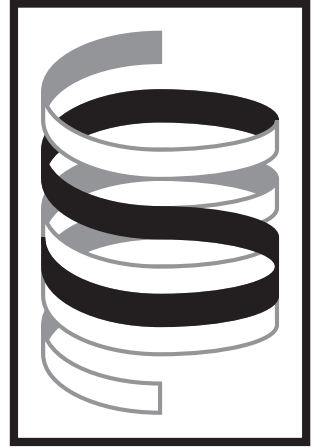
## **Summary**

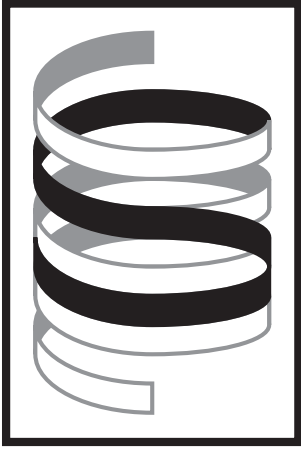
In summary, the main gateways to meeting the needs of classroom teachers in my role as Numeracy Support Consultant have been that

- I am part of a whole school approach involving all stakeholders;
- I am on site to assist in developing frameworks and networks for the future; and
- I am able to work with teachers ‘where they are at’, and celebrate with them as they take risks in the process of change.

The energy in the spring is there to be tapped. The springboard may look to be too high to achieve the desired result of the ‘perfect ten’. But when the training and the practice are put to the test with the support of on-site colleagues, the results can be seen not just in one classroom, but also in other classrooms and in the school community: numerate students.

# Appendices





# Appendix 1: The Commonwealth Numeracy Research and Development Initiative

Max Stephens  
& Vicki Steinle

National Co-ordinators for Numeracy Research Projects,  
Department of Science and Mathematics Education,  
University of Melbourne

The presentation outlines the Commonwealth Numeracy Research and Development Initiative and describes briefly its two strands. One is through the Strategic Numeracy Research and Development Projects by which funding has been provided to State and Territory government and non-government school authorities to support research and development in school numeracy education. The second is through the National Numeracy Research and Development Projects for which tenders have been advertised nationally for a range of numeracy related projects. The constituent projects are outlined and key aspects of the research and emerging findings are highlighted from current work in selected projects. These include innovative aspects of research methodology.

## Background

In March 1997 Education Ministers agreed on a new national goal: ‘that every child leaving primary school should be numerate, and be able to read, write and spell at an appropriate level’.

To help support the achievement of the national goals, Education Ministers endorsed a National Literacy and Numeracy Plan, which calls for a coordinated approach by the Commonwealth and States and Territories to improving literacy and numeracy standards. The Plan consists of the following key inter-related elements:

- comprehensive assessment of all students as early as possible, to identify those students at risk of not making adequate progress towards the national literacy and numeracy goals;
- intervening as early as possible to address the needs of students identified as at risk;
- the development of agreed national benchmarks in literacy and numeracy, against which all students’ achievement can be measured and reporting of nationally comparable benchmark data by education authorities;
- professional development for teachers to support the key elements of the National Plan.

In support of this plan the Government announced the Commonwealth Numeracy Research and Development Initiative to identify effective numeracy teaching and learning practices that lead to improved student numeracy



outcomes at the primary school level.

The Commonwealth consulted with key stakeholders to establish priorities and directions for strategic work in numeracy, with a focus on the primary school level. The Numeracy Priority Areas identified for Research and Development are:

- early numeracy;
- effective teaching practice;
- equity;
- home, school and community partnerships;
- technology;
- professional development; and
- national coordination and dissemination activities.

The Initiative has two funding strands: *National Numeracy Research and Development Projects* and *Strategic Numeracy Research and Development Projects*.

## **National Numeracy Research and Development Projects**

Commonwealth funding of up to a total of \$2 million is available for projects under this strand. These projects are expected to contribute to the body of knowledge and understanding that supports effective numeracy education and improved numeracy outcomes for all students.

Four national projects are currently under way.

### **A Mapping, Review and Analysis of Australian Research in Numeracy at the Primary School Level (Deakin University)**

This project will be completed in the near future. This will include a report and a database which contains over 1000 summaries of projects and publications from Australia, but also supplemented by key international research. The database is searchable by author, keyword and themes and not only provides a valuable overview of existing research and associated activities for researchers and interested teachers; it should also provide a guide for planning of further research activities.

### **Project Good Start (ACER)**

This project is identifying strategies that improve the numeracy outcomes for children by investigating those practices and learning experiences that support the early numeracy development of a sample of children in the year before school and during the first year of school. This project is a longitudinal study which will be completed in 2004.

### **Developing a Poster and Brochures aimed at promoting awareness of the importance of numeracy to parents (Murdoch University)**

This project is almost complete. The brochures are titled 'Numeracy: the opportunities are everywhere. Families working it out together.' Three draft brochures (Early Years, Middle Years of Primary and Later Years of Primary) have been produced and various parent and teacher groups have been consulted with very positive feedback. It is planned to distribute copies to primary schools around Australia in early 2003.

### **Project on home, school and community partnerships to support children's numeracy (University of Queensland)**

This project has commenced. The purpose of this project is to gather information on current strategies and to identify directions for effective practices in home, school and community partnerships to support children's numeracy. It aims to examine effective school-parent partnership programs in numeracy. It will provide information on the findings of a national and international literature review and on strategies to support children's numeracy in the primary years. The project will also report on the feasibility of, and options for, a possible further phase of research with the purpose of identifying key principles for effective practice. The scope and target group populations are children at the pre-primary (1–2 years prior to school) and primary school levels and will include educationally disadvantaged students, students with learning disabilities, students from Indigenous backgrounds and students from low SES backgrounds.

Further national projects may be commissioned in 2003. In the limited time available, an appreciation of the important work being conducted through these national projects may be illustrated by looking specifically at the findings to date and innovative methodology of the ACER's *Project Good Start*.

#### **Looking at *Project Good Start***

##### *Findings to date*

The *Project Good Start* team has recently analysed the data from seventy pre-school centres from around Australia. The data consist of background information, such as sex, family socio-economic status (SES) and home language (NESB), and most importantly, data on the children's cognitive development. These cognitive data were collected using *Who am I?* — an early childhood profiling tool that the project is using to profile children's numeracy achievement progress during their pre-school year. The tasks in *Who am I?* (inter alia) require children to copy figures, draw a picture, count, and write some letters, numbers and words.

While there are many aspects of the early analysis that are extremely interesting, one that is worthy of note here is the effect of family socio-economic (SES) status.

Early findings indicate that while the correlation between children's achievement scores and family SES is weak (i.e.  $r < 0.3$ , for both males and females), on average, pre-school females from mid-SES and upper-SES family backgrounds achieve at significantly higher levels than their male counterparts, independent of age. Whereas there is an indication that females from lower-SES family backgrounds develop better than their male counterparts, the mean difference is not statistically significant at the  $p < 0.05$   $\alpha$  level.

These findings suggest several further questions to be investigated, including:

1. Do mothers and female early childhood educators find it easier to communicate with girls, and do so more frequently than with boys?
2. To what extent is positive verbal communication by these persons with girls of greater duration and quality than with boys?
3. What are key socialisation factors in the home and preschool environments that appear to account for girls' apparent early language, literacy, and numeracy skills being more highly developed at this stage (on average) than those of boys?

Such questions will be raised with Centre staff and parents during the planned case-study site visits and the parent focus groups.

Interesting anecdotal information comes from the conversations that the *Project Good Start* team have had with the staff at many centres. These conversations have mainly focussed on the reactions of centre staff to using *Who am I?*.

#### *Use of innovative methodology*

Using *Who am I?* has given centre staff the opportunity to interact on a one-to-one basis with children in a focussed and consistent manner. Centre staff have been surprised at the high level of developmental progress indicated by some children. For example, the large number of four-year-olds who are able to write their own name, the number of children who can count eight objects correctly (and in many cases beyond). Staff have suggested that they will need to modify their programs to cater for the continuing development of these children.

As well as the formal aspects of the profile, centre staff commented on the value of the profile procedure in allowing them to get to know the children better. Other centre staff comments have been made on the usefulness of *A Good Start to Numeracy*, the numeracy background book prepared for participating centres and schools.

## **Strategic Numeracy Research and Development Projects**

Commonwealth funding of up to a total of \$5 million has been provided to State and Territory government and non-government school authorities to support research and development in school numeracy education under this strand of the Initiative.

Education authorities were invited to submit research and development proposals within the Numeracy Priority Areas. These education authorities are currently undertaking projects in collaboration with university-based researchers and in many cases teacher-researchers.

These projects fit into two broad categories: projects which are attempting to investigate the teaching and learning of specific content of school mathematics, and projects looking at effective teaching of mathematics from the perspective of a whole school or school system.

### **Content focussed projects**

#### **Developing Computation (Tasmania cross-sectoral)**

This project has explored the interface between mental and written computation in Grades 2 to 4 in nine Tasmanian schools. After an initial period strengthening children's mental computation, for the past nine months teachers in the project have been developing children's informal written computation, while holding to a commitment to teach no formal written algorithms for the duration of the project.

### **Teaching methods and management structures that maximise learning of the base 10 number system in a whole class setting (South Australian Association of Independent Schools)**

This action research project involved children from all years of primary school and focussed on the identification of strategies that can be used to enhance students' understanding of base ten. It became clear to project teachers that children can use manipulatives such as MAB (Dienes Blocks) in a game situation that is intended to model our Base 10 number system, and yet not make the connections that the teachers expect. Teachers in the project have indicated that they were able to gain insight into students' thinking by asking children to write about their mathematical thinking. Furthermore, the teachers indicated that it is easy to make inaccurate assumptions about students' current conceptual understanding and that this can prevent effective teaching and learning from taking place. This project will provide advice to other teachers on how to teach this important concept with the associated conceptual and procedural knowledge.

### **Teaching strategies to support all students to improve their numeracy outcomes through construction of meaningful mathematical understandings (South Australian Catholic Education Office)**

Students from Years 3–5 in ten classrooms were taught three measurement topics; linear, area and angles. Rasch modelling was used to analyse the results of the pre- and post-tests to determine the growth in each classroom. The qualitative data is being analysed to determine the factors that appear to be most significant in the classrooms that made the most improvement, according to the quantitative data. These factors include the quality of the interactions between the teacher and the students including how the teacher assisted the students with meta-cognitive thinking. The quantitative data revealed that the ESL students made considerable progress and the teaching strategies that supported this progress are now being analysed to uncover the teaching strategies that supported this progress.

An appreciation of the important work being conducted through these content focussed projects may be illustrated by looking specifically at the findings to date and innovative methodology of the Tasmanian project *Developing Computation*.

#### **Looking at *Developing Computation***

##### *Innovative methodology*

Teachers and researchers have been collecting written work samples from children at four points. These are before they have assistance in developing informal written strategies and at three stages of the intervention program. This is to show an individual child's development from written explanation of a mental solution, to 'conferenced' explanation, to application of this and to using paper to assist harder computations.

The research team has also gathered transcripts of some teachers discussing their views and recommendations. Finally, there are written responses from all key teachers describing their views regarding:

- the relevance of strengthening mental computation;
- the value of informal written computation;
- their recommendations regarding formal written algorithms; and
- their current views regarding advice they would give to other schools and teachers regarding the desirability of each of these and suggested

grade levels for introduction of these.

The project has produced specific and general suggested classroom procedures at each stage, expert informed advice to teachers as to the value of these processes and recommendations for their implementation.

Interviews with individual children will be conducted next term to provide some specific studies of these processes. To date, this project has produced practical (as well as ground-breaking) 'classroom strategies and approaches and the implications for teaching'.

#### *Findings at this stage*

- All teachers in the project agree that the concentration on mental computation has greatly increased children's competence and confidence in handling numbers and in understanding place value.
- All teachers in the project would now recommend delaying the teaching of any formal written algorithms - in most cases until Grade 4.
- All teachers agree on the benefits of developing informal written methods as a bridge between mental and formal written methods.
- Almost all teachers would still advocate the teaching of formal written methods (but at a later stage in the primary school than hitherto).
- It would be of greatest benefit to all children to develop this approach from the beginning of schooling.

## **Broadly focussed projects**

### **What's making the difference in achieving outstanding primary school learning outcomes in numeracy? (NSW, cross-sectoral)**

In 2001, case studies were conducted in a sample of 25 schools where it was indicated that outstanding numeracy learning outcomes were being achieved at or between Years 3 and 5. By the end of 2002 an additional twenty case studies will have been conducted in a sample of schools where it is believed that outstanding practices, strategies or programs have been operating within and/or across and/or beyond the school. The findings from the 25 case studies detail the processes that are operating within the school, throughout the school and beyond the school that were found to be impacting on student numeracy outcomes. A similar analysis will have been conducted on the data from the twenty sites by the end of 2002.

### **Researching Numeracy Teaching Approaches in Primary Schools Project (Vic., cross-sectoral)**

This project is intended to identify and investigate the effectiveness of a set of generic teaching approaches that teachers can consistently apply to the teaching of mathematics. The project will identify, through the analysis of extensive quantitative and qualitative data, effective classroom teaching approaches in mathematics for students in a range of primary school settings, including a specialist school, and investigate their potential for improving student numeracy outcomes. Key questions guiding this investigation are: What are the key components of teaching approaches that lead to improved learning outcomes for numeracy in the primary years of schooling? If teachers implement a defined suite of teaching approaches does this result in improved learning outcomes for students? How can these teaching approaches in numeracy best be described to support teachers to implement them effectively in their primary school classrooms to improve student learning?

### **What elements of learning environments promote enhanced student numeracy outcomes? (Qld, cross-sectoral)**

This research project is intended to identify key elements of effective learning and teaching practice through the research in 8 schools across a range of settings and within the three schooling systems in Queensland. Both quantitative and qualitative methods have been employed. For example, extensive qualitative data has been collected on practices, knowledge, beliefs and attitudes of teachers, students, parents and administrators. Furthermore, teachers and administrators are being supported to reflect on practices that will enhance the numeracy learning environment. The 'learning environment' in a primary school encompasses the school context within which students learn including, the whole school context, school programs and plans; teachers' classroom practices and their use of time, space, resources and a variety of teaching strategies to promote students' numeracy outcomes; and the impact of a range of partnerships, including those formed between teachers and students and between the school and families.

### **Profiling High Numeracy Achievement (SA, DETE)**

This study relates information from a partial-ethnographic study of whole school practices in identified high numeracy achieving schools to the existing literature. This project is also investigating factors affecting numeracy outside the classroom. The basic assumption is that if long-term and sustainable reforms are to be made that improve numeracy outcomes, then the way that classroom practices are dependent upon school structures and school culture needs to be considered. The research is developing a profile of 'good practice', based on practices that have been identified as achieving high level numeracy outcomes, that will provide direction for all schools and curriculum development policy in supporting numeracy outcomes for all students. The draft Profile is currently being trialled in a number of schools using an action research approach. Of particular interest to the researchers is the reculturing of schools. One of the strategies that they have been trialling is the use of various auditing instruments including the use of student and teacher attitude audits.

### **Assessing Numeracy in Primary Schools (ACT, cross-sectoral)**

Classroom action research is the main process in this project, with a focus on assessment approaches that complement broad-based testing programs. A range of methods (e.g. questionnaires, teacher self documentation, semi-structured interviews and classroom observation) have been used to collect information across focus areas: classroom teaching and assessment practices, student performance, student attitudes and teacher attitudes. Project outcomes will include: guidelines for how teachers can use the results of system and/or school assessment procedures to improve their classroom practice; identification/development of classroom assessment practices which complement system and/or school assessment procedures, and identification/development of teaching approaches that make effective use of assessment to support student learning, particularly for 'at risk' students.

### **Research to establish the nature and extent of the relationship between a student's mathematical knowledge and skills, and the capacity to use mathematical ideas and techniques in other contexts (WA, cross-sectoral)**

Approximately 1000 students in Years 5 and 7 are involved in this project which is addressing the following questions: Is there a relationship, and if so

what is the nature of the relationship, between student achievement in numeracy basic skills tests, school mathematics performance and their capacity to use mathematics to do numeracy-rich tasks across the curriculum? Does dealing with the numeracy issues explicitly within other learning areas have an impact on student numeracy learning? How do students deal with the numeracy demands of learning areas other than mathematics? How can teachers assist these same students to cope with these numeracy demands and assist students in improving their numeracy levels?

An appreciation of the important work being conducted through these broadly focussed projects may be illustrated by looking specifically at the findings to date and innovative methodology of the New South Wales and Victorian Projects.

## **Looking at New South Wales**

### *Findings to date*

Through a series of intensive case studies, the project has identified three sets of strategies that appear to have a strong influence on numeracy achievement. These are:

What is making the difference within the classroom?

- constructive classroom interactions
- purposeful pedagogy
- accommodation of difference
- dynamic teaching

What is making the difference throughout the school?

- a school commitment to numeracy
- school policies that support numeracy
- specialised programs that support numeracy

What is making the difference beyond the school?

- a shared vision
- communicating about learning
- mathematics at home

Each of these strategies has been described in greater detail by the project. Some of these strategies were trialled in ten schools that were keen to improve their numeracy profile. Next year, these ten trialling schools will be invited to continue for an additional intensive year-long study to provide a more longitudinal analysis of the sustainability of the cognitive numeracy learning outcomes in students at these sites. This will allow the project to determine the extent to which the changes in pedagogical and other practices initiated in 2002 are able to be continued and expanded within each school context.

In 2003, the project will research and document examples of effective classroom teaching practices that were evidenced in some of the classrooms involved in the 25 case studies from 2001 (which were selected on the basis of outstanding numeracy outcomes) and in the 20 case studies from 2002 (where it is believed that there are outstanding practices, strategies or programs operating). This will require documenting in detail a sample of lessons where outstanding teaching practices were occurring, analysing in depth the role of the teacher and student in these lessons, and then collating and reporting these classroom 'snapshots' as contributing to outstanding numeracy outcomes.

*Use of innovative methodology*

The *Numeracy Research In NSW Primary Schools Project* required a methodology that resulted in measures of students' ability beyond descriptive analyses of raw scores and percentages correct. It also required the development of a Numeracy Achievement Scale which has appropriately graded items along a continuum for students aged 4.5 to 13 years representing key aspects of numeracy across all strands of the mathematics curriculum. This required the construction and integration of a large number of items drawn from a number of sources. In order to establish the integrity of these items as a measure of numeracy it was essential to translate these items into a linear measure.

The purpose of constructing the Numeracy Achievement Scale was to assess individual student's numeracy growth through interviews at two stages in the 2002 phase of the project. A numeracy achievement scale can locate and map an individual student on a scale calibrated by tasks showing levels of attainment of a pre-defined standard of numeracy using a Rasch modelling approach. This scale of achievement is independent of age and grade. Item difficulty is calculated through a process of calibration independent of the abilities of the individuals assessed in the data collection.

Consequently, students can be located on a scale according to their score, the total number of items they answer correctly. The degree to which this score summarises the individual's profile of responses is found by identifying the 'fit' of the students' response pattern to the model. For the purpose of trialling items, student measures of mean ability were derived from one numeracy assessment interview.

Even though the trial data reports achievement at one point on time, the main advantage of using the Rasch model for constructing the Numeracy Achievement Scale was to determine whether any growth will occur in numeracy achievement measured at two points in the 2002 phase of the study. In order to measure growth between two or more points in time, ability estimates can be made of students' location on the continuum and changes in location provide measures of growth over time.

**Looking at Victoria***Innovative methodologies*

In 2002, teachers have been asked to complete at least eight Teacher Intention Surveys; these have been designed to sample teachers' planning intentions in relation to the use of a variety of numeracy teaching approaches. The forms have four sections: the first provides some background information on the lesson and the children involved, the remaining three sections provide for a description of the teacher's intent for the beginning, middle and end of the lesson respectively. At the end of the lesson, teachers have been asked to comment on what actually happened in each of the three phases of the lesson and the effectiveness of the lesson.

A Behind-the-Screen procedure has been used in 2002, and will continue into 2003. This process, a variation of the one used in Reading Recovery training, requires a teacher to engage with a small group of students or an individual in front of their peers (who are literally 'behind' a screen or one-way viewing window). Before the lesson, the teacher whose lesson is to be observed Behind-the-Screen completes a Teacher Intention Survey. This document is then annotated by colleagues looking on from 'behind the screen' along with a member of the research team. A combination of these two methodologies, together with the presence of an outside expert facilitator, have been quite powerful in involving a small group of teachers in a



much more finely-grained, intensive study of numeracy teaching approaches.

Originally it was thought that all project schools would be involved in this process but the logistics (that is, numbers of staff/students, venues and transportation) have mitigated against this option. Consequently, it has been decided to select a smaller number of research schools on the basis of their proximity to one another and access to a suitable venue. This has resulted in the identification of one entirely metropolitan cluster (3 schools), a regional/metropolitan cluster (3 schools) and one relatively remote country school.

The response to the Teacher Intentions Surveys has been most encouraging. We have had a number of comments about having to choose one category and the number of terms used to describe various interactive patterns. Given that one of the objects of the research is not only to identify the substantive interactive patterns that make a difference but to describe them in ways that make sense to teachers, it has been important to have teachers use the 'Other' category if they find the prompts too limiting. It has been important to know what words/descriptors resonate with teachers' experience and how these might be more accurately and appropriately described.

Behind-the-Screen has proved to be a valuable research tool as well as a richly rewarding experience for those involved. This activity which essentially puts numeracy teaching approaches 'under the microscope' requires the teachers involved to teach a group of students behind a one-way window which enables the rest of the group to observe and discuss what is happening. After each session, the teacher concerned returns to the group and we have a further discussion about what happened and how this might be described.

At one school the researchers have been using a digital video camera connected to the school's intranet to film the lesson in the teacher's room. The video is transmitted to the library where the remaining teachers can watch and discuss the lesson 'live'. Although it is still early days, we are seeing some wonderful teaching and engaging in some very fruitful discussions. The strength of this process is that it has allowed teachers and researchers to explore the principles of the teaching approaches in more detail. This is never meant to be a critique of the teacher, but an in-depth, focussed exploration of the nature of the specific teaching and learning processes embodied within a particular teaching approach.

### *Findings*

Some provisional findings to date include the following:

- A number of factors seem to be critical in maximising student mathematics learning in this situation. These include, matching the learning experience to students' learning needs, remaining focussed on the key mathematical ideas/strategies, and encouraging and using student discussion.
- The level of teacher support can be 'high' in different ways: the most powerful form of teacher support appears to be insightful and persistent questioning that goes beyond 'fill in the gap' (funnelling) or 'guess what's in the teacher's head'.
- The level of student independence can vary in unexpected ways during a learning experience: as one student 'gets it', they will often initiate a conversation with the person next to them, rewording and expanding upon the teacher's explanation. Peer support is clearly an important aspect of mathematics learning, being as much a benefit for the one explaining as for those listening.

- Teaching appears to be more effective where teachers are VERY clear about the mathematics they want children to learn - where teachers know where the mathematics is going and take advantage of opportunities to make connections.
- Observing other teachers teach is a very powerful professional development activity. Participating teachers report learning more about 'what works' by observing others teach and by discussing and reflecting on that experience than by any other means.
- There is enormous variation in the depth of teachers' specific content knowledge and how to teach specific areas of content, often referred to as teachers' 'pedagogical content knowledge'. (The project has identified and will continue to identify specific areas in which a concerted system-wide effort is required to improve teachers' knowledge.)

## **Other projects with a numeracy component (not part of this Initiative)**

### **An investigation of the Status of Teaching and Learning of Mathematics in Australian Secondary Schools (ACER)**

This project will research the knowledge, beliefs, understandings and practices of effective teachers of mathematics in secondary schools. This project commenced last year. ACER will report its research findings in April 2003

### **Project to investigate Literacy and Numeracy Development in the Middle Years of Schooling (University of Queensland)**

This project is identifying and investigating effective practices for promoting literacy and numeracy learning across the curriculum in a range of middle school settings (Years 5 to 9). It is due for completion at the end of 2002.

### **Project to Investigate Improving Literacy and Numeracy Outcomes of Distance Education Students in the Early Years of Schooling (RMIT)**

This project has just commenced. It has a dual focus: the role of home supervisors/tutors and the use of technology in distance education. It will conclude in mid 2004.

### **Quality Teacher Program (QTP)**

This project seeks to update and improve teachers' skills and understanding in the priority areas of literacy, numeracy, mathematics, science, information technology and vocational education in schools. The program has two components: State and Territory activities which involve professional development in these priority areas; and strategic national initiatives which include researching, investigating and evaluating teacher issues. As of April 2002, there were fifteen numeracy sub-projects and seventeen mathematics sub-projects.

## National Numeracy Research Co-ordination

In addition, the Commonwealth has contracted the services of a National Numeracy Coordinator, Max Stephens, and a Deputy Numeracy Coordinator, Vicki Steinle, to manage and coordinate the project activities of the Numeracy Research and Development Initiative. Our role has been to:

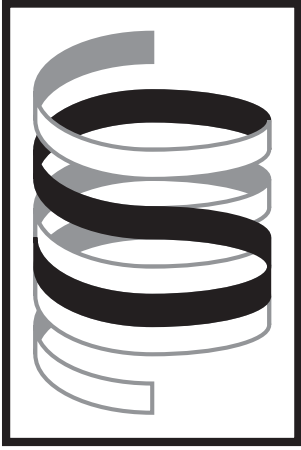
- manage the day-to-day interface among the research groups funded by DEST;
- manage the process of developing research briefs;
- contribute to the selection of tenders for projects;
- provide administrative support for projects;
- assist in dissemination and follow-up on projects; and
- provide advice to DEST as sought from time to time.

Expert academic support has been provided to the national coordinators by Professor Kaye Stacey, Dr Helen Chick and Associate Professor David Clarke. Their professional support has been available to the project, among other things, to provide a further level of support in such areas as research design, knowledge of specific research, and knowledge of established practices among researchers; and to prepare research reports as requested by DEST from time to time.

DEST also convened a national conference in October 2001 to disseminate information about projects in progress. Another of these conferences is expected to be held in late 2003.

## Summing up

It is very gratifying to note the substantial progress being made in the various projects which comprise the National Numeracy Research and Development Projects Strand. For many projects based in the States and Territories, this initiative has opened up new areas of cooperation in research between universities and sector authorities where expertise has often been focussed exclusively on teacher professional development. The experiences that have been built up over the past year have shown how university researchers and sector authorities can and must work together in order to improve numeracy outcomes for students in Australian schools.



## **Appendix 2: Around the States and Territories... according to the education authorities**

**A**t the time of the conference, the organisers sought information about current policies and programs from officers of education authorities. The material provided is a snapshot of the situation in each of the states and territories.

**Please note that information was accurate at September 2002.**

### **Northern Territory**

#### **Numeracy in the NT**

Numeracy is defined within the newly released (2002) *Northern Territory Curriculum Framework (NTCF)* as ‘the ability to analyse, critically respond to and use mathematics to meet the personal demands of life at school and at home, in paid work and for participating in community and civic life.

While numeracy development pathways are expressed within the *NTCF*’s Mathematics Learning Area component, numeracy is fundamental to learning across the eight Learning Areas and *EsseNTial* Learnings, and hence is the responsibility of all educators. Opportunities to develop numeracy are identified within all other components of the *NTCF* to support all educators in contributing to the numeracy development of all learners.

National Numeracy Benchmarks are identified in bold where appropriate, in Bands 1, 2 and 3 of the Mathematics Learning Area.

Within Curriculum Services Branch (CSB) in the NT Department of Education, Employment and Training (DEET) there are five numeracy officers including a numeracy Project Manager. These officers are based in the four largest regional centres in the Northern Territory: Darwin, Alice Springs, Katherine and Tennant Creek. They work in tandem with literacy officers and all other school support teams in CSB including the Action Curriculum Team (ACT), the English as a Second Language (ESL) team, and the Multi-level Assessment Program (MAP) team to offer integrated support to teachers and schools. The common goal of maximising learning for all NT students by providing needs-based support to teachers and schools helps to facilitate the links between these teams.

## The NT Numeracy Project

As a central component of the NT Literacy and Numeracy Plan, the numeracy project has built on the considerable outcomes already achieved by the *Numeracy in Schools Project* (1998–2000), one of Territory Wide Significance. It fosters an integrated approach to numeracy at system, cluster and school levels and provides professional development to teachers in a range of key areas.

The target group is wide ranging and includes all students, unique communities in diverse geographical locations, support people, parents and pre-service teachers. The Numeracy Project adds support to schools by:

- providing authoritative, accurate, current and relevant information;
- developing teacher, support staff and parent awareness and confidence through information sessions and workshops;
- demonstrating best practice teaching strategies;
- developing appropriate resources;
- fostering and facilitating networks and communication about literacy and numeracy;
- providing specific stage of schooling advice as required;
- collaborating with other teams and projects – e.g. ESL, Student Services, Discovering Democracy, Asia in Schools to provide a cohesive and integrated approach to literacy and numeracy across the learning areas;
- contributing to pre-service teacher education courses at Northern Territory University (NTU) and Bachelor Institute for Indigenous Tertiary Education (BIITE).

### Outcomes

Outcomes for the project focus on:

- increasing student numbers achieving numeracy benchmarks through the provision of opportunities for all students to engage in relevant and appropriate numeracy teaching and learning experiences;
- developing common understandings among all stakeholders of the specific language associated with numeracy development across the curriculum taking into account diverse cultural and ESL issues;
- enhancing numeracy development strategies and assessment practices of teachers and support staff for a consistency in practice and expectation across the system.
- developing and implementing effective programs that have explicit links between literacy and numeracy, and other key learning areas;
- provide PD to parents and support staff to assist them to become effective partners in students' literacy and numeracy development.

### Strategies

Two strategies employed to achieve the outcomes are professional development and the establishment of Learning Leadership Teams (LLT).

- *Professional development*  
Professional development is provided through a range of system-wide initiatives. Most numeracy professional development is related to projects funded through Strategic Assistance for Improving Student Outcomes (SAISO) and has supported the development, piloting, reviewing and rewriting of individual school-based projects. Other significant initiatives with major professional development components are the *Learning and Technology in Schools* (LATIS) project,

the *Quality Teacher Program* and the development of the *Northern Territory Curriculum Framework*.

- *Learning Leadership Team Development*

The team will be responsible for supporting staff in the documentation and implementation of the curriculum focus of the School's strategic plan. The team will facilitate professional development within the school and will liaise with Curriculum Services Branch personnel. The LLT will provide an avenue to recognise and utilise school-based expertise.

## South Australia

### Numeracy in South Australian Department of Education and Children's Services (DECS) sites

The South Australian government, through the Department of Education and Children's Services, recognises the importance of numeracy development to equip all learners to progress in further learning and to lead fulfilling lives. The government's commitment to numeracy education is reflected in curriculum and policy documents as well as an ongoing program of research and innovation projects, particularly those exploring strategies to improve numeracy outcomes in disadvantaged communities.

#### Policy and strategic framework for numeracy education

##### *South Australian Curriculum Standards and Accountability (SACSA) Framework*

The *SACSA Framework* is the curriculum policy document for government schools in SA. The *SACSA Framework* provides the following definition of numeracy:

The ability to understand, analyse, critically respond to and use mathematics in different social contexts.

This definition recognises the contextual nature of numeracy, the important relationship between numeracy and mathematics and the critical aspect of numeracy.

The *SACSA Framework* identifies five Essential Learnings and one of these, Communication, incorporates literacy, numeracy and information and communications technologies. Hence connections between literacy and numeracy, and literacy, numeracy and technology, are acknowledged. Changes in technology impact on the numeracy we need for life and learning and thus educators need to ensure that numeracy development equips learners for current and future numerate demands.

The *SACSA Framework* also recognises that all learning areas place numerate demands on learners and provide opportunities for learners to further develop and demonstrate their numeracy. The introduction to each learning area provides a brief description of what numeracy might look like in that particular learning area. For example in the Arts, learners might be 'gathering, interpreting and analysing data in relation to audience, viewer and user behaviour'.

The Mathematics learning area is singled out as providing core learning for numeracy development. The introduction to the Mathematics learning area states 'Mathematics learning is central to numeracy'. Further, some of the aims of mathematics learning in SACSA are to develop learners who:

- 'understand the social and work purposes, uses and practices of mathematics';
- are 'confident users of mathematics who choose appropriate and accurate means for exploring the world and conducting their lives';
- 'apply their mathematics learning to other Learning Areas, to life in the wider community, and in accessing further education and training'.

Learners who meet these aims will be well on the way to being numerate under any current definition of numeracy.

In summary, the *SACSA Framework* identifies numeracy development:

- in all learning areas, across all curriculum bands;
- throughout the Essential Learnings, in particular, through Communication;
- as being underpinned by learning in Mathematics;
- as connected with, and driven by, the increasing use of ICTs.

*In Focus, Literacy and Numeracy Strategy 2000–2005*

The Department's *Literacy and Numeracy Strategy* coordinates and extends initiatives in literacy and numeracy education. The aim of the *Strategy* is to 'improve literacy and numeracy for all learners'. The *Strategy* provides definitions of literacy and numeracy (matching those in the *SACSA Framework*), identifies Resources and Support, Connections with other programs and initiatives and expected Outcomes.

The *Strategy* also identifies four Key Elements that provide a useful framework for individual teachers, groups of teachers, schools or educational systems to plan literacy and numeracy education. These elements are: Working Together, Using Data, Intervening for Success, Adapting and Changing.

*Mathematics Strategy*

The Mathematics Strategy 2002–2006 aims to achieve fundamental reforms in the teaching and learning of mathematics in South Australian schools. The plan outlines a range of integrated strategies that support the implementation of the *SACSA Framework* and contribute to South Australian students achieving the levels of mathematical literacy and technical capacity required in a 21st century society.

The *Strategy* promotes the adoption of constructivist principles in teaching and learning mathematics and supports the work of universities and professional associations in developing professional standards.

The Mathematics Strategy 2002–2006 identifies the following strategic directions:

- extend the skills and abilities of South Australian mathematics educators to further improve the teaching and learning process;
- increase the use of current technology within Mathematics classrooms;
- establish, implement and evaluate professional standards for teachers of mathematics;
- promote an enhanced image of mathematics.

Work is under way to forge links between the Mathematics Strategy and the Literacy and Numeracy Strategy with the aim of improving numeracy outcomes for all learners.

*School Entry Assessment (SEA)*

School Entry Assessment is a mandated assessment resource that assists teachers to collect information about the literacy and numeracy children bring to school, and to tailor learning programs for them accordingly. SEA assists educators to consider what information they need about their children in their setting. It supports them to gather a range of contextual information and to observe how children operate in literate and numerate ways in the school setting. A common framework is used to describe children's literacy and numeracy development over time and support planning and implementation of programs that build on children's existing literacy and numeracy.



## Key research projects

### *Profiling High Numeracy Achievement... a research project (2001–2003)*

- Funded by DEST as a component of the Commonwealth's Strategic Numeracy Research and Development Projects.
- A research team from the Flinders Institute for the Study of Teaching is working with four schools to identify and document successful school and classroom practices in numeracy. Three of these four schools are serving disadvantaged communities. The research team is constructing a 'profile' of the school culture, leadership, structures and intervention programs, home/ school/ community links, professional development and accountability frameworks leading to improved numeracy outcomes for learners.

### *High Performance in Literacy and Numeracy in Disadvantaged Schools Project (2001–2002)*

- A research team from the University of South Australia is working with eight schools, serving disadvantaged communities, to identify and document successful school, and classroom practices in literacy and numeracy. The research team will construct a 'profile' of the school culture, leadership, structures, intervention programs, home/ school/ community links, professional development and accountability frameworks.
- These eight schools provided professional development support to 28 other project schools in 2001.

These two projects are profiling the breadth and depth of successful practices being provided by schools serving diverse communities across South Australia. The information that comes from these projects will be available to all educators online. A professional development program will also be developed to support school leaders to implement whole school change aimed at improving numeracy, or numeracy and literacy outcomes.

### *Literacy and Numeracy Learning Project (2001–2003)*

The aim of this project is to explore the relationship between literacy and numeracy, the Key Ideas and Outcomes of the *SACSA Framework* and pedagogy and track the achievements/improvements. The project involves 10 sites serving disadvantaged communities with student enrolments spanning the Early, Primary and Middle Years. Project schools are developing their own research question consistent with the project aim.

### *Using Technology in Mathematics Project (2002)*

Thirty teachers working with learners from Reception to Year 10 are using action research methodologies to explore the impact of new technologies on teaching and learning in Mathematics. The project aims to

- update and improve teachers skills
- enhance teachers capacity to improve student attainment
- enhance the status of teaching.

### *Aboriginal Education Action Research Project, Phase 2*

The outcomes of Phase 1 of this project have been published in the document *Cycles for Success*. Phase 2 builds on this work with twelve sites, R–12, across the State focussing their action research on numeracy development and the implications for Aboriginal learners. Common threads include the Essential Learnings, language and ICT in mathematics, the connections

between the knowledge and understandings of the learner, the curriculum and pedagogy and building strong contexts for successful outcomes.

*School Entry Assessment (SEA) Mentor Project*

Ten mentor schools are working with a total of 43 other schools to support junior primary staff to engage in on going professional development regarding use of SEA and to investigate the ways that SEA connects with the *SACSA Framework*. Focus areas of the project include; transition, literacy and numeracy development, assessment in the early years and the use of data.

*Local Educator Networks*

A range of locally based action research projects, funded through the Quality Teacher Program, support the implementation of the *SACSA Framework*. A number of these projects relate to the QTP priority areas of numeracy and mathematics. Groups of educators across districts and clusters are updating their skills and knowledge through collaborative research. This model

- emphasises the value of school based professional development projects that link to the schools' strategic priorities whilst taking account of district, DECS and DEST priorities
- provides access to professional development funds for schools, clusters of schools and districts.

For further information, contact John Bleckly.

## Australian Capital Territory

### Overview

The ACT *Mathematics Curriculum Framework* (1994) refers to numeracy as ‘an ability to cope mathematically with the demands of everyday life’.

Recent research through Murdoch University suggests that ‘numerate behaviour involves a blend of mathematical, contextual and strategic knowledge, and that the blend will be determined by the context and the person.’ (Kemp and Hogan, p11)

This statement represents a broader and arguably more appropriate view of numeracy than has commonly been the case both historically and internationally. In the context of schooling this view of numeracy has been described as numeracy across the curriculum.

Frequently numeracy is used in the sense of doing some mathematics well. While it is vital to pursue excellence in the teaching and learning of mathematics (or other learning areas), numeracy involves more than this. Mathematics, in its broadest sense, is an integral part of numeracy, but is not the same as it. The contextual and strategic components that are essential aspects of numeracy mean that, even if mathematics is taught well, there is no guarantee of that knowledge transferring to new situations.

In planning for numeracy development in ACT government schools we recognise that doing mathematics well and numeracy across the curriculum are not the same thing, but both are important for all students.

### Doing mathematics well

Mathematics programs in schools should allow students to develop the ability to work mathematically, and not just accumulate a collection of disparate skills. This requires a focus on teaching for understanding, without which students are limited in their capacity to use whatever skills they have. Technology should play an increasing part in the teaching and learning process, in particular to facilitate exploring mathematical concepts by liberating students and teachers from low-order procedural tasks.

### Numeracy across the curriculum

In the context of their schooling students are frequently in positions where mathematics is required to do something else well. These situations do not need to be manufactured and are indeed becoming more common; often they are important for achieving quality learning outcomes within the particular curriculum area concerned. Such situations can provide arenas for engaging with and supporting student numeracy development.

### Research projects

#### **Doing Mathematics Well: The Assessing Numeracy In Primary Schools (ANIPS) project**

This is a Commonwealth-funded numeracy research project involving ten ACT primary schools from both the government and non-government sectors. Teams of classroom teachers in each school are using an action

research approach to explore the question, 'How can the results from a variety of assessment tools be used to improve student numeracy outcomes?'

The project reflects the belief that a range of assessment approaches is necessary to identify what a student can do, and what they need to support further learning. Also, that learning is most effectively supported when it is aligned with assessment that helps shape appropriate and high quality teaching practices.

Two questions that deserve exploration are:

- Where does data obtained from population assessments in years three, five and seven fit in the school's overall numeracy planning?
- What other complementary assessment practices might be needed?

Work to date has shown the value of professional learning teams in supporting individual reflection, broader discussion, and positive changes to teaching practices. Project teachers have been allowed to focus on manageable tasks in their own and other teachers' classrooms. Many teachers have commented on the value of the concurrent professional development that participating in the action research has provided.

The project is scheduled for completion by July 2003.

### **Numeracy Across the Curriculum: the Middle Years Numeracy (MYN) project**

This project is focussing on numeracy across the curriculum in the middle years of schooling (Years 5–8) and involves the development of an effective and transferable model for supporting ongoing school-based engagement with numeracy in all learning areas. This project recognises that numeracy is an increasingly important aspect of quality learning in all subject areas, and as such is relevant to all teachers.

The project is managed by the Australian National Schools Network (ANSN) and will involve teachers and schools communities in action research through 2002/2003.

## **The future**

There has been an enthusiastic uptake of the NSW *Count Me In Too* program by ACT teachers. It is expected that the current support for the number component will continue and expand to include measurement.

A range of professional development opportunities has been available through the department and the Canberra Mathematical Association. The ANIPS and MYN projects will help inform and support professional development in numeracy in ACT schools over the next few years.

Schools will be required by the end of 2002 to draft school numeracy plans. The main purpose of these plans is to provide schools with a focus for articulating their beliefs, goals, actions and performance in numeracy, as part of their ongoing planning for the provision of quality numeracy support for all students. It is expected that schools will address both doing mathematics well and numeracy across the curriculum in their planning.

For further information, contact Rick Owens.

## Western Australia

The Western Australian *Curriculum Framework* describes numerate behaviour as the disposition and competence to use mathematics in the service of endeavours other than mathematics. While the major responsibility for developing students' numeracy lies within the mathematics learning area the Curriculum Framework identifies three ways in which learning areas other than mathematics contribute to the enhancement of students' numeracy:

- providing rich contexts in which students can use their mathematics;
- expecting students to use their mathematics in other learning areas; and
- maintaining common and challenging standards.

(*Curriculum Framework*, p. 215)

Government schools in Western Australia are in the fifth year of the *Curriculum Improvement Program*. This major strategic initiative seeks to implement an outcomes-focussed approach to curriculum in all schools within the government system. Numeracy programs and resources including the *Getting It Right Literacy and Numeracy Strategy*, *First Steps in Mathematics* and the *Numeracy Net K–7* assist schools to implement outcomes-focussed approaches to mathematics teaching and learning. The research conducted by the department's *First Steps in Mathematics* project team during 1995–2002 contributed significantly to the comprehensive and cohesive professional development and curriculum materials provided to schools through these programs.

For further information, contact Glenys Reid.

## Tasmania

### Current initiatives

#### **Numeracy Consultation**

In 2002 the Department of Education has conducted a numeracy consultation to identify needs and make recommendations for the future provision of numeracy professional development and to inform the state literacy/numeracy plan. This process has involved consultation with teachers and community members and an examination of current research in relation to numeracy teaching and learning.

#### **Essential Learnings Framework**

Like many other systems worldwide, the Department of Education has re-examined curriculum and developed a new view of future curriculum provision. The Essential Learnings framework highlights the importance of students becoming numerate and provides Tasmanian educators with further impetus to re-think approaches to curriculum, assessment and teaching and provides a framework for teachers to explore new and broader views of numeracy. It also challenges teachers to consider new approaches to teaching which focus on the development of deep understanding of big ideas and the use of rich classroom assessment to inform teaching.

### Projects

A small number of numeracy projects have been undertaken in Tasmanian schools in recent years. These include:

#### **Trial of the *Count Me In Too* program**

Over the past three years a number of schools have participated in trials of the *Count Me In Too* program in early childhood classes. The focus of the program has been teacher development and those involved report greater understanding of how children develop ideas about number and of the importance of matching activities to identified student needs. The program has led to an increased focus on the development of mental strategies and recognition of the value of probing students' understanding of important ideas in number. This program will conclude at the end of 2002, with the key learnings from it being incorporated into future numeracy initiatives.

#### ***Thinking and Working Mathematically Project***

This project has focussed on the Prospect High School cluster in the north of the state. Teachers from Prospect High School and its feeder primary schools have explored the ideas of thinking and working mathematically and have focussed on ways to develop schools cultures which foster thinking and working mathematically as key emphases in the school program. Teachers involved have developed new ways to assess student understandings and have explored different classroom approaches, which promote communication, investigation and metacognitive processes.

**Developing Computation — Commonwealth research project**

This project has involved schools from the government, independent and Catholic systems and has focussed on the move from mental computation to written computation in lower primary classrooms. Associate Professor Alistair McIntosh from the University of Tasmania has worked with the teachers to investigate ways to help students develop strong mental strategies for dealing with numbers and gradually move to recording their thinking in increasingly sophisticated ways. Teachers involved in the project have observed students becoming more confident with number and the development of a range of strategies for dealing with number.

**Improving Numeracy for Indigenous Students in Secondary Schools (INISSS) project**

This project is targeted to improving numeracy outcomes for Indigenous students but has benefited all students in the classes involved. Teachers have explored the use of hands-on, investigative classroom activities and alternative assessment tasks.

**Changing Places Project**

Changing Places is a primary school project targeted to Indigenous students, which has numeracy as one component of its teacher development. Teachers involved have worked with Doug Williams and have used the approaches advocated in the Maths 300 project to develop units of work, which engage students in meaningful, hands on activities.

**Developing and trialling a Post-Graduate Certificate in Teaching for numeracy**

This project has involved practitioners working with the Department's Recognition Services Branch to develop and accredited Post-graduate Certificate In Teaching For Numeracy and the accreditation of a small number of teachers in 2002. This process recognises current competence and allows teachers to develop rich evidence of their innovative work in teaching for numeracy.

**Quality Teacher Program**

Mathematics/numeracy has been a focus for Tasmanian schools involved in the Quality Teacher Program. Teachers have been involved in personal professional learning of both mathematics and pedagogy and projects, which meet the needs of particular clusters of schools. The program has attracted large numbers of teachers and has had positive effects on teaching and learning for numeracy.

For further information, contact Denise Neal.

## Queensland

### Overview

A variety of definitions of numeracy appear within the mathematics literature. These differences reflect differing purposes and interpretations of what numeracy is and what it involves. Each numeracy project in Queensland selects a definition for their specific project purpose. The definitions range from a narrow focus on mathematical skills or test performance, to broader issues relating to the need for individuals to be able to function effectively in our society.

The most common definition used from policy documents is the following:

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.

### Current research

The Strategic Numeracy Research and Development project funded by the Commonwealth will identify the elements of learning environments that lead to measurably enhanced student numeracy outcomes in Queensland State, Catholic and Independent schools. In achieving this aim the project will:

- identify current numeracy achievement and teaching-learning practices in a diverse sample of State, Catholic and Independent primary schools in Queensland;
- support teachers and administrators to reflect on practices that will enhance the numeracy learning environment; and
- monitor the effect of enhancements in learning environments on students' numeracy learning outcomes in participating schools through quantitative and qualitative research techniques.

Those involved in the research are a consortium of key personnel that includes five members of the Faculty of Education at Queensland University of Technology (QUT), two members from the school of Education at James Cook University, and one member each from the Education Faculties of the Australian Catholic University and Griffith University.

### Numeracy initiatives

The Year 2 Diagnostic Net process monitors student achievement in numeracy using number developmental continua. This mapping informs development of appropriate learning programs for individuals and groups of students, as well as provision of additional support for students experiencing learning difficulties in these aspects of early numeracy.

The Appraisalment Process for students experiencing learning difficulties and learning disabilities is being implemented over a number of years. The appraisalment process will help to determine student's strengths in numeracy, determine barriers to learning, develop quality education programs that meet students individual learning needs and establish and maintain home-school relationships.



## National Literacy and Numeracy Plan

In response to this, Queensland has developed materials to support the existing Year 2 Diagnostic Net material in Number. These resources are Space, Measurement, Chance and Data: Improving Learning Outcomes and Support a Maths Learner: Number

## Technology, Mathematics and Science Centres of Excellence

These centres are designed to focus on the curriculum in Technology, Mathematics and Science. At these centres students can enhance their interest and achievements in these areas through an extensive array of programs and activities. As sources of innovation and enrichment, the centres provide opportunities for Queensland students and teachers to move to the forefront of modern schooling and play a leading role in shaping these curriculum areas. One school has chosen to look at numeracy education for Indigenous education in the Outback.

## Related research

Education Queensland in conjunction with Queensland University of Technology (QUT) are at present conducting projects in numeracy education for New Basics and Inclusive Education. Further information for these projects will be available in 2003.

## Numeracy position from Queensland Studies Authority

The Years 1–10 key learning area syllabuses developed by the previous Queensland School Curriculum Council and which are now the responsibility of the newly formed Queensland Studies Authority collectively contribute to four cross-curricular priorities, one of which is numeracy.

The *Position Paper: Numeracy* (2001) describes numeracy as follows:

Numeracy is the manifestation of practices and dispositions that accurately, efficiently, and appropriately meet the demands of typical everyday situations involving number, space, measurement and data.

The numeracy position paper describes a generic categorisation of numeracy that is independent of any particular key learning area — to highlight that numeracy is NOT just part of mathematics, and that all teachers of all parts of the curriculum have a responsibility to contribute to students' numeracy. The *P–10 Curriculum Framework* (unpublished) used by the key learning area curriculum developers describes a range of knowledge, practices and dispositions that characterise the eight key learning areas, as well as the four cross-curricular priorities. The specific intent of referring to 'knowledge, practices and dispositions' was to break away from the traditional taxa of 'content, processes, skills, and attitudes'. One can observe a tendency to disregard 'attitudes' and 'affective objectives' in favour of 'knowledge' and 'skills'. With respect to 'numeracy', the 'knowledge, prac-

tices and dispositions' framing allows a focus beyond 'drill and skill' notions of numeracy. This framing allows a focus on the 'desire to be numerate' — a desire to recognise and engage successfully with the numeracy demand of a particular situation.

The generic categorisation of numeracy is based on the 'four practices' model of the companion literacy position paper. This is intended to make it easier for teachers to conceptualise and put into operation their curriculum planning. It also serves a small 'p' political and professional purpose: while literacy and numeracy are often mentioned in the same breath, some opine that there is a greater awareness of, and commitment to, 'literacy'. Framing the 'numeracy' story in ways that fractal the 'literacy' story makes it easier for teachers to enter current conversations.

'Resources' for four 'practices' are described: foundational practice, linking practice, pragmatic practice, and critical practice.

Broad descriptions of levels of numeracy informed writers of key learning area syllabuses and associated curriculum materials so that core learning outcomes in the different key learning areas had a similar sense of numeracy demand. Additionally, specific numeracy practices were described for each of the key learning areas.

Current work on developing materials for the trial of a new 'preparatory year' includes identifying early years numeracy practices.

For further information, contact Rhonda Eggerling.

## Victoria

In Victoria, excellence in student mathematics achievement, and ongoing improvement of this achievement, is a high priority. The Victorian *Mathematics Curriculum and Standards Framework* states that learning mathematics involves mastery of several components:

- Knowledge of facts and technical skills
- Depth of conceptual understanding
- Ability to apply what has been learned to solve real problems.

Mathematics in Years preparatory to 10 is based on the strands: Space, Number, Measurement, Chance and Data, Reasoning and Strategies and Algebra (from Year 7).

As students engage in learning mathematics and achieve the outcomes for each level, they will acquire numeracy skills that enable them to use mathematics sensibly and confidently in a variety of different situations. In Victoria the *National Numeracy Benchmarks for Years 3, 5 and 7* form a subset of the indicators for some *Mathematics Curriculum and Standards Framework* learning outcomes in selected strands.

Early years numeracy advice and professional development for schools is based on research in mathematics. The Early Years Numeracy Program is a resource for schools to use in planning and implementing a strategic and comprehensive approach to early mathematics teaching and learning in the first five years of schooling. It includes the Early Years Numeracy Teacher Pack and Early Years Numeracy Parent Pack.

Professional development and training based on a multi-layered approach of region- based trainers and school-based coordinators supports teachers in implementing effective classroom programs. Further information can be accessed at <http://www.sofweb.vic.edu.au/eyes/num>.

Innovative and highly effective numeracy professional development in both the early and middle years of schooling is also delivered to teachers throughout Victoria via Schools' Television. These professional development programs focus on outcomes from research, high quality classroom practice and developing and extending teacher knowledge and understanding of effective numeracy teaching practice. Parent booklets inform parents of current numeracy instruction in schools and how they can support their children's numeracy achievement at home.

The development of middle years numeracy in Victoria is being informed by the *Middle Years Numeracy Research Project*. Advice and professional development for schools will provide a strategic and coordinated approach to the teaching and learning of numeracy for students in Years 5–9.

*Middle Years Numeracy* professional development has been delivered at a state level during 2002 and regional coordinator training throughout the state is commencing. Further information on the *Middle Years of Schooling* in Victoria can be accessed at <http://www.sofweb.vic.edu.au/mys/Num>

## Current research

### Early Numeracy Research Project

The *Early Numeracy Research Project* (ENRP) 1999–2001 was a joint venture between the Victorian Department of Education & Training, the Catholic Education Office Melbourne, the Association of Independent

Schools of Victoria and the Australian Catholic University. The project was conducted in thirty-five trial schools and thirty-five matched reference schools in Years Prep to Year 2. More detail is available at <http://www.sofweb.vic.edu.au/ey/num/enrp.htm>.

Data from 1999–2001 showed that while there was significant and important growth in student knowledge and understanding in reference schools, the growth in trial schools was particularly outstanding in every one of the content areas compared: Counting, Place Value, Addition and Subtraction Strategies, Multiplication and Division Strategies, Time, Length, Properties of Shape and Visualisation and Orientation, at each grade level. There is substantial evidence that there were also considerable cognitive and affective gains, with students making a positive and promising start to their study of mathematics.

### **Researching Numeracy Teaching Approaches in Primary Schools**

The *Researching Numeracy Teaching Approaches in Primary Schools* (September 2001 – June 2003) is a Commonwealth-funded project. This project is researching numeracy teaching practice through identification of effective classroom teaching approaches in mathematics for students in Years Prep to Year 6. The research is being conducted in sixteen trial and sixteen matched reference schools drawn from the Government, Catholic and Independent sectors. Over 6000 Prep–Year 6 students will be assessed during the project. The final report is due in late 2003.

### **Middle Years Numeracy Research Project: 5–9**

The *Middle Years Numeracy Research Project* (MYNRP) 1999–2000 was commissioned by the Victorian Department of Education & Training, the Catholic Education Commission of Victoria and the Association of Independent Schools of Victoria to provide advice on improving the teaching and learning of numeracy in Years 5 to 9. The project commenced in September 1999 and was completed in December 2000. The MYNRP involved the collection of base line data in November 1999. 20 trial schools were selected to explore what works in relation to improving numeracy outcomes. The project found that it was possible to measure numeracy using rich assessment tasks and that the quality of the item analysis supported the development of an Emergent Numeracy Profile to map student numeracy performance and inform subsequent instruction. The research showed that there was as much difference in student performance within year levels as there was between Years 5 and 9 students overall and that there was at least as much difference between classes at the same school as there was between schools. All trial schools demonstrated an improvement in student numeracy performance.

Further information about this project can be accessed at <http://www.sofweb.vic.edu.au/mys/MYNRP>.

### **Mathematics Annotated Work Samples**

The work of the Department of Education & Training is complemented by the Victorian Curriculum Assessment Authority's *Mathematics Annotated Work Samples* which were published in 2001 and the corresponding professional development program and resources which are running in 2002, coordinated through regional networks throughout Victoria. Further information about the *Mathematics Annotated Work Samples* can be accessed at <http://www.sofweb.vic.gov.au/csf/WorkSamples/websiteinfo.htm>

## **Future plans**

### **Professional Development**

Early Years Numeracy Trainer Training provides an opportunity to participate in high quality and comprehensive professional development on effective numeracy teaching strategies. Additional Early Years Numeracy Trainer and school-based co-ordinator training programs will be held in 2002 and early 2003.

### **Additional Numeracy Funding**

The Victorian 2002 State Budget allocated \$34.6 million to employ the equivalent of 150 early years numeracy coordinators for Victorian schools. The school based numeracy coordinator will play a pivotal role in implementing and maintaining the Early Years Numeracy Program in Victorian schools. The funding is for a three year period 2003–2005.

### **Schools for Innovation and Excellence**

The Victorian 2002 State Budget allocated \$84.3 million over the next 4 years to encourage both primary and secondary schools to work closely together to deliver innovation and excellence in Victorian education. Clusters of primary and secondary schools will receive, on average start up funding of \$200 000 in the first year to develop strategically effective education programs to advance student learning. The clusters will then receive \$80 000 a year to implement these programs and employ an educator committed to innovation and reform.

### **Access to Excellence**

The Victorian 2002 State Budget allocated \$81.6 million over four years to employ an extra 300 teachers at targeted secondary schools across Victoria to boost literacy, participation, retention and attendance rates.

For further information, contact Cathy Beesey.

## **New South Wales**

*Following is the statement on numeracy from the (draft) K–6 and Years 7–10 Syllabuses.*

*Final approval of these documents is expected very soon.*

Numeracy is the ability to effectively use the mathematics required to meet the general demands of life at home and at work, and for participation in community and civic life. As a field of study, mathematics is developed and/or applied in situations that extend beyond the general demands of everyday life.

Numeracy is a fundamental component of learning across all areas of the curriculum. The development and enhancement of students' numeracy skills and understanding is the responsibility of teachers across different learning areas that make specific demands on student numeracy.

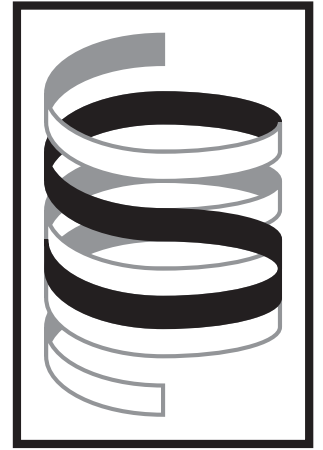
To be numerate is to use mathematical ideas effectively to make sense of the world. Numeracy involves drawing on knowledge of particular contexts and circumstances in deciding when to use mathematics, choosing the mathematics to use, and critically evaluating its use. Numeracy incorporates the disposition to use numerical, spatial, graphical, statistical and algebraic concepts and skills in a variety of contexts and involves the critical evaluation, interpretation, application and communication of mathematical information in a range of practical situations.

The key role that teachers of mathematics play in the development of numeracy includes teaching students specific skills and providing them with opportunities to select, use, evaluate and communicate mathematical ideas in a range of situations. Students' numeracy and underlying mathematical understanding will be enhanced through engagement with a variety of applications of mathematics to real-world situations and problems in other key learning areas.

For further information, contact Peter Gould.

# Appendix 3:

## Commonly used acronyms



AAMT	Australian Association of Mathematics Teachers
ACER	Australian Council for Educational Research
ACU	Australian Catholic University
ACT	Australian Capital Territory
ANIPS	Assessing Numeracy in Primary Schools (Project)
ANSN	Australian National Schools Network
BIITE	Bachelor Institute for Indigenous Tertiary Education
CMIT	Count Me In Too! (Project)
CSB	Curriculum Services Branch
CSF	Curriculum Standards Framework
DECS	Department of Education and Children's Services (South Australia)
DEET	Department of Employment, Education and Training
DEST	Commonwealth Department of Education, Science and Training
DETE	Department of Education, Training and Employment (now DECS)
DETYA	Commonwealth Department of Education, Training and Youth Affairs (now DEST)
DMT	Diagnostic mathematical task
ELs	Essential Learnings
ENRP	Early Numeracy Research Project
ESL	English as a second language
EYNP	Early Years Numeracy Program
GST	Goods and services tax
HECS	Higher Education Contribution Scheme
HPE	Health and physical education
ICT	Information and communication technologies
INOP	Indigenous Outback Numeracy Project
LATIS	Learning and Technology in Schools
LLT	Learning Leadership Teams
MAP	Multi-level Assessment Program
MERGA	Mathematics Education Research Group of Australasia
MYN	Middle Years Numeracy (Project)
NESB	Non-English speaking background
NIELNS	National Indigenous English Literacy and Numeracy Strategy
NSW	New South Wales

NT	Northern Territory
NTCF	Northern Territory Curriculum Project
NTU	Northern Territory University
PD	Professional development
PISA	Programme of International Student Assessment
QSA	Queensland Studies Authority
QTP	Quality Teacher Program
QUT	Queensland University of Technology
RMIT	Royal Melbourne Institute of Technology
SA	South Australia
SACSA	South Australian Curriculum Standards and Accountability Framework
SAPPA	South Australian Primary Principals' Association
SAISO	Strategic Assistance for Improving Student Outcomes
SEA	School entry assessment
SNAP	Student Numeracy Assessment Program
SOSE	Studies of Society and Environment
TCE	Tasmanian Certificate of Education
TIMSS	Third International Mathematics and Science Study
WA	Western Australia