

Resources and Teaching Strategies to Support Aboriginal Children's Numeracy Learning

A review of the literature

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June 1999

This project was commissioned by the Office of the Board of Studies NSW. The views expressed by the authors do not necessarily reflect the views of the Office of the Board of Studies NSW.

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Acknowledgements

This review of Research into K-6 Aboriginal Numeracy in NSW was commissioned by the New South Wales Board of Studies.

The research for this review was undertaken in consultation with Dr Margaret Valadian and Natascha MacNamara from the Centre for Indigenous Development, Education and Research at the University of Wollongong. Their knowledge and understanding of Aboriginal education issues is based on a wealth of expertise and experience. I thank them for their input into this project and their ongoing support for ACER research which aims to improve learning outcomes for Indigenous students.

Thanks also to my ACER colleagues Graeme Withers and Dr Sue Fullarton for their valued comments on early drafts and proofreading of the final report.

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Overview

The themes that emerged from the literature on numeracy development and Aboriginal students are consistent with a wider body of research pertaining to effective teaching and learning strategies for Aboriginal children in general and effective strategies to enhance numeracy learning for all children, particularly those who do not come from a home background which already reflects what happens in school.

The following factors emerged as key considerations for the development of numeracy materials for Aboriginal primary school students in New South Wales:

The *teaching strategies* suggested for numeracy activities should:

- reinforce that teachers' beliefs and understanding of their pedagogical practice is essential for effective numeracy teaching;
- equip teachers with a range of teaching strategies to reflect the diverse learning needs and ways of learning of their Aboriginal students;
- provide a supportive environment in which Aboriginal students feel confident as learners and risk-takers;
- recognise that mathematics classes are essentially a linguistic exercise and a very complex one for Aboriginal students given their diverse backgrounds and language needs;
- encourage the provision of positive, non-threatening, language-rich environments in mathematics classrooms; and
- support parents and communities in becoming or being further involved in their children's learning.

The *content* of numeracy materials should:

- value Aboriginal students' diverse cultural and linguistic heritages;
- make explicit the difference between Western mathematics and Aboriginal mathematics, and value both equally ;
- make explicit the link between community, home and school mathematics;
- provide realistic and real-life classroom contexts for mathematics activities;
- be developed in consultation with local communities and Aboriginal education workers; and
- be open to and encourage modifications of content and pedagogy to reflect particular students' interests and learning needs;

If these resources are to be *used effectively* in classrooms they should:

- encourage teachers to become aware fully of the complexity of the cultural and social contexts in which Aboriginal students learn mathematics;
- encourage teachers to explore and use the particular contexts, especially numeracy ones, for their Aboriginal students;
- encourage teachers to identify the particular learning needs and preferred ways of learning of each of their Aboriginal students;
- invite teachers to reflect on their practice and to identify and build on what works for their Aboriginal students; and
- reinforce the critical relationship between high teacher expectations, a positive classroom climate and student achievement.

Introduction

This literature review focuses on teaching and learning strategies that support the development of numeracy skills in Aboriginal children. The purpose of the paper is to provide a theoretical framework that will inform the development of numeracy materials to support teachers of Aboriginal children in New South Wales primary schools.

The report of the Numeracy Education Strategy Development Conference, *Numeracy = Everyone's Business* (DEETYA, 1997) provided the following description of numeracy to inform work in numeracy education:

To be numerate is to use mathematics effectively to meet the general demands of life at home, in paid work, and for participation in community and civic life.

In school education, numeracy is a fundamental component of learning, performance, discourse and critique across all areas of the curriculum. It involves the disposition to use, in context, a combination of:

- *underpinning mathematical concepts and skills from across the discipline (numerical, spatial, graphical, statistical and algebraic);*
- *mathematical thinking and strategies;*
- *general thinking skills; and*
- *grounded appreciation of context.* (p.15)

Although 'numeracy' may be defined more broadly than 'school mathematics' much of the literature focuses on the teaching and learning of numeracy in the key learning area of mathematics. The research on Aboriginal children learning mathematics is part of a wider body of literature concerned with general teaching and learning strategies which enhance educational outcomes for Aboriginal children. This more general research will be briefly referred to in the review to provide a broader picture of issues relating to effective teaching programs and resources for Aboriginal children.

The literature on the development of numeracy skills in Aboriginal children is not vast. Much of the research relating to Aboriginal children and mathematics has been conducted in geographically remote areas of Australia. However it should be recognised that the great majority of New South Wales Aboriginal people live in areas that are classified as urban (29%) or other urban (67%; in areas with a population cluster of 1000 or more people). While it is important to be mindful of the diversity of circumstances in which Aboriginal students live (traditional and non-traditional communities or dispersed) there are many general themes which emerge in the literature (for example, identifying the mathematics that exists in the child's home environment) that can be applied to both urban and rural Aboriginal children.

The search of literature was undertaken using the facilities of the Cunningham Library at ACER, the Australian Education Index and the Internet. It was decided to limit the search to books and articles written over the last 10 years and to focus on empirically based research and work by practitioners rather than on the theoretical literature. It was thought that this

scope would be the most relevant for informing discussions about the development of numeracy resources for NSW Aboriginal students.

Structure

Although the body of research reviewed for this paper is relatively small, a number of key themes consistently emerged to inform a framework for the development of numeracy resources for Aboriginal children. These come under the broad headings of:

- teaching Aboriginal students;
- cultural frameworks;
- engaging in the language of mathematics; and
- contextualising mathematics.

In addition to the research literature, reference is made to numeracy programs and resources currently being used in schools that focus on Aboriginal students. In most cases there is little empirical evidence regarding their effectiveness.

An annotated bibliography is included so that particular references and resources may be assessed for their usefulness in more directly supporting the development of the resource materials.

Context

The context for this review is the continued focus of both Federal and State Governments on improving educational outcomes for Aboriginal and Torres Strait Islander students along with a growing focus on improving numeracy skills for all children.

The *National Aboriginal and Torres Strait Islander Education Policy* (AEP) (Commonwealth of Australia, 1989) articulated that the long-term goal for schools should be 'to enable Aboriginal attainment of skills to the same standard as other Australian students throughout the compulsory schooling years' (p.15).

Successive Commonwealth, State and Territory government policies have consistently called for the implementation of culturally appropriate curricula, pedagogy, assessment and reporting practices to improve literacy and numeracy achievement of Aboriginal and Torres Strait Islander students.

The *National Strategy for the Education of Aboriginal and Torres Strait Islander Peoples 1996-2002* (MCEETYA, 1995) called for the:

- cultural evaluation of mainstream literacy and numeracy programs including a determination of their appropriateness for Aboriginal and Torres Strait Islander students and, where necessary, the development of new approaches;
- introduction of technology and technology information to assist the development of literacy and numeracy skills;

- identification and utilisation of computer software packages that can assist achievement in educational outcomes in the key learning areas; and
- development of high quality curriculum and resource materials which include Aboriginal and Torres Strait Islander perspectives in the identified key learning areas. (p. 55-56)

The New South Wales Department of School Education's *Aboriginal Education Policy* (1996) outlined a set of strategies designed to improve the literacy and numeracy achievement of Aboriginal students:

- targeting resources on transition to school and early literacy programs;
- preparing Reading Recovery teachers to work with Aboriginal students and communities;
- accepting and valuing Aboriginal English and developing teaching programs which use it as a teaching tool;
- providing intensive literacy and numeracy programs with accompanying resources including Aboriginal content and perspectives for use at all stages of schooling; and
- researching appropriate methodology and content across all key learning areas. (p. 10)

Although some improvements have been achieved, it is clear that a substantial gap continues to exist between educational outcomes for Indigenous and non-Indigenous people.

The *National Review of Education for Aboriginal and Torres Strait Islander Peoples* (1995) reviewed the extent to which inequality for Indigenous people in terms of educational outcomes continued to exist. Based on an analysis of results of the range of state assessment programs in literacy and numeracy a Discussion Paper for *The National Review of Education for Aboriginal and Torres Strait Islander People* (1994) reported that:

- about one in five Aboriginal and Torres Strait Islander students achieve at levels above the average for students as a whole;
- overall, the literacy and numeracy achievement of about 45% of Aboriginal and Torres Strait Islander students is lower than one standard deviation below the mean achievement level of other Australian students;
- the differences between Aboriginal and Torres Strait Islander students and other Australian students in literacy and numeracy achievement are smaller in urban areas and greater in rural (including remote) locations;
- in urban locations, about 27% of Aboriginal and Torres Strait Islander students achieve at levels above the average for students in urban locations as a whole; in rural (non-town) locations about 20% of Aboriginal and Torres Strait Islander students achieve above the average for students in rural (non-town) locations as a whole; and
- Aboriginal and Torres Strait Islander girls consistently record higher achievements in literacy than boys, but there is little difference in the achievements

of girls and boys in numeracy. These gender patterns are similar to those for all Australian primary school students. (pp. 23-24)

Barriers to achievement

The reasons for poor educational outcomes for Aboriginal children as a group are many and complex. Aboriginality is not in itself a reason to expect poor educational outcomes. However Aboriginal and Torres Strait Islander people as a group have the highest degree of overlap with other educationally disadvantaged groups, such as those with low literacy and numeracy skills, the long term unemployed, those in custody, and those living in rural and isolated areas. Poor educational outcomes may also be related to poverty and to the covert discrimination and racism experienced by many Aboriginal children, ranging from low teacher expectations to peer harassment (Adams, 1998).

As well, many Aboriginal children experience health problems (especially hearing loss resulting from *otitis media*), many are ESL learners or speak a non-standard dialect at home or have parents with low literacy levels. These children experience an education with predominantly non-Aboriginal teachers who are not adequately trained to meet their needs and in a learning setting which is not culturally appropriate (Batten, Frigo, Hughes and McNamara, 1998).

Munns and Connelly (1996) linked the poor educational achievement of Aboriginal students in a Sydney inner-city primary school to a mismatch between the culture of the home and the culture of the school. The students' behaviour at school was characterised by lack of risk-taking in the classroom, fear of being shamed and refusal to work which often resulted in absence or suspension from school.

Indigenous children who live in rural and remote areas may experience additional barriers to successful learning at school. The literature review carried out as part of the *Desert Schools* project identified a number of key issues in the educational disadvantage experienced by Indigenous people in remote schools including, culturally inappropriate teaching strategies and forms of assessment, the relevance of school, teacher training, teacher expectations, student motivation, student-teacher relationships, language issues, attendance, housing, health, substance abuse and community funding resources (National Languages and Literacy Institute of Australia (NLLIA), 1996):

In some instances, there was a lack of seriousness and rigour in the teaching of English and other curriculum areas. This appeared to result from a tendency in some schools to seek to improve attendance by an emphasis on entertainment, without students achieving sufficient satisfaction or real outcomes from their learning achievements ... Experienced and confident teachers took their students out of the formal school setting and tried to relate their learning to collaborative tasks in the community context, thereby bringing meaning and a shared purpose to the activity. (p.338)

It is known that recurrent mild to moderate hearing loss can result in a range of communication and linguistic problems which are likely to affect the development of literacy skills and subsequently of numeracy skills. The incidence of educationally significant hearing loss is found to be particularly widespread in Indigenous communities. In many instances, teachers are not aware of the incidence of hearing problems in the classroom as other behaviours may mask hearing loss. The effect of hearing problems can be severely exacerbated if the child also comes from a non-English speaking background (Nienhuys and Burnip, 1988).

Cultural frameworks

Mathematics education is embedded in cultural frameworks. The predominant framework in Australia is Western, and there are many differences between this and the framework in which Aboriginal mathematics is embedded. Bishop (1994) argues that it is important to distinguish between Western mathematics and Aboriginal mathematics and to recognise that the learning of mathematics is essentially an enculturation process. Mathematics is a socially constructed way of knowing.

In the context of describing the dichotomy between Western and Aboriginal mathematical schema, Cooke defines of three kinds of mathematics:

- *Western Mathematics. Mathematics is a Western schema for ordering, patterning, relating and operating on, quantities based in a European system of logic, where this schema is applied in ordering social activity and in seeking to understand, explain and define the structure and behaviour of whatever exists.*
- *Pan-cultural mathematics. Mathematics is the manifestation of a universal human cognitive characteristic reflected in the behaviour of people as they locate in time, space and society. The categorisation of any given behaviour or linguistic item as Mathematical in quality, is based on the presence of a clear conceptual link with Western Mathematical notions.*
- *Mathematics as a cultural schema. Mathematics is a culture's system for encoding, interpreting and organising the patterns and relationships emerging from the human experience of physical, spiritual and social phenomena. (in Jones et al., 1995, p. 25)*

This type of model makes it possible to overcome what Stanton refers to as a 'preoccupation with Piagetian development stages and the blind following of primary school concept development and technique master traditions', which ultimately ranks Western mathematical thinking as superior to other world views (in Jones et al., 1995, p. 15). As an illustration of these differences, Mandawuy Yunnipingnu explained some of the Yolngu learning methods and their mathematics:

It is different in that it is centred on kinship; centred on a system that is governed in a social sense - how we relate to each other and how things are

run; everyday normal sort of things. We learn and abide by the kinship system and it can be applied to Western areas where Yolngu people have traditionally had trouble grasping concepts, such as mathematics and the sciences. In mathematics you have recursive processes and even though it is an ongoing thing it keeps on coming back - similar in that after 10 you keep on counting from one to the next ten. By applying the recurring themes of our kinship system. This is an area to which Aboriginal students can be linked. There are similarities which can help us grasp the concepts of mathematics and ultimately enable Yolgnu people to function in a contemporary world. (Potter, 1994, p.3)

The *National Statement on Mathematics* (Australian Education Council, 1991) recognised the cultural limitations of the mathematics curriculum which:

has tended to emphasise values and concerns which are more middle class than working class, and to draw on experiences which are more relevant to children of Anglo-Celtic descent than those of Aboriginal descent or those from non-English-speaking backgrounds ... Cultural appreciation of mathematics should include an understanding of the richness of mathematical ideas which were part of Australian society before the arrival of Europeans. (p. 15)

To illustrate the difference between Western mathematics and the mathematics in some Aboriginal communities, *Numeracy = Everyone's Business* (DEETYA, 1997) provides the following illustration of numeracy expectations for an 8-9 year old child from a traditional Aboriginal community:

The fundamental expectation, and the response to the 'dual worlds' these children inhabit, is that they are moving towards being comfortable using both the western mathematics and the Aboriginal mathematics of their community:

basic understanding of kinship system; understanding of, and understanding of how to use, money (eg to buy single items); understands local seasonal time ie hunting; has capability with mental computation in the context of card games, sporting games etc.; has knowledge of such things as processional order, dance protocol, order and pattern of events in the conduct of relevant ceremonies; has facility with traditional counting 1, 2, many, big many as well as western counting and processes; recognises and can produce symbols in artwork; uses the language of comparison, particularly in relation to measurements; has and uses sense of direction; has knowledge of homeland; uses language of relative position in a ceremonial context. (pp. 78-79)

Pam Harris (1989; 1990) worked with remote communities in the Northern Territory examining the context of teaching and learning mathematics in Aboriginal schools. She argued that the distance between Aboriginal languages and English is much greater than

that between migrant languages and English and provided many examples of conceptual differences between the two. She argues that it is these differences that pose potential barriers to meaningful communication between teacher and students. For example:

- *Space*. Harris relates stories that show the importance of East, West, North, South, up and down to the Warlpiri children she taught, even from a very young age. Left and right were not considered as essential directions in your body and they found these terms more difficult. Harris's research suggested that some Aboriginal parents viewed their children's spatial ability as a measure of intelligence in the same way that Anglo-Australian parents valued their children's ability to count as an indication of intelligence.
- *Time*. The Aboriginal children in Harris's research were likely to have different concepts of time, a different time orientation and different values of time from non-Aboriginal teachers working from a Western mathematics syllabus. In Aboriginal cultures time is cyclic, the past repeats itself (for example, through skin names) and the passage of time is related to events; whereas Western time is linear, dates are fixed to past knowledge and time is divided into measureable quantities. She argues that the rush to get Aboriginal children to perform well on pencil-and-paper tests of *telling the time* ignores the need to develop their *understanding* of the time concepts, orientation and values of non-Aboriginal Australia.

A model of curriculum planning at Yirrkala Community School incorporates both Western and Yolgnu mathematics. Western mathematics includes counting, working with numbers and play money, and describing space using coordinates and compass bearings. Yolgnu mathematics includes drawing large maps that illustrate kinship webs and homeland connections, recording chains of obligation through details of ancestral journeys, division based on a Yolgnu point of view (for example, sharing food along status lines) and describing space through analogs (Jones et al., 1995).

Graham (1988) argued that acknowledgment must be made of the bi-cultural situation of many Aboriginal students. Where necessary students need to be given time to develop numerical concepts, and where visual-spatial skills are a strength of students, this should be recognised and developed while 'where there is a conflict between ways of perceiving, talking and thinking about reality they must be presented as alternatives' (p.131).

Graham (1988) presented a number of pointers for educators, including the following:

- that mathematics is about communicating, sharing and making meaning rather than a top-down passing on of information;
- that the learner is the meaning maker and makes meaning from past experience and from the environments around them;
- that teachers need to know their students and to understand the significance of social and cultural differences which may exist;

- that it is useful for teachers to have some understanding of the student's home language but this is not always enough as philosophical differences may block learning;
- talk is important; and
- more research is needed regarding the creation of bi-cultural teaching programs.

Aboriginal and Torres Strait Islander children come to school from diverse backgrounds in terms of cultural and linguistic heritages and with a range of experiences and abilities. Watson (1988) has argued that many previous attempts to develop mathematics education programs for Aboriginal children failed because they failed to recognise the diverse circumstance of Aboriginal communities and the wide range of individual needs of Aboriginal children. She contends that Aboriginal children might actively resist engaging in the learning involved in mathematics, rejecting Western cultural concepts that are value-laden.

Howard (1997) further explores the complex issues which result from imposing a Western education and mathematics on Aboriginal children:

Aboriginal children want to learn mathematics, they want to do well and they want to maintain their identity. There are critical implications for the overall mathematics program of any school. Teachers need strategies that address the Aboriginal child's learning of mathematics. The evaluation of the quality, accuracy and appropriateness of the mathematics curriculum for Indigenous students continues to require attention. However, for many Aboriginal children in Years 5 and 6 the mathematics classroom becomes an alien place characterised by tensions and conflicts about relationships and the value of what they are being taught. (Howard, 1997, p. 17)

Jones et al. (1995) argue that the enculturation of Aboriginal children in Western mathematics must not be at the expense of traditional values and ways of knowing. Acknowledging the presence cultural and linguistic factors that affect the learning of Western mathematics, and of trying to minimise their impact, is not enough. This is a minimalist type of accommodation which has not been proved to be effective.

Engaging in the language of mathematics

As well as an awareness and understanding of a child's cultural heritage there is a need to be aware of and value a child's linguistic heritage. Current teaching practices focus on the need to work through processes with the child and to talk about mathematics, to discuss and make explicit mathematical ideas and concepts. The focus on language is even more important when the home language is not the school language. Home language for Aboriginal and Torres Strait Islander students may include Aboriginal languages, Aboriginal English and Creoles.

Graham (1988) illustrated the importance of language in mathematics and gives a number of examples of dialogue between teachers and students to highlight both effective and

ineffective exchanges. She then challenged teachers to think about what the students are actually learning: whether they are learning to use mathematical language and, if not, to think about how it might be possible for the way in which particular concepts are taught to be changed to accommodate the students' different ways of learning. She concluded with a suggestion that teachers should tape their classes and examine the language used in the classroom.

The 'good teaching practice' in mathematics lessons observed by Eckermann (1994) in a number of culturally diverse classrooms in urban and rural NSW (many of the latter containing significant numbers of Aboriginal children) were characterised by a 'process' approach, lots of 'talking and doing'.

Eckerman emphasised that children whose home language is not English have the double task of learning English and learning through English, and that for these children every lesson is an English lesson.

The Aboriginal Education Workers interviewed by Howard (1997) believed that there were two systems of learning occurring in the mathematics classroom. Aboriginal children had to learn to talk in a way that was acceptable at school, which was often different from the way they talked at home. They also argue that the focus of mathematics classes was often inappropriately on the use of the English language, not on the acquisition of mathematical concepts:

Just in asking teachers questions Aboriginal children were often corrected on the English they used rather than supported in the mathematics understanding that they were seeking. Much has been written about the necessity for Aboriginal children to understand the specific meaning of the mathematical language being used in the classroom. The Aboriginal educators identified the situation of where Aboriginal children do not understand the mathematics, they are unsure of the mathematics language being used but get corrected for their English usage when asking classroom questions. (p. 16)

The difficulties discussed centre on language and attitude. Eckermann argued that teaching strategies used with NESB students (and students with poor literacy skills) need to address language acquisition in general as well as language related to mathematics. These strategies may include:

- appropriate pacing of lesson delivery;
- the use of concrete materials and visual teaching aids;
- peer support;
- discussion of concepts; and
- carefully designed assignments and assessment tasks.

Attitude towards mathematics is also vital. Children often perceive mathematics to be a difficult subject, perhaps because of the way that standardised tests are designed or because language becomes more formal in mathematics classes. However to avoid using certain

mathematical words and terminology because they are hard is to disempower students by limiting their exposure to such concepts (Bucknall, 1995).

While a 'process approach' may help to address this, Eckerman noted that not everyone will see this as 'real maths' and suggests that teachers need to work closely with parents to ensure support for the teaching and learning strategies used in the classroom.

Although many of the classrooms successfully used computers for literacy activities, Eckermann cautioned against the use of computers for mathematics:

[the] use of computers in mathematics is growing, although it is fraught with some difficulties. When children use computers to create language, they are in control of the language. When, however, they use computers for mathematics, the language necessary to manipulate numbers is assumed within the program. This assumed knowledge may prove problematic. (p. 166)

Dawe and Mulligan (1997) examined the influence of language factors on the mathematical performance of children participating on the New South Wales Basic Skills Test. They provide many illustrations of linguistically difficult questions on which children from Indigenous and non-English speaking backgrounds perform poorly. The implication of their findings for teachers is the importance of recognising and making explicit the difference between 'mathematical' English and 'natural' English. Enabling children to become 'mathematically literate' is dependent on assisting them to make the link between their real worlds and the symbolic world represented in 'mathematical' English:

Tackling teaching by conceptualising the children as thinkers about mathematical problems rather than empty vessels intended to be filled with knowledge implies that children should be given every opportunity to talk about their mathematical experiences... (p. 32)

Mathematics classes are essentially a linguistic exercise. Engaging in the language of mathematics enables students to explore and express their understanding of mathematical processes. Teachers need to be aware of issues regarding the way in which language is used not just in mathematics classes but in Western classrooms generally, the importance of interactive versus teacher-directed language and strategies for teaching and assessing students whose home language is not standard Australian English.

Contextualising mathematics

Contextualising mathematics refers to the importance of recognising and building on the mathematical knowledge that Aboriginal students utilise outside the classroom. The *National Statement on Mathematics for Australian Schools* (1991) stated that 'students are more likely to respond to the experiences they have in school if they feel that those experiences relate to the lives of their communities' (p. 24).

Contextualising mathematics also means finding ways of providing experiences and strategies in which students can gain meaning and develop the appropriate language that enables them to extend their skills in Western mathematics.

Boulton-Lewis et al. (1987) tested Aboriginal and non-Aboriginal children on tests of cognitive ability that contained tasks familiar to Aboriginal communities, and concluded that there were no significant differences in skills. This led them to conclude that the lower levels of mathematics achievement shown by many Aboriginal children may be explained by motivation, educational and environmental factors. Mathematics instruction should therefore be related to important issues and everyday activities to be meaningful.

Graham (1987) suggested a number of mathematical activities relating to classification, space, pattern, and measurement that build on the types of experiences that children have outside the classroom. Where concepts are less familiar, the author argued that teachers must ensure that children are exposed to the concept before it is formally taught and students must have the opportunity to verbalise this:

Before any new or largely new mathematical idea is introduced, children must have the opportunity to experience or live the idea. Therefore, before we teach children to count they must be immersed in a counting environment. (p. 101)

Dawson (1991), who was Assistant Principal at Sheperdson College, outlined her rules for best-practice mathematics teaching which centre around finding the mathematics in the everyday real life activities in which she and her students engaged. Primarily these were activities that were interesting and fun, such as organising class excursions, ordering materials for the classroom and discussing bell-times. She also stressed the importance of teaching strategies which recognise and incorporate Aboriginal learning styles: watching and copying, little teacher-talk, students trying for themselves many, many times, real life performance, learning when you need/want to and friendly relationships so that people will learn with each other.

Bucknall (1995) noted that students can spend a lot of time ritualistically 'doing maths' without really understanding what it is that they are doing or being able to relate it to outside the classroom. She argued that teachers need to find out what kinds of mathematics exist in the students' communities as this forms the basis of the students' own mathematical knowledge base. Ways of collecting this information may include sketches, tapes, photos, charts. Sums can eventually be devised to represent data in an abstract form.

Shared experiences are also encouraged by Bucknall (1995) as a useful teaching strategy. A few examples are given as ways of developing group projects similar to Gray's Concentrated Language Encounters:

an interacting approach to language learning through modelling and sharing ideas with students as they negotiate meaning ... If mathematics is part of everyday speech, consideration should be given to extending the boundaries that isolate mathematics to a certain time on the timetable each day. (p. 29)

A number of papers emphasise the importance of consultation with Aboriginal parents, communities and education workers as a way of investigating real-life and realistic contexts for classroom mathematics (Roberts, 1997; Walsh, 1991).

Student teachers from the Remote Area Teacher Education Program (RATEP) were asked to take a situation in their own communities and develop a teaching unit which demonstrated to children the importance and usefulness to adults in their community of technological mathematics. The students also produced big books related to their communities which incorporated a number of mathematical situations which require problem-solving (Putt et al., 1995).

The South Australia Education Department's *Aboriginal Education R-12 Resource Papers* (1991) include a collection of papers that focus on *Teaching and Learning Mathematics*. The aim of the booklet is to document ideas, strategies and examples of lessons which educators of Aboriginal children use every day. successfully

The Aboriginal students who took part in these case studies were a diverse group and differed in the way that they responded to various teaching strategies (structured versus unstructured; group and pair-work versus individual). Although there were a number of common themes which highlighted 'good teaching' practices, one participant, an Aboriginal Education Worker, pointed out:

Teachers shouldn't make generalisations about the way Aboriginal children learn maths. They need to look at, and cater to, each individual child's needs and style of learning. (p. 68)

Common themes which emerged from the case studies related to the language and vocabulary of mathematics; the need for individual and collaborative learning; the impact of self-esteem on learning outcomes and the importance of the student-teacher relationship.

... mathematical learning for Aboriginal children is enhanced by a happy, secure classroom environment where the children are in control of their learning, have access to a wide range of concrete materials, when sharing is an acceptable and desirable aspect of learning, where there is freedom to work in situations in which the children feel comfortable, and where they can choose a method of recording which fulfils their needs. (p.65)

More specifically, participants emphasised the importance of mathematics teaching strategies which encompassed some of the following:

- process, activity based, mathematics as a way of catering to the needs and individual learning styles of all children;
- modelling by peers and teacher;
- progressing from hands on to a more abstract experience¹;
- a combination of different teaching approaches;
- listening to students' language;
- acknowledging and valuing children's base languages;
- promoting language in the classroom (stories, games and songs with mathematical terms);
- ensuring that mathematical terminology is used and discussed across all curriculum areas;
- providing supportive environments to encourage risk taking and for reporting back sessions (same gender or culturally based discussion groups; having an Aboriginal Education Worker or resource teacher present);
- practical activities which involve doing, experimenting and modelling from peers;
- determining the way that students prefer to learn (informal sharing with individual students versus formal sharing with a whole group, allowing students to work individually but in close proximity to others, in groups, structured/unstructured, with Aboriginal Education worker);
- good teacher-student relationships as the key to successful learning;
- Aboriginal Studies units and mathematics units which include examples of Aboriginal culture;
- time for repetition, and time to listen, watch and copy;
- use of mathematics reading libraries and free mathematics activities; and
- involving siblings, parents and extended family to participate in mathematics activities during family mathematics sessions.

Patrick-Rolf (1990) stressed the importance of working with Aboriginal Education Workers to create a good mathematics environment. This should be done at several levels:

- at the planning stage to establish student's prior learning;
- using relevant Pitjantjatjara language to assist development of concepts and in preparing aids/charts;
- to discuss aspects of lesson delivery including work completed or not completed, use of equipment, working mode (individual, pairs, groups), types of recording used, acceptance of challenges, willingness to report back to group; and
- to meet with AEW/team teacher and reflect on aspects of lessons that worked well and those that have not worked well.

¹ Graham (1988) warns that the use of concrete materials should not lead to a watered-down version of mathematics.

Keper (1993) described a series of professional development activities he conducted with Aboriginal and non-Aboriginal teachers from the Northern region of the Northern Territory. They explored ways in which mathematics activities could incorporate local cultural concepts and these included mapping kin relationships, language groups and totems, mapping the country and introducing fractions.

The group was able to list many overlapping concepts - concepts that were present in both Aboriginal and western mathematics. It is this rich untapped area of mathematics that promises to offer a pathway to successful teaching for these Aboriginal students. Certainly it is an area that the Aboriginal teachers are keen to explore. (p. 282)

A group of student teachers from the *Koorie Teacher Education Program* (1990) speak of the consequences for students if they cannot understand the concepts and the way that classrooms operate:

If they are made aware that they already know and use mathematics a lot, and just need to build on their understanding, then they will feel in control. But if mathematics continues to be taken out of familiar contexts and presented as though it will never be applicable to every-day life, then many students will withdraw. It is too easy for teachers to see this reaction as the result of laziness, poor learning ability, or deprived backgrounds. Racist stereotyping allows teachers to blame the student, rather than to work at

- *changing the social relationships in the classroom;*
- *adapting the curriculum;*
- *examining the suitability of the methods of instructions; and*
- *altering the way performance is assessed. (p. 309)*

Teaching Aboriginal children

The literature contains examples of research studies and articles which attempt to identify the types of teaching strategies which are more effective in engaging Aboriginal children. The research relating to general classroom teaching strategies, particularly those for literacy development, will be considered followed by strategies more specifically for the mathematics classroom.

Adams (1998) argued the need to develop education theory and a pedagogy that takes into account the Indigenous world view as well as curriculum content resources relevant for and inclusive of Indigenous students, in addition to the elimination of racism. In the 1980s, much was written about Aboriginal learning styles. The main informal learning strategies identified by Stephen Harris (1984) were:

- learning by observation (where the child is initially a passive observer);
- learning by trial and error;
- learning in real-life situations;
- context-specific learning; and

- person orientated instruction, where knowledge is valued because of who gives it.

Culturally different behaviours may not be acceptable to a non-Indigenous teacher, and the mismatch between Western teaching and Indigenous learning styles might inhibit effective learning.

Nicholls, Crowley and Watt (1996) argue that these learning styles reflect those of many working-class children and are not exclusive to Indigenous people. What is important is that this type of learning preference contrasts with the teaching styles of many Western classrooms, which emphasise verbal instruction, demonstration and artificial activities that take place outside a real-life context.

A study by Malin (1994) highlighted a number of factors beyond cultural differences which resulted in a differential allocation of resources (including teacher time) and affected educational outcomes for one group of Indigenous students. She argued that the social organisation of the task plus the social relationship between teacher and student is crucial to whether or not learning takes place. A lack of awareness of differences in cultural background, which forms a basis for community values and social practices, may affect the interaction between teacher and student.

Aboriginal children may experience greater social equality with adults and more independence and freedom; they often have a range of practical abilities used at home, and can be trusted to perform these tasks; use Aboriginal English, silence, indirect courtesy and avoid eye contact; they may show a strong sense of affiliation to peer groups; and may try to avoid making mistakes when approaching new tasks (Howard, 1994). Useful teaching strategies may therefore include:

- contract work, independent work stations, forums for evaluation and more freedom through choice;
- trust activities and allowing children to experience trust;
- exploratory talk and shared experiences rather than direct questioning;
- group work, peer and cross-age tutoring and having class layout so children can monitor peers; and
- patience, reaffirming the child's identity and creating a safe environment.

A number of edited books bring together key papers and research articles that highlight effective teaching strategies which acknowledge the contexts of Aboriginal children. Recurring themes in teaching programs which have been found to be successful with Aboriginal and Torres Strait Islander students are those that encourage teachers to:

- recognise the individuality of students;
- acknowledge and accommodate socio-cultural differences;
- acknowledge and accommodate differences in home background;
- provide a rich language environment;
- contextualise learning activities;
- respond to students' preferred ways of learning;
- value Aboriginal ways of teaching and learning;

- identify individual language and literacy needs;
- acknowledge and value Aboriginal English as a home language;
- develop positive relationships with students;
- incorporate a variety of teaching methods in their programs, including explicit teaching;
- incorporate a variety of assessment methods into their programs;
- work with Aboriginal educators; and
- adopt strategies to deal with hearing loss, homework completion and absenteeism. (eg Harris and Malin, 1994; NLLIA, 1994, 1996; Batten et al., 1998)

Effective teaching strategies also include the identification of health problems such as hearing loss and adapting classroom organisation and teaching techniques to maximise auditory input for affected students.

A teaching ESL teaching program successfully devised by Trouw (1994) involved the withdrawal of a small group of Indigenous and non-Indigenous students from class each week. She identified cultural factors which may act as constraints for urban Aboriginal children learning in a Western culture. These factors included a preference for informal learning, a reluctance and reticence to take risks, independence, cultural differences in use of questioning, communication, ritualistic approach to school learning, incompatibility with Western decontextualised ways of learning, lack of pre-literacy skills, and lack of parents' understanding of school. Trouw then incorporated strategies which encouraged children to explicitly learn about the subcultures of Western schooling including two-way verbal interaction, mainstream classroom behaviour, learning in decontextualised settings and successfully taking responsibility for their own learning.

Aboriginal children in the mathematics classroom

The development and implementation of numeracy resources should also be informed by literature regarding effective numeracy teaching for all students.

The Numeracy Strategy Development Conference Report *Numeracy = Everyone's Business* (DEETYA, 1997) made a series of recommendations regarding effective numeracy education. The report provides an extensive list of features for schools and teachers that are seen as important in terms of curricula, pedagogy and whole school organisation to enhance numeracy outcomes for all students. In particular, the report considers aspects of the teaching and learning environment which are critical in enhancing students' numeracy achievement. These include taking the notion of 'context' seriously and making explicit the relationship between Western mathematics and the traditional Aboriginal world view.

The degree to which numeracy resources can effectively support teachers is dependent on the pedagogical beliefs and understanding underpinned their teaching of numeracy, their expectations of their students and themselves.

In a study by Askew et al. (1997) a sample of effective teachers of numeracy in the UK was identified on the basis that their students have achieved a high average gain in achievement

on numeracy tests in comparison with other classes from the same year group. Key factors in their successful teaching practice included the teachers’:

- emphasis on discussion of concepts (in whole classes, small groups and individually) to establish student understanding;
- use of practical equipment;
- delayed introduction of abstract concepts until students were ready for them;
- good understanding of the primary mathematics curriculum;
- had usually engaged in professional development activities (effectiveness was not associated with qualifications in mathematics);
- high expectations of their students and, therefore, of themselves.

Significantly, it was the teachers’ beliefs and understandings of pedagogical purposes behind particular classroom practices that seemed to be more important than the forms of practice themselves.

The importance of making meaning of mathematics in the real world was stressed by Christie (1987). His Aboriginal students would happily sing their times tables and while his more competent students could compute 7 multiplied by 4 they were unable to solve 'real-life' problems. He contended that:

Mathematics is different from reading. Reading, if properly taught, is always meaningful ... But mathematics is different. It is possible to compute efficiently without any idea of the meaning of or use for mathematics in the real world.
(p. 62)

He believed that the key to teaching mathematics was to ensure that students understood the questions and the only way to do this was through discussion and to bring real-life situations to the classroom.

Howard (1995) differentiated between the intended curriculum content, the reality of what happens in the classroom and what is attained or learnt by the student. His interviews with parents, educators and students lead him to suggest:

- the use of activities using mathematics encountered outside the classroom;
- displaying work;
- discussing beliefs about mathematics;
- establishing problem-solving contexts;
- small group work (editing, conferencing, discussions);
- students generating questions;
- listing mathematical terms;
- students identifying instances when mathematics is of use to them;
- establishing a supportive environment ('student error is not the focus of assessment');
- recognising cultural differences in communication and learning style where these exist; and

- supporting students self-esteem and belief in self.

Appropriate assessment strategies are also important:

It was through written mathematics tests that many Aboriginal children were failing. This was occurring because of the mismatch between how mathematics was taught and how it was formally assessed. A rethink in how mathematics was assessed or a development of appropriate strategies within the children to feel confident in attempting mathematics tests appears to be required. (Howard, 1997, p. 17)

Treagust et al. (1991) described a bridging chemistry and mathematics program for secondary students who had completed Year 10 and were commencing Year 11. The chief characteristics of the program design were matched to Aboriginal teaching and learning styles. Flexibility was a key factor, as was the program's emphasis on regular diagnostic assessment (to remedy problematic background knowledge), individualised instruction (recognising individual student needs and allowing for a flexible time structure), short-term learning goals (to encourage motivation through the experience of success) and independence of learners.

Knight (1994) described a program introduced at Driver High School which included a class of no more than 20 Indigenous students who were taught the same mathematics units as the mainstream classes, by mathematics teachers who rotated on a semester basis. These students were assessed by an English as a second language teacher who remained in the class as a constant throughout the year. Students cycled through the class according to their needs. Students self-selected to attend the class or were nominated by their teacher. The benefits of such a model include the following:

- with the use of an ESL model, the student's own language is valued as they are supported to use mathematical terminology;
- there is a focus on enhancing student's self-esteem;
- the production of a learning environment that values the cultural background of students;
- the provision of real-life learning activities and realistic experiences;
- the use of teaching and learning strategies that have been found to be effective with Aboriginal learners;
- the development of a more informal style of classroom interaction including the whole group (as opposed to traditional teacher centred);
- the use of relevant, interesting and appropriate resources and activities;
- a focus on the development of positive relationships among students and staff;
- regular encouragement and reward and regular feedback on assessment progress;
- professional development for teachers; and
- the involvement and awareness of the whole school community of the nature and outcomes of the program.

In this program, teachers model the process of mathematical enquiry and act as mentors for their students. The learning sequence involves a focus question which invites students to engage in a learning sequence. This focus question may involve gathering data, testing conjectures, making connections, generalising or developing procedures.

Once these students acquire confidence and have improved their mathematics achievement, they return to mainstream classes. Support is ongoing as each teacher of a mainstream class spends time with the group over the year. Studying mathematics in this enclave situation provides the students with a learning environment that values their cultural background and uses strategies appropriate for them.

Numeracy resources and programs to support teachers of Indigenous students

New South Wales

The NSW Department of School Education *Count Me In Too* program caters for students from low socioeconomic and high non-English speaking background areas, and various groups such as Aboriginal and Torres Strait Islander students. It involves school focused training and development in understanding the relative sophistication of students' solution strategies. The differential impact of the project on various groups including Aboriginal and Torres Strait Islander students has been evaluated, although this evaluation did not appear to be available publicly. Further work is being undertaken to broaden the learning framework. The techniques used in *Count Me In Too* are based on the *Maths Recovery Program* developed at Southern Cross University by Bob Wright.

Northern Territory

The Northern Territory Department of Education's Aboriginal Schools Curriculum Materials Project led to the production of a number of mathematics resource books for teachers of Aboriginal children. The total package, called *Maths in Context*, contains Early Childhood and Primary units of work, checklists and worksheets.

The philosophy behind the production of the package is an acknowledgement that Aboriginal students bring to school with them a different knowledge system for organising and exploring their world and a corresponding linguistic system. These units are based on real or realistic contexts so that the mathematics taught is the mathematics applicable to aspects of the daily lives of students when they come into contact with the majority Australian culture. The booklet also contains information regarding the importance of language in teaching mathematics. The Primary units of work are each titled: Travelling around; Growing your own garden; Flight; Water Habitats; and Shape a Litre.

Also published by the Northern Territory Department of Education is *Maths Works for Me*, which contains 35 mathematics activities written by educators from a range of schools and institutions. Some of the activities have been adapted from other sources by teachers of Aboriginal students who value inclusion of the following features in their teaching:

- visual imagery;
- estimation;
- problem-solving;
- cooperative group work;
- effective use of technology; and
- relevance and purpose.

Each lesson follows the format of presenting the task, features, content, learning outcomes preparation and resources; learning activities, student assessment, extensions and reflection (evaluative strategies).

Queensland

Education Queensland's Aboriginal and Torres Strait Islander Branch in far north Queensland has published the *Torres Strait Mathematics Program (TSMP)*. The program is primarily for use by teachers in the Torres Strait and many topics are Torres Strait specific but can be adapted to suit other surroundings. Other general resource materials available through the Branch are School Weather Station, School Shop, School Sports, School Tuckshop and Interventions: Rules and Games.

At the time of writing information on resources could be obtained at <http://www.qed.qld.gov.au/tal/atsi/vps>

South Australia

The Contextualising Mathematics package is based on the English Language Acquisition (ELA) framework implemented in South Australian schools. It is argued that the framework and methodology used to teach mathematics to Aboriginal students needs to reflect the language needs of the students.

As teachers, we must realise that for learning to be relevant and meaningful for students, the starting point for the learning must come from the knowledge, skill and value base of the student as the learner. Classroom mathematics context, therefore, needs to encourage the student's participation in relevant tasks, where the learning can be seen as being useful to the students now, as well as later in their life, and not simply learning being done to please the teacher. (Gillespie, 1995, p. 143)

In describing the philosophy behind the development of the package, Gillespie notes that traditionally students are firstly introduced to mathematical facts and operations which are then applied to more meaningful contexts. Many students have difficulty linking this new, abstract information to their existing knowledge: many teachers have found that some students respond better if they move from the known to the unknown.

It is important the teachers do not assume that all children come to school with similar expectations about learning and that they value the language, knowledge and skills that Aboriginal children bring with them to school.

The Supporting ELA and Contextualising Mathematics support packages aim to:

- value the code of Aboriginal English that students speak;
- assist students to gain competence and confidence in using Australian English and mathematical skills;
- encourage the development of critical thinking and learning skills;
- extend students' ability to work independently and collaboratively in small groups;
- assist students to utilise resources and obtain information from a wide range of resources;
- assist students to develop oral skills which enable them to discuss and reflect on the skill and processes that they are developing, and which allow students to successfully and actively engage in their own learning; and
- support students to take control of the learning and assessment of their learning.

Students and teachers negotiate a context for learning, students are active participants in the process and the end point to be achieved is related to the starting point and celebrated once reached. This works for Aboriginal students because background knowledge, skills and language are valued; the process begins from where the students are at; it encourages explicit teaching; students see purpose in their learning and are empowered through making decisions about the learning process; content is drawn from context; and students are empowered.

Tasmania

Tasmania's *Flying Start Program* is a literacy, numeracy and social skills intervention in schools designed to provide:

- extra resources in the Years P-2;
- increased opportunities for teachers to work with parents;
- a small teacher-pupil ratio for critical learning and teaching times;
- assistance for classroom teachers in assessing and planning for intervention for low-performing students; and
- additional professional development for classroom teachers and resource teachers.

A Flying Start resource teacher assists the classroom teacher in the classroom, providing a smaller pupil-teacher ratio, assists in assessment and planning for intervention and works with or assists the teacher in work with parents.

Victoria

The *Early Years Literacy Program* (formerly Keys to Life) outlines an additional assistance pathway which provides a process to support all students who are not achieving at a satisfactory level. Based on research by Peter Hill, the program involves early identification; home-school support group; and a teaching program to enhance literacy learning and ongoing assessment and monitoring. An *Early Years Numeracy Program* is under development. At the time of writing information about the program was available at <http://www.sofweb.vic.edu.au/eys/ctl.htm>.

The Department of Education in Victoria has also published a comprehensive set of assessment and reporting support materials including *Assessment and Reporting Support Materials - Koorie Students*. At the time of writing this could be downloaded from <http://www.dse.vic.gov.au/assess.htm>

Western Australia

The *First Steps* program, developed by the Education Department of Western Australia and involving resource material and professional development courses for teachers, is also used on a system-wide basis in Queensland and has been implemented in many individual schools throughout Australia. The foundation underpinning the program is the 'Developmental Continuum', a conceptual map of children's literacy development. First Steps professional development courses are run nationally and internationally and the Continua are part of Queensland's Year 2 Diagnostic Net process.

The Education Department of Western Australia is currently developing a First Steps continuum for mathematics.

The *English Language and Numeracy Program for Aboriginal Students* (ELAN) was introduced into Western Australian schools in 1991. It incorporates curriculum, school and professional development and support for teachers in schools with high Aboriginal

populations. Overall, the initiative is reported to have been successful in enhancing educational outcomes for Aboriginal students at an individual, class and school level (Jarred, 1994). Of particular importance are:

- the recognition of the social and cultural context of the student;
- the use of developmental *First Steps* continua to map student progress in a way that is one ongoing and consistent. This includes the use of computer packages to record and analyse data and inform whole school decisions about resource allocation; and
- the insistence on helping students within the classroom context rather than through withdrawal.

Summary

There were a number of common themes that emerged from the literature on numeracy and Aboriginal students. These themes are consistent with a wider body of research on effective teaching and learning strategies for Aboriginal children in general and effective strategies to enhance numeracy learning for all children, particularly those who do not come from a home background which already reflects what happens in school.

According to this research, numeracy materials which are developed for use in classes with Aboriginal students should: incorporate culturally appropriate and contextually relevant content; suggest appropriate and effective teaching strategies; and encourage teachers to reflect on the individual learning needs and preferred ways of learning for their particular Aboriginal students.

The materials should support teachers to convey mathematical concepts in a culturally appropriate, contextually relevant and interesting way to students. The activities suggested in the materials should encourage an environment that allows Aboriginal children to be confident learners and risk-takers. The explicit teaching of Western mathematics should be done in a way that values the cultural and linguistic difference of Aboriginal learners and may include teaching Aboriginal mathematical concepts.

Language plays a central role in mathematics classrooms. An understanding of 'mathematical English' is crucial if students are to successfully learning about, understand and use Western mathematical concepts. Many Aboriginal children do not speak standard Australian English at home. The complexity of linguistic issues in mathematics learning must be recognised and dealt with in a way that supports the learner.

If the materials are to be contextually relevant for particular Aboriginal students, this requires that teachers actively investigate the backgrounds of their students, as opposed to selecting activities based on assumptions and inaccurate stereotypes or generalisations.

The linking of home and school mathematics offers an opportunity to encourage and support parents and communities to become to involved in their children's learning. However, this must be done with sensitivity and appropriate support so that the experience is

a positive one for all. The support of Aboriginal Education Workers has been favourably mentioned in several instances in this paper.

The teaching strategies suggested in materials should equip teachers with a range of approaches reflecting the diverse learning needs and preferred ways of learning of Aboriginal students. However the materials should also reinforce that it is the teacher's underlying beliefs and understanding which are essential in effective numeracy teaching.

Finally, teachers should be encouraged to actively reflect on what works for particular students and to make modifications to the materials and their own teaching practice as necessary. It is crucial that teachers are encouraged to have high expectations for all of their students and therefore of themselves.

The limited amount of current research in this area suggests a need to monitor and evaluate teachers' use of the resources while providing them with a support mechanism to enhance their professional development. The lack of information the emphasis given to cultural issues in numeracy development in teacher training courses may also warrant further investigation.

The next section of this report provides an annotated bibliography of research and resources used to inform this discussion.

Annotated Bibliography

Adams, I. (1998). The educational plight of Indigenous Australian students in the early years of schooling. *Unicorn*, 24(1), 5-15.

An overview of factors influencing the effectiveness of educational provision for Indigenous Australian students and considerations for improving educational provision and enhancing educational outcomes.

Askew, M., Brown, M., Rhodes, V., Johnson D. and William, D. (1997). *Effective Teachers of Numeracy: Final Report*. London: School of Education, King's College London.

This report presents the findings of a study which explored the knowledge, beliefs and practices of a sample of effective teachers of numeracy. Highly effective teachers were distinguished by their beliefs and understanding which underpinned their teaching of numeracy, their expectations of their students and themselves.

Atweh, B., Cooper, T. and Kanes, C. (1992). The social and cultural context of mathematics education. In B. Atweh and J. Watson (Eds.), *Research in mathematics education in Australasia 1988-1991*. Kelvin Grove Qld: Mathematics Education Research Group of Australasia (MERGA).

Overview of some of the research pertaining to Indigenous students and mathematics during this period.

Australian Education Council. (1991). *National Statement on Mathematics*. Canberra: AGPS.

Bishop, A. J. (1994). Cultural conflicts in the mathematics education of indigenous peoples. In *Proceedings of South East Asia Conference on Mathematics Education (SEACME - 6) and the Seventh National Conference on Mathematics: Surabaya, 7-11 June 1993 Indonesia*, pages 402-408.

In this article it is argued that the social dimension of mathematics education operates at different levels, all of which are relevant in considering the situation of Indigenous peoples and mathematics education. Underlying all these influences is the status of mathematics as a form of cultural knowledge. The individual person is influenced in their mathematical education, by other people acting at these different levels, and at each level there are particular sources of cultural conflict.

Boulton-Lewis G. M., Neill, H. and Halford, G. S. (1987). Information processing and mathematical knowledge in Aboriginal Australian children in southeast Queensland. *Australian Aboriginal Studies*, 2, 63-65.

It was concluded that Indigenous children from rural communities possessed information processing skills similar to non-Aboriginal children on tests of cognitive ability which were designed to minimise the influence of background knowledge. Test items were chosen which would be familiar to Aboriginal communities.

Boulton-Lewis, G. (1990). Young children's thinking strategies and levels of capacity to process mathematical information. In L. P. Steffe and T. Wood (Eds.), *Transforming*

Children's Mathematical Education: International Perspectives, pp 156-160. Hillsdale, N.J., Erlbaum.

In this study it was found that Aboriginal children had the same capacity to process information as non-Aboriginal children of same age. A mathematics and non-mathematics test were used. It was concluded that low mathematics achievement is not related to lower skill levels or a lower capacity to conceptualise mathematically but may be attributed to educational and social factors.

Bucknall, G. (1995). Building bridges between Aboriginal and Western mathematics. *Aboriginal Child at School*, 23(1), 22-31.

The author stresses the importance of recognising and building on the mathematical knowledge that Aboriginal students utilise outside the classroom. It also examines ways of providing experiences and strategies in which students can gain meaning and develop the appropriate language that enables them to extend their skills in Western mathematics.

Christie, M. (1987). Everyday life in a primary classroom. In M. Christie, S. Harris and D. McClay (Eds.), *Teaching Aboriginal children: Milingimbi and beyond*. Mount Lawley WA: Western Australian College of Advanced Education, Institute of Applied Aboriginal Studies.

This chapter describes the weekly teaching routine of the author in a number of learning areas including mathematics. The Yolgnu children in these classes loved to sing their times-tables but had difficulty making meaning of the mathematics in the real world. The author stresses the importance of discussion in the mathematics classroom to ensure that students understand the questions asked of them and of bringing real-life situations to the classroom.

Commonwealth of Australia. (1989). *National Aboriginal and Torres Strait Islander Education Policy. Joint Policy Statement*. Canberra: Department of Employment, Education and Training.

The policy statement, commonly referred to as the AEP, comprises three sections: the purpose of the policy (responding to Aboriginal needs and aspirations); common goals (educational principles, long-term goals, and intermediate priorities); and arrangements for policy implementation. It was endorsed by all states and territories in 1989 and has been reaffirmed in subsequent triennia up until 1999.

Currie, J., Kissane, B. and Pears, H. (1992). An enriched mathematical program for young Aboriginal children. *Aboriginal Child at School*, 20(1), 15-37.

This paper provides early results of a project which explored the use of an intervention program which provided a rich mathematics environment to enhance mathematics learning for students in remote communities. The findings however were inconclusive and the paper outlines some of the difficulties including the selection of an appropriate group for comparison and appropriate assessment techniques.

Dawe, L. (1988). The impact of culture in the mathematics classrooms of multicultural Australia. *Cultural Dynamics*, 1(2), 195-209.

This article contrasts the world view, child rearing practices and beliefs about how mathematics should be taught/learned between children of Asian immigrants and Aboriginal families in highlighting the changing culture of the Australian mathematics classroom.

Dawe, L. and Mulligan, J. (1997). Classroom views of language in mathematics. In B. Doig and J. Lokan (Eds.), *Learning From Children: Mathematics From a Classroom Perspective*. Melbourne: ACER Press.

An examination of BSTP data providing insights into the impact of language factors on large-scale mathematics assessment results, particularly for children from Indigenous and non-English speaking backgrounds.

Dawson, G. P. (1991). Maths encounters. *Aboriginal Child at School*, 19(4), 37-53.

An article full of ideas for 'Concentrated Maths Encounters' in which teachers are encouraged to make explicit the mathematics present in everyday classroom activities such as bell times, tidying the work area, ordering things for the classroom and organising excursions.

Department of Employment, Education, Training and Youth Affairs. (1997). *Numeracy = Everyone's Business*. Canberra: Commonwealth of Australia.

Report of the Numeracy Education Strategy Development Conference. The outcome of the conference was a series of recommendations regarding what constitutes numeracy, coordinating the implementation of the national plan, identification and intervention for 'at risk' students, assessment in the first years of schooling, assessment and national reporting, research, professional development, teacher education and community education.

Eckermann, A-K. (1994). *One Classroom, Many Cultures*. NSW: Allen & Unwin.

In this project, documentation was collected and interviews and classroom observations carried out in 21 government and Catholic schools in rural and urban NSW; many of the former included significant numbers of Aboriginal children. The report provides accounts of policy and practice to assist teachers of classes which have a high percentage of students from culturally different backgrounds.

Education Queensland. (1989-1994). *Torres Strait Mathematics Program (TSMP)* Queensland: Aboriginal and Torres Strait Islander Education Sub Centre Far North, Video and Print Services, Education Queensland.

Developed for use by teachers in the Torres Strait; many topics are Torres Strait specific but can be adapted to suit other surroundings.

Gillespie, K. (1995). Mathematics acquisition for Aboriginal students - the importance of contextual teaching. In A. Richards (Ed.), *FLAIR, Forging Links and Integrating Resources: Proceedings of the 15th Biennial Conference of the Australian Association of Mathematics Teachers, Darwin, Northern Territory, July 1995*, pp 142-148. Adelaide: Australian Association of Mathematics Teachers.

This paper argues that the framework and methodology used to teach mathematics to Aboriginal students needs to reflect the language needs of the students. It discussed the theory behind the development of a package based on the ELA framework implemented in South Australian schools.

Graham, B. (1987). Finding meaning in maths: an introductory program for Aboriginal children. In M. Christie, S. Harris and D. McClay (Eds.), *Teaching Aboriginal children: Milingimbi and beyond*. Mount Lawley WA: Western Australian College of Advanced Education, Institute of Applied Aboriginal Studies.

The author suggests a number of activities appropriate to classrooms that build on the types of experiences that children have outside the classroom such as classification, space, pattern, and measurement. Where concepts are less familiar, the author argues that teachers must ensure that children exposed to the concept before it is formerly taught.

Graham, B. (1988). Language and mathematics in some Aboriginal classrooms. *Aboriginal Child at School*, 16(1), 27-32.

The author discusses the importance of language in mathematics, that is discussing and making explicit mathematical ideas. She gives a number of examples of dialogue between teachers and students to highlight both effective and ineffective exchanges.

Graham, B. (1988). Mathematical education and Aboriginal children. *Educational Studies in Mathematics*, 19(2), 119-135.

In this paper, the author reviews the literature available on Aboriginal students and mathematics and argues that acknowledgment must be made of the bi-cultural situation of Aboriginal students, that students need to be given time to develop numerical concepts, that where visual-spatial skills are a strength of students, this should be recognised and developed. She also warns that the use of concrete materials should not lead to a watered-down version of mathematics.

Harris, J. (1987). Australian Aboriginal and Islander mathematics. *Australian Aboriginal Studies*, 2, 29-37.

In this paper, the author argues that Aboriginal languages have many more words for numbers than have previously been accepted and that many Aboriginal communities count with some precision. This misconception has led to false views about the cognitive ability of Aboriginal students and lowered teacher expectations.

- Harris, P.** (1989). Contexts for change in cross cultural classrooms. In N. F. Ellerton and M. A. Clements (Eds.), *School Mathematics: The Challenge to Change*. Waurin Ponds, Victoria: Deakin University.

This chapter is concerned with mathematics education in cross cultural situations, especially remote communities in the Northern Territory, where students are members of a linguistic and cultural minority group, and where teachers are usually members of a dominant majority group. Historical, socio-political, linguistic, cultural and philosophical contexts are related to the classroom context of teaching and learning mathematics in Aboriginal schools. Potential barriers to meaningful communication of mathematics in the classroom are highlighted, as are strategies for change.

- Harris, P.** (1991). *Mathematics in a Cultural Context: Aboriginal Perspectives on Space, Time and Money*. Geelong, Vic: Deakin University.

The author has a long association with Aboriginal education and culture, having taught Aboriginal children in remote areas and researched Aboriginal mathematical thinking. This book draws together the findings of the Mathematics in Aboriginal Schools projects in the Northern Territory. The book aims to highlight conceptual differences between Aboriginal and Western cultures including time, space and money, pointing to ways of teaching which take cultural and linguistic differences into account.

- Harris, P.** (1992). Australian space: pushing back the frontiers. In B. Southwell, B. Perry and K. Owens (Eds.), *Space - the first and final frontier: Conference proceedings of the Fifteenth Annual Conference of the Mathematics Education Research Group of Australasia (MERGA) held at Hawkaid Conference Centre, University of Western Sydney, 4-8 July 1992*, pp 55-72. Kingswood NSW: Mathematics Education Research Group of Australasia.

This edited transcript of a keynote address to this conference contrasts Western and Aboriginal navigation and maps. It draws on work from the Mathematics in Aboriginal Schools Project.

- Harris, S.** (1984). *Culture and Learning: Tradition and Education in North-East Arnhem Land*. Canberra: Australian Institute of Australian Studies.

The author describes the factors which were found to influence the learning of the Yolngu (Aboriginal) students at Milingimbi, in terms of cultural factors, problem-solving approaches and learning strategies. He identifies five main Yolngu learning strategies and implications for the classroom.

- Harris, S.** (1990). *Two-Way Aboriginal Schooling: Education and Cultural Survival*. Canberra: Aboriginal Studies Press.

A detailed consideration of the principles and practice of two-way schooling as the author has experienced it in Aboriginal schools in remote areas of the Northern Territory, Western Australia, South Australia and Queensland. It explores the theory of biculturalism as it applies to Aboriginal schooling, resulting in a theory of schooling that promotes Aboriginal cultural maintenance and academic success.

- Harris, S. and Malin, M.** (Eds.), (1994). *Aboriginal Kids in Urban Classrooms*. Wentworth Falls NSW: Social Sciences Press.

The articles in this book provide an overview of the barriers to achievement by urban Aboriginal children suggests culturally appropriate teaching strategies and ways to promote more effective learning environment are suggested.

Howard, D. (1994). Culturally responsive classrooms: A way to assist Aboriginal students with hearing loss in urban schools. In S. Harris and M. Malin (eds), *Aboriginal Kids in Urban Classrooms*. Wentworth Falls, NSW: Social Sciences Press.

This paper discusses ways of Aboriginal learning and types of teaching strategies which need to be emphasised particularly with Aboriginal children who experience conductive hearing loss.

Howard, P. (1995). Listening to what people have to say about mathematics: primary mathematics and the thoughts of one Murri student. *Aboriginal Child at School*, 23(2), 1-8.

This study was undertaken in north west New South Wales and investigates the views of parents, students and teachers towards the learning of mathematics in Years 5 and 6. This paper reports on an initial analysis of the views held by one of the students interviewed.

Howard, P. (1997). *Aboriginal voices in our schools*. Paper presented at the Annual Conference of the Australian Association for Research in Education (AARE), 30 November - 4 December 1997, Brisbane.

The study reported on in this paper investigated the expressed beliefs of Aboriginal parents, Aboriginal educators, Aboriginal children and their teachers towards the learning and teaching of mathematics in Years 5 and 6 of primary school. This paper reports specifically on the views expressed by Aboriginal educators related to the categories of Learning, Teaching, Context and Family.

Howard, P. (1998). *Contextual issues related to Aboriginal children's mathematical learning*. Paper read at Australian Association for Research in Education, at Adelaide.

This study investigated the beliefs about teaching and learning in mathematics in the last two years of primary schools. This paper explores beliefs related to the category of Context which includes beliefs about Aboriginal children and school, discrimination and racism, community, discipline and behaviour, Aboriginal parents, expectations, teacher's role and language. The author argues that these contexts are critical in Aboriginal students' learning of mathematics.

Jarred, A. (1993). English Language and Numeracy Program for Aboriginal students. In National Languages and Literacy Institute of Australia (Ed.), *Best Practice in Aboriginal and Torres Strait Islander Education*. South Australia: University of South Australia Printing.

The English Language and Numeracy Program for Aboriginal Students (ELAN) was introduced into Western Australian schools in 1991. An ELAN teacher, appointed from within the school, undertakes professional development in First Steps, Aboriginal learning styles and teaching English as a second language. The ELAN teacher then becomes a resource person for other staff members. This favourable review of ELAN relates mainly to the literacy component. *First Steps* continua for Mathematics are currently being developed.

Jones, K., Kershaw, L. and Sparrow, L. (1995). *Aboriginal Children Learning Mathematics*. Perth, Western Australia: MASTEC, Edith Cowan University.

This is one of a series of monographs on issues in primary mathematics education. This book includes chapters on cross cultural cognition, ways of knowing, mathematics in remote schools, curriculum elements, two-way Aboriginal schooling, Garma mathematics and technology.

Keper, B. (1993). Aboriginal students communicating mathematics. In A. W. M. Stephens, D. Clarke and J. Izard (Eds.), *Communicating Mathematics: Perspectives from Classroom Practice and Current Research*. Hawthorn, Vic: Australian Council for Educational Research.

This article describes a series of professional development activities conducted by the author with Aboriginal and non-Aboriginal teachers from the Northern region of the NT. The focus of the activities was to explore ways in which the social contexts could be introduced into mathematics activities.

Knight, M., Hurley, R. and Flavel, S. (1994). Mathematics and language: teaching with an Aboriginal perspective. In *Best practice in Aboriginal and Torres Strait Islander education: NLLIA celebrates the International Year of the World's Indigenous Peoples: proceedings of the conference held in Canberra on 17-18 November, 1993*, pp 48-53. Deakin ACT: National Languages and Literacy Institute of Australia.

The key features of this program, introduced at Driver High School, included a class of no more than 20 Indigenous students who were taught the same mathematics units as the mainstream classes, by mathematics teachers who rotated on a semester basis and were assisted by an English as a second language teacher who remained in the class as a constant throughout the year. Students cycled through the class according to their needs.

Koorie Teacher Education Program. (1990). Access to Mathematics for Aboriginal students. In M. A. Clements (Ed.), *Whither Mathematics*, pp305 - 311. Melbourne, Victoria: Mathematics Association of Victoria.

Summarises important social and cultural issues which impact on mathematics learning for the Koorie child.

Malin, M. (1994). Make or break factors in Aboriginal students learning to read in urban classrooms: A socio-cultural perspective. In S. Harris and M. Malin (Eds.), *Aboriginal Kids in Urban Classrooms*. Wentworth Falls NSW: Social Sciences Press.

This study reports involved the monitoring of a R-1 reading class which included a number of urban Aboriginal children. Findings indicate that factors beyond cultural differences affected educational outcomes for these students. There appeared to be a differential allocation of resources which could be attributed to 'micro-political processes' in the classroom. This is discussed with reference to broader implications for teachers of Aboriginal children.

McRoberts, R. W. (1990). Counting at Pularumpi: a survey of a traditional mathematics and its implications for modern learning. *Aboriginal Child at School*, 18(2), 19-43.

This research study, undertaken at Melville Island, Northern Territory, reports on a survey of traditional mathematics, focusing on numeracy, measurement, applied

mathematics in real life situations, and methodological practices in Aboriginal numeracy education.

Ministerial Council on Education, Employment, Training and Youth Affairs. (1995). *A National Strategy for the Education of Aboriginal and Torres Strait Islander Peoples 1996-2002*. Canberra: Commonwealth of Australia.

This report cross-references the recommendations from the National Review of Education for Aboriginal and Torres Strait Islander Peoples with the 21 goals of the National Aboriginal and Torres Strait Islander Education Policy and details strategies for implementation and performance measures for each outcome.

Munns, G. and Connelly, J. (1996). *'When are you fellas gunna teach these 'ere little black kids how to read and write?'* *Literacy for Aboriginal students: Learning from past failures*. Paper read at the Annual Conference of the Australian Association for Research in Education, Singapore.

The paper describes Aboriginal students' opposition to school which was linked to a mismatch between the culture of the home and the culture of the school. The authors argue for a non-threatening yet challenging pedagogy, combined with a culturally inclusive curriculum, to enhance Aboriginal students' literacy acquisition.

National Languages and Literacy Institute of Australia. (1994). *Best practice in Aboriginal and Torres Strait Islander education: NLLIA celebrates the International Year of the World's Indigenous Peoples: Proceedings of the Conference held in Canberra on 17-18 November 1993*. Deakin ACT: National Languages and Literacy Institute of Australia (NLLIA).

The purpose of this forum was to identify successful practice and celebrate positive aspects of the education of Aboriginal and Torres Strait Islander students. The collection of papers published addresses a wide range of issues relating to Indigenous education including early childhood education, English literacy programs and Aboriginal studies. One paper specifically focuses on mathematics teaching.

National Review of Education for Aboriginal and Torres Strait Islander Peoples. (1995). *Final Report*. Canberra: Commonwealth of Australia.

The principal findings and recommendations of this Review of the Aboriginal and Torres Strait Islander education are presented under the following headings: involvement and self-determination; information as a prerequisite for decision-making; equitable access; raising participation: equitable and appropriate outcomes; reporting, monitoring and evaluation; and resources and needs.

New South Wales Department of School Education. (1996). *Aboriginal Education Policy*. Sydney: New South Wales Department of School Education.

This policy aims to promote educational achievements by Aboriginal students (including literacy and numeracy achievement) and to educate all students about Aboriginal Australia through curriculum, teaching and assessment programs that are challenging and culturally appropriate.

Nicholls, C., Crowley, V. and Watt R. (1996). Theorising Aboriginal education: Surely it's time to move on? *Education Australia*, 33, 6-9.

Discusses the theory concerning 'Aboriginal learning styles' and the work of Stephen Harris. The authors argue the importance of clarify what this very important debate is really about.

Nienhuys, T. and Burnip L. (1988). Conductive hearing loss and the Aboriginal child at school. *Australian Teacher of the Deaf*, 28, 4-17.

This article contains a discussion of the incidence of Aboriginal hearing loss and its educational implications, and suggests strategies to make the classroom a more friendly environment for students with hearing problems.

Northern Territory Department of Education. (1993). *Maths in Context*. Darwin: Northern Territory Department of Education.

This teacher resource package consists of three books: *Early Childhood Units of work*, *Primary Units of work*, *Checklists and Worksheets*. Also included is an Australian Geographic poster, Australian Bird Migration, and fact sheets on the Dugong, Sea Turtles and Mangroves.

Northern Territory Department of Education. (1994). *Maths Works for Me*. Darwin: Northern Territory Department of Education

A collection of mathematics activities contributed by a range of schools, institutions and teachers.

Patrick-Rolf, M. (1990). Creating a good maths learning environment. *Aboriginal Child at School*, 18(5), 15-30.

This paper comprises of a table which outlines key factors in establishing a good mathematics learning environment. The table was developed by three students of the Anangu Teacher Education Program and their lecturer.

Potter, C. (1994). Mathematics and Aboriginality. *Aboriginal Child at School*, 22(1), 3-11.

General discussion of the needs of Aboriginal children in the mathematics classroom.

Putt, I., Henderson, L. and Stillman, G. (1995). Teaching mathematics education at a distance via interactive multimedia, video, and projects. In R. P. Hunting, G. E. Fitzsimons, P. C. Clarkson and A. J. Bishop, (Eds.), *Regional Collaboration in Mathematics Education 1995, International Commission on Mathematics Instruction April 19-23, 1995*. Monash University, Melbourne, pp 593-602. Clayton, Victoria: Monash University, Faculty of Education.

The Remote Area Teacher Education Program (RATEP) is delivered, using interactive multimedia and electronic technology, to Aboriginal and Torres Strait Islander students within their home communities. The paper describes units from the mathematics content and curriculum subjects to illustrate ways in which the instructional computer-student interface design can be contextualised in a culturally appropriate way in order to promote learning through interactive multimedia. The pedagogy models ways in which the topics may be taught from a problem-based perspective to primary school children.

Roberts, T. (1997). Aboriginal maths: can we use it in school? In N. Scott and H. Hollingsworth (Eds.), *Mathematics, Creating the Future: Proceedings of the 16th Biennial Conference of the Australian Association of Mathematics Teachers, Melbourne, July 1997*. Adelaide: Australian Association of Mathematics Teachers.

The author and her son spent a day with an Aboriginal family with whom they were friendly. The paper discusses the mathematics involved in the activities that they participated in which included making a didgeridoo and organising a fishing trip. Where appropriate, the author states that these types of activities should be incorporated into school mathematics programs but cautions that this should occur only if members of the community determine that these links are appropriate. The original purpose for the skill or important knowledge underlying the skill might be lost.

South Australian Education Department. (1991). *Teaching and learning mathematics. Aboriginal education R 12 resource papers. Theme: Aboriginal students and education*. Adelaide: Education Department of South Australia.

This booklet is one of a series of resource papers produced by the South Australian Education department to support teachers of Aboriginal children. The focus of this booklet is the teaching of mathematics, and a number of teachers reflect on action research projects where they recount strategies that they have found valuable.

Treagust, D. F., Malone, J. A. and Fraser, B. J. (1991). Development of tertiary bridging rights for Aborigines. *Curriculum Perspectives*, 11(4), 26-31.

Describes a bridging program suitable for students who had completed Year 10 and were commencing Year 11. The program consists of discrete units in 12 Chemistry and 17 Mathematics of which students complete a subset depending on the requirements of the tertiary course for which they want to qualify. The chief characteristics of program were matched to Aboriginal teaching and learning styles.

- Trouw, N.** (1994). An effective language program for urban Aboriginal children. In S. Harris and M. Malin (Eds.), *Aboriginal Kids in Urban Classrooms*. Wentworth Falls NSW: Social Sciences Press.

An example of a language program designed to acknowledge and accounts for differences in Aboriginal learning styles. A small group of Indigenous and non-Indigenous students was withdrawn from class each week and lessons incorporated teaching strategies which encouraged the children to learn about the subculture of Western schooling while developing pre- and early reading skills. Evaluation of the program suggests positive outcomes.

- Walsh, P.** (1991). Learning needs consultation. In South Australian Education Department (Ed.), *Students and schools. Aboriginal Education R 12 resource papers. Theme: Aboriginal students and education*. Adelaide: South Australian Education Department.

This article looks at the relationship - and consultation process - between a district Aboriginal education resource teacher and Aboriginal children and their teachers. The aim of the consultation process was to establish how best to work with Aboriginal children and their teachers. In the course of the consultation process issues such as Aboriginal culture, social and emotional development factors, subject areas, and literacy and numeracy aspects were discussed.

- Watson, H.** (1988). Language and mathematics education for Aboriginal-Australian children. *Language and Education* 2, 255-273.

The author argues that attempts to develop mathematics education programs for Aboriginal children have failed because they fail to meet the wide range of individual needs of Aboriginal children. In particular, she highlights the different schemas of meaning that some Aboriginal students bring to their mathematics learning.