



Maths in the Kimberley: Reforming mathematics education in remote Indigenous communities

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Maths



in the

Kimberley:

**Reforming Mathematics
education in remote
indigenous communities**

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This project is funded through a Linkage Grant with the Australian research council. The partner organisation is the Association of Independent Schools of Western Australia.

Preface

The *Maths in the Kimberley* project is funded through the Australian Research Council Linkage Grant scheme with the Association of Independent schools of Western Australia (AISWA) as the industry partner. The grant is jointly held between Griffith University, Brisbane, and Monash University in Melbourne, Australia. In addition to Professor Robyn Jorgensen, Professor Peter Sullivan and Dr Peter Grootenboer, the project's Chief Investigators, the project also has two partner investigators, Professor Stephen Lerman from London South Bank University and Professor Jo Boaler from the University of Sussex. Dr Richard Nietzsche is the Research Fellow on the project

The aim of the *Maths in the Kimberley* project is to address the issue of underperformance of remote Indigenous students in mathematics through using a framework of high demand mathematics along with an innovative pedagogical model.

The papers in this volume consist of a variety of journal articles and papers emerging from the *Maths in the Kimberley* project between 2008 and early 2010. Papers are generally arranged in chronological order but have also been arranged in two main parts. The first part consists of mainly exploratory reviews of theory and literature as well as an outline of the main aspects behind the project. The second section of papers begins to draw upon the data that have been collected to start to draw out varying levels of analysis. These papers have been previously published and acknowledgements are provided in a footnote at the start of each paper.

This collection is not meant to be a definitive and final account of published works from the project as a number of future publications/proposals are currently in press, under review, and being written. This collection is therefore intended as a resource for the industry partner, teachers, schools and communities to provide them up-to-date information on the project's progress, as well as a resource for new teachers and staff to the schools involved. We would also like to thank all of the participants involved in the project so far for their time and effort in their hard work and valuable contributions without which this project would not have been possible.

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Executive summary

The collection of papers that make up this book have been generated through a grant funded by the Australian Research Council through its Linkage Grant scheme. In 2006, the Association of Independent Schools of Western Australia (AISWA) approached Prof Peter Sullivan and myself to work with them in the remote area of the Kimberley region. For the previous two years, they had been working with consultants to provide mathematics professional development for 6 community schools in the Fitzroy River region. This region is one of the more remote areas of Australia and the six schools were community schools that offered primary through to secondary education. The schools varied in size, with the smallest school being a two-teacher school in which one of the staff was also the principal, through a larger school that had 6 separate classrooms and ran along similar lines as would be expected in most urban settings. However, the provision of education in these regions has unique issues, quite different from urban and rural Australia. First, the students are Indigenous students, and aside from the few students whose non-Indigenous parents work in the communities, the schools were effectively 100% Indigenous. The cultures of the students and communities are still deeply connected to their original cultures with many cultural activities and ways of seeing and being in the world still a part of the rich tapestry of the schools. The home language spoken in communities is that of the local culture so that instruction in English creates unique learning contexts for teachers, students, and teacher aides.

For readers unfamiliar with Australian geography, The Kimberley is a large expanse of land, almost the same size as the UK. It is in the top north-west corner of the continent and has some of the most magnificent scenery in the country. Historically it was cattle country and employed many of the local people in a range of capacities associated with the cattle industry. More recently it has become a large tourist destination. As a remote region, there are vast distances to travel. For the research team, it meant flying from the East coast to Perth, then to Broome. We would then travel to the schools some of which were close to Broome (about 200kms inland) whereas the furthest was over 800kms from Broome. Reaching communities often involved 2 days travel in one direction. All communities were off the main road, with some communities close to 100kms from the main road, along a dirt track. Communities had few facilities for visitors so it was not uncommon to bring bedding but essential to bring in food.

As with many remote communities, education provision in the Kimberley is usually undertaken by early career teachers and where leadership is provided by early career principals, many of whom were teachers in the schools and may only be a few years out of their initial teacher education programs. The early career teachers present both opportunities and challenges for education provision, not only in terms of deep teaching and pedagogic knowledge but also in the turnover of teachers. Unlike many remote communities where the

average stay of teachers is quite short, the teachers in the Kimberley schools often stayed the two years of their contracts and quite often for a year or two beyond this. Even while these figures may buck national trends, there is still quite a large turnover of staff, making sustainability of teaching and curriculum a significant challenge. However, this is not unique to this context, but is commonplace in remote education provision.

In this context, AISWA sought to provide a coherent framework to mathematics curriculum that would help to change the low performance of the students, not only as formally measured on national testing, but for the students and communities. Self government in the communities focused on many matters, one of which was education and there was a belief from elders that their children should have success in schools and be able to take on roles within the communities. To this end, Peter and I worked with Steve Lerman from the UK who has a strong background in mathematics but also equity. We also sought to work with Prof Jo Boaler from Stanford University in the USA. Jo's seminal work with disadvantaged schools in the UK and USA has challenged many of the orthodoxies found in these contexts and she has reported significant outcomes from reform approaches to teaching school mathematics. Drawing on this corpus of work, and Peter's and my own work, we developed framework to rethink the teaching in these areas.

In 2010, Dr Peter Grootenboer was invited to join the team to support its operations from the host University while I took leave to work in a remote Central Australian community. Dr Richard Niesche was employed as the research fellow to work on the project. Richard brought his particular lens, leadership, to the project which helped to formulate many of the ideas around curriculum leadership. We also recognise the support we have received from Andrea Kittila who was worked with all of us in developing publications and this document. We also recognise the editorial work provided by Jill Moriarty in producing this document and making sure the broad collection of papers were presented in an appealing manner rather than as they appeared in their initial format.

What is contained in this book is the collection of publications that arose from the project from its inception to the end of 2010. We sought to compile the collection of publications in order to share our learnings with the participants and communities so that there was some legacy of the project in the sites where the research was conducted. Also, the learnings from this project can also be shared with others working in the field. It is not meant to provide a coherent story of the project but rather to highlight the depth and breadth of our learning about remote education provision.

We trust you enjoy reading this collection. If you have any further queries regarding this project or any of our similar work, please contact us.

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Reforming mathematics classrooms: A case study of remote Indigenous education

Robyn Jorgensen and Richard Niesche

Introduction

In this paper we seek to develop a case for the need for significant reform in the teaching of school mathematics. The approach that we propose is one that is sound for all students but most particularly, we are concerned with redressing the social and educational outcomes for Indigenous Australian students. On every measure, Indigenous students are more likely to perform poorly in comparison with their non-Indigenous peers. Not only is this a concern in the early years of schooling, but it is also recognised that the educational gap widens as students progress through schooling (MCEETYA, 2006). The problems are complex so a radical shift in approaches is needed. We believe that traditional methods of teaching where basic skills and reduced content levels are not the answer. What has been consistent in research for a considerable amount of time is that the traditional modes of teaching school mathematics do not create learning opportunities that foster deep and/or conceptual understandings of mathematics. This is for all students and yet such models pervade reforms, particularly for Indigenous students. Furthermore, teachers' beliefs about a student's capacity to learn exacerbate learning outcomes. As Gray (1999) has shown in the area of literacy, having high expectations of learning which translate into successful performance can be achieved when the appropriate scaffolding and environments are provided by schools and teachers. As such, this paper is a working document on how to engage with the challenge of ensuring Indigenous Australian students get the best chance to succeed in school.

* This paper was first published as: Zevenbergen, R. & Niesche, R. (2008). *Reforming mathematics classrooms: a case of remote Indigenous education*. Working Paper No. 2, Brisbane: Griffith Institute for Educational Research, Griffith University.

Defining 'Indigenous'

Prior to commencing this paper, we need to define what is meant by "Indigenous". It is not a biological construct that once pervaded the social conscience of Australia. In contemporary times it is recognised as being an issue of identity and how a person identifies themselves as being Indigenous and how they are recognised by their communities as being a part of that community. As such, Indigenous people self identify. It is also important to recognise that there is not one overarching Indigenous people but it is made up of many people from many different groups. There are people who live on the mainland of Australia as well as those who live in the Torres Strait. The diversity among Indigenous people as is as great as it is among any other groups of people. For this paper, we need to be able to express the focus of our writing in ways that will help support the coherence of the text. To enable this, we adopt the protocol of referring to "Indigenous Australians" but are cognisant that this is a shorthand term that reflects a multitude of people, cultures and languages. It is not meant to devalue the diversity of Australian Indigenous people. Much like the debate that Bourdieu (1987) has noted around social class as a defining category, we adopt the same approach by proposing that it is what unites Indigenous people and makes them different from non-Indigenous people that helps to make a construct from which to talk about the issues around Indigenous mathematics education.

Background: The Context of Indigenous Education

In this section we outline the general life circumstances for Indigenous Australians. These conditions impact on the lived circumstances for Indigenous people and which, ultimately, impact on their education – either as students, families or communities.

Social and Economic Conditions for Indigenous Australians

As a group, Indigenous people make up about 2.2% of the national population, with approximately 410,000 people identifying as Indigenous on the 2001 census. The educational outcomes for Indigenous people cannot be separated from their lived worlds. The issues confronted by Indigenous Australians are significant. In terms of income, Indigenous people earn half that of their non-Indigenous peers (Appleyard, 2002). It is not uncommon for a family to have no employed adults within that unit thus making them entirely dependent on social security for their income. Part of the difficulty with employability is the lack of education, thus rendering many Indigenous adults without good levels of education or training and as a consequence, most vulnerable to the employment market.

In terms of health, Indigenous people have had no significant improvements in comparison with their non-Indigenous peers over the past few decades. For example, low birth weights still remain, hearing problems have not decreased, and infant mortality remains significantly higher than for the non-Indigenous population. Health problems, such as diabetes, are significant among Indigenous people with Indigenous people having a life expectancy 17

years shorter than the non-Indigenous population. The most vulnerable period of life for Indigenous people is in the period of 35-54 years of age where the death rates are 5 to 6 times than for non-Indigenous people. Indigenous people are 10 times more likely to have kidney disease and 3 times more likely to have diabetes than non-Indigenous people (Steering Committee for the Review of Government Service Provision, 2007).

Housing conditions are often very meagre with poor buildings and significant overcrowding. For example, in one case study of a community in Western Australia of 489 people there were 40 houses – of which 18 were condemned and 4 needed to be knocked down. In comparison with statistics in Sydney where the average occupancy is 3 people per house, there would have been 163 dwellings (Myers, 2007).

Indigenous people are disproportionately overrepresented in the justice system - either as offenders or victims. Indigenous imprisonment rates were 15 times higher than for non-Indigenous people with 77% of Indigenous people having been in prison previously (Australian Institute for Criminology, 2006). For Indigenous youth, 52% of those in Juvenal detention centres were Indigenous. The youth Indigenous incarceration rate is 23 times that for non-indigenous youth (Australian Clearing House for Youth Studies, 2008). In some cases, authors (Ogilvie & van Zyl, 2001) have argued that youth incarceration is at such a high rate that for many Indigenous people it is seen as a rite of passage. Such a view is, however, not without criticism in that it normalises the institution of Indigenous youth. Moreover, is a worrying trend that incarceration rates are increasing at a faster rate for Indigenous people than for non-Indigenous people (Wijesekere, 2001). In part, this increase could be due to self-identification thus skewing some of the reporting due to more Indigenous people identifying with their heritage.

Distribution of Indigenous People

From the 2001 census data, it was found that nearly 90% of Indigenous people live in major cities or inner regional areas. The break up of the location of Indigenous people is that:

30 per cent of Indigenous people lived in major cities, and 20 and 23 per cent lived in inner and outer regional areas, respectively. Nine per cent lived in remote areas and 18 per cent in very remote areas. (Steering Committee for the Review of Government Service Provision, 2007, p. 2)

When considering the distribution across the states, 30% lived in NSW, 27% in Queensland; 14% in WA; 12% in Northern Territory, 6% in each of Victoria and SA, 4% in Tasmania; and 1% in the ACT. These figures indicate that the significant distribution of Indigenous people is in urban areas. However, educational outcomes for rural and remote communities are compounded by the distance that students live from major urban or regional centres.

Education and Training

With the national benchmarks, the success rates for Indigenous students are alarming. In those states where there are considerably remote regions (Western Australia, South Australia, Northern Territory and Queensland), the scores are very different from those states where the Indigenous students are predominantly in regional and urban settings. It would appear that geo-location exacerbates differences in performance.

When performance is considered in concert with expenditure per student and teaching/student ratios, there is more cause for concern as it would appear that such variables are not correlated strongly with performance. For example, the expenditure on students in the Northern Territory for the 2002-2003 was \$14709/student compared with \$8017 students in Victoria (Lowe, 2006). Part of these funding disparities must be due to the dispersed education provision in remote areas. Furthermore, when considering teaching ratios in 2003, in NSW the ratio is 17.3 to one whereas Northern Territory is 13.9 to one (Lowe, 2006). Such figures indicate that while considerable money has been allocated to education, the expenditure is not producing gains in outcomes. For governments, this is a particularly disconcerting. However, in economic analysis, Junankar (2003) has shown that the social benefit coming from educational expenditure is significant and that more money (not less) is needed for the education of Indigenous people if there are to be significant changes in the benefits to communities.

Attendance and retention are also concerning for Indigenous students. Only 22% of indigenous students are likely to complete Year 12 compared against 47% for non-Indigenous students (Steering Committee for the Review of Government Service Provision, 2007). In terms of absenteeism for Indigenous students, there have been numerous studies on this issue.

Despite a lack of national school attendance data and a lack of consistency in the definition and measurement of non-attendance it is, nevertheless, clear from the literature that absenteeism among Indigenous students is markedly higher than among non-Indigenous students. Indigenous students also have higher rates of suspension and lower retention rates than non-Indigenous students (Bourke, Rigby, & Burden, 2000, p.1).

Such absenteeism and transience among schools reduces learning opportunities for Indigenous students creating gaps in the learning for many students. This is particularly difficult for a curriculum area such as mathematics where, for many teachers, there is a belief that learning follows a linear model. Where students are absent, it is believed that important concepts are not developed and thus reduce the continuity of concept development. However, such a model has been significantly challenged by new research.

Hard-to-staff schools: Transience, Stability and Sustainability

The staffing of schools in remote areas is a perennial problem and has been noted by Noel Pearson, a national Aboriginal Activist, as a problem that exacerbates the quality of schools, teaching and learning for Indigenous students. In a plan similar to that of the *Teach First* program in the UK and the *Teach for America* in the US, Pearson advocates a significant change in current practice so as to attract the most qualified and experienced teachers to work in Indigenous schools (Cape York Institute, 2007).

Many of the schools in remote and rural areas are staffed by graduate teachers. Sharplin (2002) cites figures where in Western Australia, 90% of graduates were placed in rural and remote settings and with similar figures of 87% of Queensland graduates similarly placed in these schools in the first two years of their teaching careers. While graduates may come with enthusiasm, they lack the experience and repertoire of skills to teach in these schools, and do not gain mentoring in their early careers due to the high numbers of similarly qualified teachers in the schools.

The big problems confronting schools in remote and rural areas is initially attracting teachers to the schools, and then the high turnover of staff with most teachers taking up appointments for short term contracts. The difficulties of attracting adequately qualified teachers in discipline areas are particularly poignant in the secondary school sector so that it is not uncommon for teachers to be compelled to teach outside their discipline areas.

Within this complex milieu, teaching quality programs of mathematics is a challenge. Any program must take account of the multitude of factors that impact on learning. However, such variables should not be seen as an excuse for the provision of impoverished or lesser learning experience. Rather, high expectations and quality learning environments have been consistently recognised as being critical to the success of students.

The Policy Context

The poor educational outcomes for Indigenous people in this country have been well documented in numerous government reports, academic books and papers as well as reported in the media. Looking back over the various National and State Government policies to Indigenous education in the last 40 years, it seems that there are few areas which have received as much government focus and funding for such little improvement. We believe that policies have been very slow to understand and thus address the barriers to Indigenous educational achievement, and that these issues have been more complex and difficult to tackle than has been acknowledged. In addition, the conflicting responsibilities between the Commonwealth and the states over Indigenous policy have demonstrated the failure of such arrangements in addressing the needs of Indigenous peoples and students

(Beresford, 2003). As has been detailed above, the educational outcomes for Indigenous people have been significantly behind that of non-Indigenous groups for a very long time. While there has been some overall improvement, the gap is far from closing. In fact, in recent years, evidence suggests that in some areas it has widened further (MCEETYA, 2006). The aim of this section is therefore to provide a brief outline of some of the major Federal policy approaches over the last 20 years that have led up to the current situation. We acknowledge the various policy histories of the states but feel that to wade through such varied and contested terrain would detract from the main arguments of this paper.

The history of Aboriginal educational policy in this country is one that has been characterised by forces of racial inferiority, segregation, assimilation (Beresford, 2003). We see the continuing poor educational outcomes for Indigenous people in this country to be a major human rights issue and as the recent Social Justice Report (2007) outlines, measures such as the Northern Territory Intervention raise serious concerns about the consistency of such legislation with human rights standards. This is not to say that tackling issues of family violence and abuse is not important. It is. However, there needs to be effective participation of Indigenous peoples in decision making that affects them (Social Justice Report, 2007). This active participation of Indigenous groups needs to be an essential aspect of any reforms in Indigenous education and has only received attention as an issue in recent years.

The 1967 referendum marked a significant turning point in government approaches to Indigenous issues and education as this signalled the beginning of a period of Commonwealth activity into Indigenous education. It therefore wasn't until the 1970s until the poor state of Indigenous education became apparent (Beresford, 2003). The 1971 Census and research by Watts (1978) highlighted issues of remoteness, truancy and attendance, culturally inappropriate curricula, and racism as contributing factors to the poor educational achievements of Indigenous students. While this research was beginning to paint a picture of what was happening to Indigenous students in schools, both National and State policies were unable to effectively address the needs of these students in any real way.

The first significant policy into indigenous education came with the Report of the Committee of Review of Aboriginal Employment and Training Programs (Miller, 1985), in which links were made between Indigenous disadvantage and education and employment. Following this came the setting up of the Aboriginal Education Policy Task Force in 1988 which was to report on all aspects of Indigenous education. The aim of the task force was to review research and reports into Indigenous education and provide recommendations for future policy approaches. This increased level of activity into Indigenous education culminated in the National Aboriginal and Torres Strait Islander Education Policy (NATSIEP) in 1990. This policy was significant for a number of reasons. First, the policy attempted to launch a process of involvement of Indigenous communities in the development of policies and programs. This can be seen through the policy's five key objectives:

- To achieve equity in the provision of education to all Aboriginal children, young people and adults by the year 2000;
- To assist Aboriginal parents and communities to be fully involved in the planning and provision of education for themselves and their children;
- To achieve parity in participation rates by Aboriginal people with those of other Australians in all stages of education;
- To achieve positive educational outcomes for Aboriginal people in school and tertiary education;
- To improve the provision of education services across the nation at the local level.

It would be hard to dispute the intent and sentiment of such aims, but there was little, if any real understanding of the sorts of barriers education systems would face trying to achieve these aims (Beresford, 2003). Luke et al. (1993, p. 148) succinctly describe some of the key limitations of this policy:

Throughout, the discourses on the complex causes and consequences of Aboriginal educational programs are subordinated to a linear model of cost-efficiency delivery. Yet an emphasis on performance indicators here has the force of deferring and glossing questions about the structures, experiences, and conditions of schooling...To put it simply, they may just signal increased participation in a systematically disempowering education.

While acknowledging the limitations of the policy, it is important to remember that it provided a key shift in thinking towards recognising the importance of the inclusion of local groups to become actively involved in decision making in local sites, although even to this day, more needs to be done in consultation with, rather than to Indigenous groups and communities.

After a period of review of the programs and goals established in NATSIEP and subsequent programs, in 1996, the National Strategy for the Education of Aboriginal and Torres Strait Islander Peoples marked the coming together of the Commonwealth Government and MCEETYA to focus on educational outcomes rather than financial inputs, which had been the previous focus for a number of years. In 2000, the National Indigenous Education Literacy and Numeracy Strategy (MCEETYA, 2000) marked a 'new strategy that now openly set out to achieve literacy and numeracy standards for Indigenous students that match those of non-Indigenous students. This could possibly be in part response to the 1990 report which aimed for equal achievement levels for all Australians by the year 2000! The rhetoric of Government reports and policies since 2000 has been one of expectations for increased achievement levels and the increasing of the pace at which outcomes for Indigenous students will match those of the rest of the Australian student population. According to a Queensland Report in 2004 (MACER, 2004), one of the significant shortcomings of previous

policies in Indigenous education in this country is due to the lack of collective responsibility and accountability frameworks in the various state and Federal systems. The report states that:

The sub-committee concludes that a failure to clearly articulate the accountabilities of education officers and teachers for improved Indigenous student outcomes is the major silence in previous Indigenous policies (2004, p. 8).

This report is referring to not only policies in Queensland but also other states in addition to the Commonwealth level. It seems that despite an abundance of policies at both the state and Federal level, the educational outcomes across most benchmarks have not only failed to increase but have even declined from 2004-2005 according to the National report on Indigenous Education and Training 2005. Key issues such as intergenerational disadvantage, combined with schooling practices that work to marginalise Indigenous students continue to plague the educational systems in Australia. In response, in this paper, we emphasise localised resistances to these systemic practices through notions of productive leadership (in a later section) and reforming pedagogy, particularly in the teaching and learning of mathematics.

Theoretical Framing of Reform in Mathematics

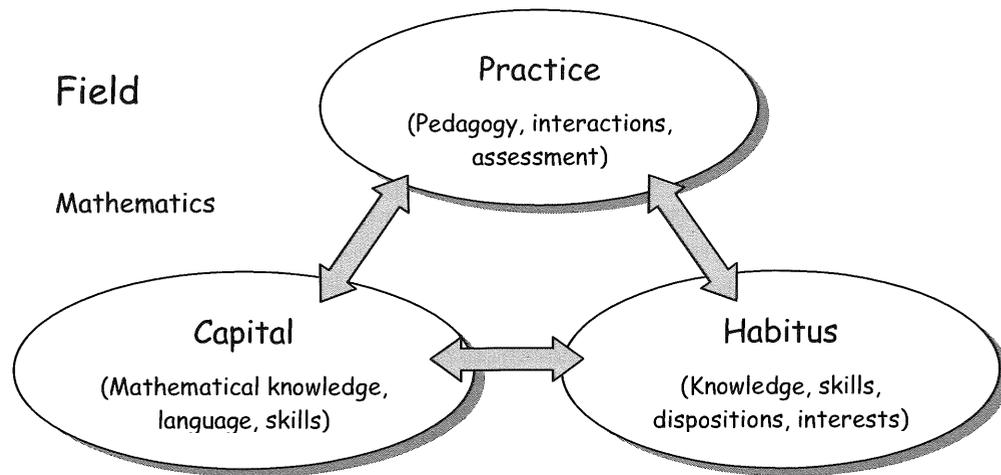
The systemic failure of Indigenous students in Australia, and internationally, is a problem of significant importance. Coming to understand why so many students are systematically performing poorly on measures of performance requires radical reconceptualising of the teaching of school mathematics if we are not to repeat the errors of the past. For many “innovations” in mathematics, the practices of the past are embedded in the new so that the reform is simply a disguised or, even worse, a deficit model of learning. As we will show in this paper that the practices that are valued within the school system work to exclude, marginalise and reify cultural differences to the detriment of indigenous learners. Within this framing, “learning mathematics” is not an individual characteristic, but rather a tension within the processes which indigenous students encounter as they come to learn school mathematics and those that they bring to school. To theorise this tension, the theoretical project of Pierre Bourdieu is most useful, and in particular, his notions of field, practice, habitus and symbolic violence are particularly pertinent to framing the “learning mathematics” faced by Indigenous learners as they confront the world of school mathematics.

Understanding “Learning Mathematics” as a Structuring Practice

In this paper we seek to develop a position on why learners of Indigenous backgrounds are less likely to be successful in the study of school mathematics. Rather than see this as an individual characteristic, we propose that the practices within which mathematics is taught/learned by students are structured in subtle and coercive ways that facilitate the chances of success so as to favour particular groups of students and to marginalise Indigenous students (along with other disadvantaged groups).

Students most likely to be successful in the study of school mathematics are generally those from the dominant culture. Teese (2000) has shown how the practices of school mathematics correlate strongly patterns of social structures. Taking such a perspective makes it possible to better understand the systematic exclusion of Indigenous students from participating in the field of mathematics. Such a process enables a richer theorisation of the reproduction of power through school mathematics and why it takes considerably more effort for teachers and learners if students from these backgrounds are to be successful in their study of this discipline area.

In framing the paper through the use of Bourdieu’s constructs, we plan to show how the field of school mathematics has particular practices that seek to facilitate the growth of a mathematical habitus. This habitus may require significant reconstitution of the primary habitus of Indigenous students for whom the practices reified in the field of school mathematics are at loggerheads with the primary habitus brought from the home environment. The practices of the field of mathematics can be seen in written texts such as curriculum documents, texts books; through assessment practices such as external examinations, school-based assessments or incidental assessments such as teacher observations which are then reported in formal documents such as reports or through personal interactions with the student; and through pedagogic practices such as ability grouping, small group work, teacher interactions and so on. It is not possible to consider each construct without considering the other constructs simultaneously. The habitus only can have capital within a particular field. For example, within the field of Indigenous knowledge, the spatial habitus of an Indigenous person may include knowing how to map the land within cultural/historical markers. Such a habitus may convey particular status (and hence capital) but within the field of mathematics education, such ways of mapping the land hold no/little status and hence cannot be exchanged for forms of capital within the field of mathematics education. Similarly, the practices within the field of mathematics education are seen as valued (or not) within that field. These practices are shaped by the participants within the field (generally those with the capital of the field). If one considers the ways in which what is seen as legitimate knowledge (such as behaviourism or constructivism) within the field at a particular time, then those with the habitus of that time may exchange their knowledge for forms of capital (such as promotions or grants). Fields are in a state of flux where they form and reform where products (knowledge, taste, and ways of thinking working acting) are re-valued so that the forms of capital are undergoing change over time.



In coming to understand the field in relation to the success of Indigenous students becomes possible using this tripartite model. When the habitus of Indigenous students is different from what is seen as valued (as per the practices of the field), then there is little chance for success for the students (as recognised through the accumulation of capital). The role of education then becomes one of critical inquiry into the barriers for learning for students (reconstitution of the primary habitus) and the constitution of the practices within the field so as to accommodate learners within the field or to reconstitute the field in ways that recognise the habitus of indigenous learners so that the practices of the field become challenged to accommodate new forms of knowing and practice.

Drawing on Bourdieu's notions of capital and symbolic violence, the practice of school mathematics can be seen as one where the ways of thinking, acting, talking and working have become reified through documents and other objective structuring practices that define what is seen as legitimate knowledge. Those who have such knowledge, and dispositions to acquiring and displaying the same, are more likely to have considerable power within this field. That is, if a student is able to display what is seen as valued knowledge within the field, then they are more likely to be described as successful learners. Consider the young child who comes to school knowing how to count, classify, articulate names of geometric shapes and other mathematical objects. The pre-school familial practices have enabled the child to acquire particular forms of knowledge that are valued within the practices of schools mathematics. When the child displays particular counting skills for example, then the teacher ascribes the child to be an effective counter. However, the familial circumstances within which a child experiences some fundamental learnings are very much shaped by the culture of the family. Through this early socialisation, the child has developed a particular habitus that predisposes him/her to act in particular ways. This habitus now acts as a medium through which the child displays and acquires new forms of knowledge.

Where the primary habitus that the child acquired in the early years of life aligns with the practices he/she will encounter upon entering school, then there is greater chance for success within that secondary context. What can be in the early years of schooling is that a child displays the forms of knowledge that the teacher sees as valued and ascribes certain general characteristics to the child. Conversely, where a child does not display the characteristics that are seen to be integral to school mathematics, then the child is most likely ascribed as being deficit in some way or another such as being a non-counter or not recognising numerals, colours or shapes. However, acquiring such knowledge is often linked to the home experiences. Middle-class parents are more likely to interact with their children in ways that are similar to the interactional patterns of schooling, such as posing pseudo-questions (Heath, 1983) or using particular language forms such as the use of binaries (more and less) (Walkerline & Lucey, 1989) which positions the child as school-ready prior to their entry to school.

The familial experiences position the child prior to school in ways that are critical to their potential success in school. For example, in many Indigenous communities or remote communities the need for number is limited so that out-of-school experiences are limited. The child enters the school with a restricted repertoire of number experiences and language. Conversely, Harris (1990) has shown Indigenous students enter schools with a rich repertoire of spatial knowledges but these are not part of the school mathematics curriculum. Similarly, Willis (2000) has argued that very young Indigenous students may be able to subitise but do not demonstrate those counting skills that are part of the early years curriculum (one-to-one correspondence, rational counting, etc). In this way, the entering habitus of the students is different from the skills and dispositions that are embedded in the school curriculum. The practices of school mathematics thus valorise the entering habitus of some children and deny (and marginalise) the habitus of students whose out-of-school experiences are different from those reified in the curriculum. This process effectively differentiates learners on the basis of their primary habitus in ways that are coercive and effectively only lines of race, culture, language and gender. When framed this way, learning difficulties are not part of a deficit of individuals or part of an inherently individual nature but along structured and systemic lines that help to support the status quo.

In the remainder of this paper we draw on Bourdieu's notion of symbolic violence as a way to frame the hegemonic role of school mathematics to better understand the difficulties faced by students whose backgrounds are not those valued by the curriculum (where curriculum is seen in its broadest sense). For Bourdieu, symbolic violence is a process where the victims are complicit in their domination. Rather than overt violence, symbolic violence is where a "body of knowledge that entices the dominated to contribute to their domination by tacitly accepting, outside of any rational decision or decree of the will, the limits assigned to them" (trans in (le Hir, 2000, p.135). This approach is not to place the blame on the victims (which has been a criticism of the construct) but as a tool through which the processes of domination can be better understood and that through this understanding, a first step is made towards their elimination.

Teaching Indigenous Students: An Act of Symbolic Violence?

The current modes of teaching of mathematics to Indigenous students can be seen to be an act of symbolic violence when using a Bourdieuan framework. Such an approach implies that learner and teachers are complicit in the reproduction of dominant forms of knowledge to the detriment of marginalised groups. Through their complicity in what is seen to be an apolitical act, dominant groups are able to maintain their status within the social order without any need for overt force or violence. Through the processes implicit in the act of teaching, dominant forms of knowledge and knowing retain their hegemonic role in preserving the status of the dominant groups. This is to the detriment of Indigenous knowledges and ways of knowing. For Bourdieu, this is summed as follows:

The theory of symbolic violence rests on a theory or belief or, more precisely, a theory of the production of belief of the work of socialisation necessary to produce agents endowed with the schemes of perception and appreciation that will permit them to perceive and obey the injunctions inscribed in a situation or discourse (Bourdieu, 1998, p.103).

But symbolic violence does not occur without considerable preliminary work to be undertaken. In the case of mathematics, there have been centuries of repression of forms of knowledge such as those of the Islamic and Asian contributions to mathematics (Joseph, 1991) so that the legitimate knowledge of the curriculum is that of a western orientation and where other forms of knowledge are replete from the knowledge base. Through this process, a reinforcing of Western ways of knowing have become the taken-for-granted forms of knowledge. Similarly, the ways of teaching have become accepted as the dominant modes of pedagogy. Considerable work in the reform of school mathematics has been undertaken but as Gutierrez (1998) argues, along with many other mathematics educators, the change process in mathematics is very difficult. This reflects an assumption about the taken-for-granted ways of teaching mathematics that have become resistant to change despite considerable research to show that such practices do not meet with success (e.g. Boaler's extensive cross cultural work in the UK and USA, (Boaler, 1997a, 2008).

For a symbolic act to exert without a visible expenditure of energy, this sort of magical efficacy, it is necessary for prior work - often invisible, and in any case forgotten or repressed - to have produced, among those who submit to the action of imposition or injunction, the dispositions necessary for them to feel they have obeyed without even position the question of obedience (Bourdieu, 1998, p.102-103).

Thus, for us, much of the teaching of school mathematics can be seen as an act of symbolic violence when undertaken in many contexts - Indigenous, working-class and so on. This is particularly the case where cultural forms of knowing are not an integral part of the curriculum. The *National Inquiry into Rural and Remote Education - 'Emerging Themes'* suggests Australian Indigenous people 'have become alienated from the school system'. (2000, p. 58). In part this is due to the lack of synergies

between the parents' and communities' expectations of school and what schools offer. When framed within Bourdieu's project, the difference between the culture of school mathematics and the culture that the students bring to school is not simply an apolitical act, but one where the misrecognition of the two cultures enables mathematics to maintain its power base and for those who fail to assume something inherent in their own ability and thus become complicit in the production of their own oppression. This, as Bourdieu noted above, it done in a way that remains hidden to those participating in the act. Within this framing, the truancy that is seen to be an endemic issue among Indigenous students (and noted in earlier sections of this paper) may be a reasonable act of resistance to the symbolic violence being enacted upon Indigenous people.

Where the complicity between beliefs and practice becomes apparent is when teacher frame for lack of success on factors such as attendance, health, transience, family expectations and so on and then offer an impoverished curriculum for students. But this need not be the case. In the area of literacy Gray (1999) has argued that such factors should not be seen as an excuse for poor performance of Indigenous students and that, with appropriate scaffolding, teachers can offer a very rich literacy program for Indigenous students. Similarly, there is every potential for Indigenous students to come to learn mathematics provided there is adequate provision made to scaffold students' learning to enable a bridging between the two cultures. In mathematics, there have been numerous studies that have shown that students from disadvantaged backgrounds can be offered a very rich mathematical curriculum and have success (Boaler, 1997b, 2008). However, as Boaler's comprehensive work has shown, the learning environments are critical to the success of these students. Transplanting a traditional pedagogy into a classroom where there are considerable disadvantaged students offers little chance for success. Rather, as her detailed study of "Railside" has shown, by radically changing pedagogy to meet the cultural dispositions of students while offering a rich mathematical learning, students can succeed in school mathematics.

Mathematics Teaching as Symbolic Violence

Much of the current teaching of mathematics involves the transmission of knowledge that is inherently that of the dominant classes. There has been a strong criticism of the hegemonic forms of knowledge that are embedded in school mathematics. Similarly, the ways that different teaching approaches are organised can similarly create difficulties for learners when their cultural know ledges and ways of knowing are not part of the repertoire of teaching practices. The need for an approach that is culturally inclusive has been recognised by some educators:

Teaching methodologies that recognize and build upon the pupil's cultural heritage and the specific ways in which children are taught to process information can play a critical role in addressing this concern. Inclusive instructional strategies that recognize and embrace this cultural dimension can help teachers ensure that all students in mathematics classrooms become successful learners (Varghese, 2007, p.2).

Teaching School Mathematics in Remote Indigenous Contexts

Many of the teachers working with Indigenous students are non-Indigenous and are very early in their teaching career. Frequently, the teachers in remote schools are often in their first teaching position.

The teaching practices observed in schools often align with the rote, drill and skill methods. In their work in Queensland schools, Warren et al. (2005) reported that the teaching approaches they observed could be seen to be of this form and were informed by narrow views of what was seen as appropriate knowledge and ways of teaching for indigenous students. Adding to this Howard and Perry (2005): reported that teachers failed to take into account the particular needs of Indigenous children in classes and were ignoring their cultural needs:

Even though there were significant numbers of Aboriginal children in their classes, teachers were not considering them and appreciating their cultural needs in the mathematics classroom (Howard & Perry, 2005, 158).

Other researchers have documented the phenomenon that Indigenous students can learn mathematics and that the performance on test items is not due to a deficit in capacity but rather to educational and social factors (Boulton-Lewis, 1990), thus debunking the mythology of inherently flawed cognitive skills for Indigenous learners.

The literature suggests the current practice in the teaching of school mathematics to indigenous students:

- Follows a very lock-step, rote, drill and skill approach
- There is little recognition of the cultural difference Indigenous students bring to the classroom – either as learners or as bearers of different knowledges
- Indigenous students are often rendered invisible in the accounts made by teachers as they talk about practice, even when there are significant numbers of indigenous students in their classrooms.

Indigenous Knowledges and Background Mathematics

There are two dominant ways of thinking about incorporating Indigenous mathematics into school mathematics. One alternative is to preserve the hegemony of school mathematics by searching for mathematics in Indigenous activities (akin to the ethno-mathematics approaches) and to suggest that such activities provide evidence that Indigenous people are able to undertake forms of mathematical understandings and hence are capable of learning school mathematics.

There is often a sense that Indigenous students do not bring much mathematical understandings or knowledge to the school context. In her comprehensive work of Indigenous communities in the Northern Territory, Harris (1990) reported Indigenous understandings of time, space, and money from the perspectives of the people. Similarly, in his early work searching for mathematical universals, Bishop (1988) argued that there a number of mathematical activities found in every culture. However, this work was framed by a Western perspective thus rendering some forms of knowledge to a western mathematical standpoint. Other approaches have sought to investigate activities undertaken by Indigenous people in order to unpack the mathematics involved in the activities and then to use such activities as the basis of curriculum activity. An example of this type of work can be seen in examples of card games (Baturu, Norton, & Cooper, 2004) that are common to many Indigenous communities. Collectively, such approaches take the Indigenous activity and search for the Western mathematics within that activity. Dowling (1991) has convincingly argued that such approaches reinforce the (high) status of Western mathematics while subjugating the Indigenous activity at the expense of Western mathematics.

Conversely, Watson (1987) worked with the Yolgnu people in Arnhem Land in Northern Territory to develop a both-ways education program. Working with the Yolgnu people, they developed a mathematics program that recognised both Western and Indigenous ways of knowing as legitimate. In this work, for example, the ways of understanding the land (mapping the landscape) were undertaken through both school mathematics and Indigenous approaches. Such an approach seeks to develop border crossings between one culture and another with neither culture being fore-grounded but recognising that each has particular strengths. Indeed, it could be argued that incorporating Indigenous knowledges into school mathematics may enrich the experiences for all students. In an international context, others have approached border crossings in this way. For example Ezeife (2002) illustrated the power of building bridges between the culture of the students and that of school mathematics.

Recognising the Need to Reform School Mathematics

Lowe (2006) suggests that there are five elements to making for a successful change in schooling. These are adequate infrastructure to support the reform; strong leadership; quality programs (in her case, literacy); school-wide programs; and community involvement. In so many reforms, the importance of leadership has been an integral part of the success of any reform initiative. As such, we will now focus on the literature on leadership, particularly on the models of leadership and their relevance to Indigenous education. As we have noted elsewhere, the value of leadership within reforming schooling is critical to sustained practice that will enable greater engagement and success in education (Zevenbergen, Walsh, & Niesche, 2009).

Leadership

Before we discuss the potential of a reform mathematics, we recognise that despite having the best possible innovation, the uptake of any reform is strongly influenced by leadership at the school level. In the following section, we define leadership very broadly and do not confine it to the principal who is often seen as the leader of a school.

We include a section on leadership in this paper as we view good educational leadership to be crucial in reducing the gap between the educational achievements between Indigenous and non-Indigenous students. From our work in Far North Queensland (Zevenbergen, Delaforce, & Niesche, 2008) we found that despite the best intentions, the rollout of policy is strongly influenced by leadership at the school level. While there is no direct link between leadership practices and improved student outcomes, leadership must be considered an essential factor in making hope practical for Indigenous students (Lingard, Hayes, Mills & Christie, 2003). Lingard et al. (2003) argue that the task of school leadership is to *lead learning* by creating the and importantly sustaining the conditions which not only facilitate social change but maximising social and academic learning. As such we argue that leadership in schools must tackle issues of curriculum, pedagogy and assessment as fundamental issues of concern in the day to day business of schooling. Our approach to these particular issues is discussed in later sections of this working paper.

The term leadership is a heavily contested one and discourses of leadership are now largely ubiquitous given the breadth of both conceptual and research literature (Gronn, 2003a). There has been a huge growth in the business of leadership studies in recent years as it seems that the term 'leadership' has become privileged over other terms such as management or administration. Leadership has often been associated with notions of influence, power, authority, control and supervision (Yukl, 2002), although certainly recently the term leadership has gained significant favour. It is easy, when thinking of the term leadership to immediately conjure up images of 'great men' such as Gandhi and Nelson Mandela, or 'infamous men' such as Hitler or Stalin. To understand leadership, Gunter and Ribbins (2002) argue that leadership needs to be understood as not just tasks and behaviours, but understood through the gathering of professional experiences within different contexts coupled with a theorising of agency and structure. In this section we use the work of Lingard and Christie (2001) and Lingard et al. (2003) to conceptualise leadership as a form of influence that can exist at any point within (or outside) an organisation, and not just considered synonymous with the head of an organisation or a particular individual. More specifically, leadership should be seen as being "practised by many teachers, principals and parents in a range of educational sites and in a number of informal as well as formal administrative positions" (Blackmore, 1999, p.6). This view of leadership as being exercised at all levels of the school is synonymous with distributed, dispersed or parallel leadership (Crowther et al., 2000; Crowther et al., 2002; Gronn, 2002, 2003b, 2006; Spillane, 2006). Thus, leadership is not exclusive to any one position, and certainly does not only revolve around the position of principal. Leaders can emerge from anywhere within the organisation. It must be

noted, however, that the principal is usually constructed as the centre of control in the school by numerous leadership and schooling discourses. The principal is placed in the position of 'head' of the school, and such structure of schooling makes it very difficult for others to participate in decision-making processes if they are not within this hierarchical structure. As stated by Lingard et al.:

Discourses of schools constitute principals as their 'heads'. Indeed it is difficult to imagine schools without principals because it is common for the administrative heart of the school to be clustered around the principal's office and for this to be the point of interface between the school and the community. The principal's office is also commonly constituted as the locus of control and discipline and there is also a line of command designed to ensure the seamless transfer of power in the event of the principal's absence (2003, p. 141).

Kotter (1990) stresses the importance of leadership as being fundamental to bringing about change. In doing so, Kotter is forging a particular place for leadership in the field of management studies, that is, working on a dualism that sees management as 'running things' and leadership as 'changing them'. While Kotter's perception of leadership is very top-down oriented, his emphasis on change can be useful, as not only are principals expected to enact change within their school but also to deal with and manage constant changes within complex policy contexts. The principal's position is important as he or she is the only one in the school who actually has knowledge of the organisation as a whole, and as a result, has to deal with the boundary issues of the institution. Thus while Fullan's sentiment of, "every person is a change agent" (Fullan, 1993, p. 39) is important, it does not reflect this particular position of principals within the organisation structure. It is therefore crucial that leadership is understood in terms of an ongoing relationship between participants, not just in terms of a great visionary individual and not just as a top down one way flow of authority. In order to avoid this type of dominant and pervasive discourse, it is necessary to examine the contextual factors upon which leadership discourses are constituted. This links to the arguments of both Gronn (2003a, 2003b) and Blackmore (1999) about avoiding a view of leadership that sees it as something exceptional but rather to see it as everyday practice. Further to this, Christie and Lingard argue that "leadership needs to be understood in terms of the complex interplay of individual, organisational and the broader social, political and economic contexts" (2001, p. 19). This type of approach is complex, yet necessarily so in order to adequately convey the multitude of factors at work.

Similarly, in a search for new perspectives on leadership, Sinclair (2004, 2005) and Sinclair and Wilson (2002) argue that leadership must be understood through its political, cultural and historical contexts. Dimmock (2003) and Dimmock and Walker (2005) have also emphasised the importance of culture in educational leadership. Initiating a study of leaders through their "complex cultural roots", Sinclair and Wilson (2002, p. 2)

provide an illuminating analysis that may diffuse the need to conform to traditional leadership stereotypes. Exploring leadership through a discourse of complex cultural roots is an avenue of study that takes the notion of leadership away from the dominant discourse that constructs leaders as white, male and with exceptional visionary purpose. Similarly, Sinclair's work (2004), through personal narrative, emphasises a view of leadership that moves away from objectified, disembodied, de-gendered and positivist approaches. These types of contributions to the field promote leaders as coming from a variety of different backgrounds, whether it is on a basis of gender, ethnicity, race, or socio-economic factors. We believe that context needs to be more strongly recognised in approaches to leadership.

There have been a number of shifting attempts to pin down the discursively and polysemic notion of leadership over the years. Such discursive constructs as trait (Stodgill, 1948, 1974; Goleman, 1995), situational and contingency theories (Hersey & Blanchard, 1974), transformational (Burns, 1978; Bass, 1985; Leithwood, 1992; Leithwood, Jantzi & Steinbach, 1999), distributed leadership (Gronn, 2002, 2003, 2006; Spillane, 2006), authentic or instructional (Hallinger, 2003; Southworth, 2003), moral (Fullan, 2003), and sustainable (Hargreaves & Fink, 2003), have not been able to fully resolve the quest for a definition of leadership. Nor do we aim to do this. The notion of generalising across place, time and space is one that does not take into account the specific contexts or 'thisness' (Thomson, 2000, 2002) of the school setting as well as the complex interplay of power relations at work within schools and across educational systems. As Christie and Lingard state:

Educational leadership involves storied individuals, within the organisational contexts of schools as institutions for systematic teaching and learning, at particular times and places, while also recognising that there are multiple and contingent factors which come together in the creation of educational systems and schools (2001, p. 8).

All of the leadership models listed above do not allow for the production of context specific principal subjectivities which are formed through multiple and competing discourses. A result of this de-contextualising of leadership is the drawing up of leadership frameworks based upon standards and competencies which leaders much exhibit. Such leadership by design frameworks (Gronn, 2003b) emphasise the search for distinctive leadership roles and qualities which we believe to be problematic. Thus we are not searching for the characteristics of what makes a good leader in Indigenous schools or communities but rather emphasise the importance of providing storied and textured examples of leadership in Indigenous schools and communities that we can better understand the multitude of complex factors at play in the day to day lives of educational leaders (Niesche, 2008).

Indigenous Communities and Leadership

It is important to note that the above discussion around leadership is prefaced around western notions of leadership. That is, notions of leadership from Australia, Britain and the USA. What is implicit in these

theories, and what we consider to be largely problematic, is the idea that such notions can be transported and legitimated across homogenous educational systems (Fitzgerald, 2003a, 2003b). While there has been significant work undertaken in regards to gender and leadership (Blackmore, 1999; Collard & Reynolds, 2005; Limerick & Lingard, 1995; Ozga, 1992; Shakeshaft, 1987), there still needs to be more work examining how leadership can be theorised in terms of ethnicity and in particular amongst Indigenous Australians. This does not simply mean the 'adding on' of issues of ethnicity to existing leadership structures but actively valuing and negotiating difference. As Blackmore (1999, p. 203) argues, leadership diversity is about leadership for and not necessarily of diversity.

Adopting a number of values drawn from Indigenous perspectives, the report from the Australian Institute of Aboriginal and Torres Strait Islander Studies (1998, pp. 15-16) promotes:

- Initiation of the role of the leader and authority to speak and represent indigenous communities;
- Benefits and connectedness to indigenous communities by their leaders and wider benefits through interaction with non-indigenous groups;
- Representation and articulation of issues for and within Indigenous communities and links with non-indigenous groups;
- Legitimation of authority from indigenous communities as a core credential for leadership; and
- Accountability to indigenous communities for the actions and activities of leaders.

Such principles that include multiple voices must be central to educational leadership and not simply an 'add-on' to existing normative leadership models and frameworks.

Case Study: Pine Rivers Community School¹

The example of the Pine Rivers Community School in Queensland provides an interesting example of leadership of and within an Indigenous Community school that adopts a similar approach to the points listed above. With the current debates in the media concerning ways forward for Indigenous education in this country, Pine Rivers is providing a successful model of a school embracing Indigenous values and ways of being coupled with community ownership of their communities' learning outcomes. One of the purposes of including this case study is that:

Narratives of the real life of schools attempting to change, narratives based on empirical study that do not seek to create 'best practice' and models, but rather tell particular stories that

¹ A pseudonym has been used for privacy reasons.

exemplify potentially useful principles for ways of working, have some hope of connecting with the reform efforts of other real life schools (Thomson, 2002, p. 189).

Not only does this school signify a struggle for Indigenous peoples to obtain community control and ownership of schools and other educational facilities, but also for understanding the importance of cultural beliefs and practices in the children's development (Downey & Hart, 2000).

Pine Rivers is an independent community-based school in a metropolitan area of Queensland. It has been operating since 1986 and has progressed from a focus on primary school to now incorporating both high school and community based education services. For its first ten years the school was located in an inner city area in a disused Catholic primary school. At this site there were only three classrooms and almost no playing areas for the students. The school then moved to its current location where it is now more able to suitably fulfil the needs of the children. The school is the only community based independent Indigenous school in its area. Over the years the school has responded to the needs of the students by implementing a number of programs and strategies to enable a successful schooling experience for the students. For example, the school runs a private bus system to transport the students to and from school each day, often from all over Brisbane. The school runs a nutritional program whereby the students are provided breakfast, morning tea and lunch so that they are ensured regular meals during the school day. The school also runs a health out-clinic to monitor general health and wellbeing as well as a learning skills centre that caters for the wider Indigenous community, including adult education. In terms of staff, it is school policy to ensure a large percentage of teaching staff are of Indigenous background. There is also a full-time child and family support worker as well as a speech therapist/pathologist. These are just some of the important services offered at the school to meet the wide ranging needs of the students and Indigenous community in general. The school maintains a very low fee structure for parents as a significant percentage of parents receive welfare benefits and/or are in low income employment. This is an example of the commitment the school has in achieving the participation of Indigenous children in primary and secondary schooling.

The role of the community has also been of particular importance for the school and has provided significant emotional and financial support for the school and the tutoring program. The Aboriginality of the students, staff and school is something that is celebrated and is part of the school's philosophy. In addition, the school's vision states, "In respect of our peoples, our cultures, our land, we foster an inclusive learning environment which promotes empowerment, identity and success through education" (Pine Rivers School Handbook, 2008, p.1). The literacy program run at the school is funded through The Indigenous Tutorial Assistance Scheme (ITAS) and was started in 1994 due to concerns over the very low levels of literacy among its students. The program is closely aligned with the view that:

Schools largely operate within a system of communication that is suited to life in a white Australia context whereas Aboriginal

students usually come to school equipped with an Indigenous worldview and context including history, culture, politics, economics, sense of time and space and spirituality (Malcolm, Kessariss & Hunter 2003: 93).

The program was designed with the assistance of a speech therapist to address needs of students with a particular focus on improving reading and associated literacy skills in ways that are culturally appropriate for Indigenous students. This is important as issues of literacy in this school are not portrayed as a 'holy grail' for literacy instruction but rather a program that intimately links literacy with the students' cultural understandings, that is, their communities, languages, cultures and discourses (Freebody & Luke, 2003). While this program is focused on literacy, there are certainly a number of principles central to the program that could be applied to models of reform pedagogy across different curriculum areas. The importance of highlighting this program within this case study is an example of the school's leadership working closely with curriculum and pedagogy, along with not just recognition of diversity but working with multiple world views. The day to day running of the literacy program is also handled by the program coordinator, so the dispersal of leadership within the school needs to be highlighted.

The entire Language and Literacy Program is comprised of the following components:

1. The assessment of each student's language and literacy skills.
2. Designing a program to meet the specific needs of each student.
3. Advice to the teachers from the program co-ordinator and tutors regarding each student's abilities and needs.
4. The employment of suitable tutors to implement the program on a one-to-one basis with the children, and training of tutors where necessary.
5. A regular monitoring of the program by the co-ordinator, speech therapist and tutoring staff.
6. An annual review of the student's performance to determine their progress in the program.

One of the central tenets of this program is the understanding that many of the schools students speak "Murri English"² and that the program aims to broaden their options by teaching them to use and understand Standard English as well. Thus the emphasis is not to replace but to augment their language skills. The students are explicitly told that their language that they speak is just as valuable as any other and that there are different 'languages' used in different places, for example, in the school classroom there is a certain type of English that teachers expect kids to use in both written and spoken form. This is where the community based nature of the

² The term Murri is colloquially used in Queensland.

school is important as the school places a very high importance on maintaining cultural traditions. One of the benefits of the one on one instruction is that as well as promoting academic skills, the tutoring programme provides every child with a potential mentor and supporter in the school community. As a result many children regularly ask for more tutoring sessions and often come to see their tutors if they are upset or having any problems. The tutoring session is a good place to 'check in' with the student and see how they are managing in class and in school generally. Also if a particular child is proving problematic in class there is the option of the teachers sometimes being able to ask tutors to take a child in order to settle them down. The school will often call upon the tutors in the literacy program to help with any issues the student may be having at school as each child in the primary school will have at some point been involved in the literacy program. One of the main aims of the literacy program is the development of a one on one relationship between tutor and student and this relationship is very important in the achievement of students within this program. Thus, a relationship is usually developed between tutor and child, with children benefiting from a kind of informal 'pastoral care' as well as from academic encouragement. The support and encouragement of the tutors can assist the students to learn more effectively and interact more appropriately in the school community. Frequently poor literacy skills are a significant factor for truancy and behaviour problems (Gray 2000). This is one of the things that Gray and Partington (2003) argue is essential for the students' academic success and regular attendance, that is, the formation of social relationships with teachers and others at school.

As a result of this program, the children at the school have regularly outperformed other indigenous students in the Queensland Years 3, 5 and 7 tests, particularly in the reading and viewing component. In many cases, the children have not only achieved on par with the state averages but also exceeded them (Pine Rivers School Annual Report, 2006, 2007).

While we see the example of Pine Rivers as an excellent case study of success for Indigenous students and communities, we do not advocate Independent Indigenous schools as the solution or blueprint for the troubles that plague Indigenous Education. What this case study signifies is that:

Organisations that have emerged from within the Aboriginal community and which reflect Aboriginal aspirations and priorities are functioning better than other structures that are imposed by the government' (House of Representatives, 1990, p. 45).

We see this type of school as one aspect, albeit an important one, of working towards greater Indigenous ownership and community voice in the management of their own educational outcomes.

Towards a Reform Program in Teaching Mathematics

In this final section, we move towards a model of reform teaching in complex classrooms where the goal is to enable Indigenous students to learn and perform well in school mathematics. While this discipline has

been quite outside the realms of many of the life worlds of Indigenous people, what we have shown in the earlier sections of this paper is that 90% of Indigenous people live in urban settings so have exposure to numerate cultures. This is less likely to be the case for Indigenous people living in isolated and remote communities. The alienation from school that has also been noted in the earlier sections can be considered in terms of rational reaction to the symbolic violence enacted through school processes. Expectations held of learners are also critical to success. Further, the belief that mathematics is a linear model and where Indigenous students have absences from schooling that there are considerable gaps in their learning has been significantly challenged by the work of O'Toole and colleagues where mathematics learning should be seen as a network and where learners have many paths through the maze of mathematical concepts. These pathways will be influenced by many factors but as O'Toole has shown, the linear model is not appropriate for mapping student learning. Further, both-ways education models have acknowledged that there was significant possibility in providing curriculum that legitimated Western and Indigenous models of learning and knowledge (Watson & Chambers, 1989). In the extensive research from literacy education, it has been found that provision of quality pedagogy and appropriate scaffolding along with high expectations of learners has resulted in significant gains for Indigenous students (Gray, 1999). Currently many of the mathematics programs that have been implemented for learners of mathematics have been founded on deficit models – of learners and of the curriculum. They often rely on old models of learning that have been premised on models that have (unsuccessfully) been employed in schools. As Clements (1989) had argued, what most students learn from their exposure to school mathematics is that they can't do it. This begs the question why such models still pervade but even more so, in the context of Indigenous education, why such models are transported into these contexts and expected to work? Collectively, these earlier iterations draw attention to the need for a model of reform that has high expectations of learning mathematics.

Boaler's corpus of work on reform classrooms in the UK and US has shown that rich learning environments have enhanced the depth of mathematics learning for students from disadvantaged classrooms. Her comprehensive work undertaken in the US where classrooms used Complex Instruction (Cohen & Latan, 1997) documented the high success of mathematics classrooms in some of the most disadvantaged communities in California. Based on a wide range of research, Complex Instruction has a number of features that enable a rich pedagogy, high levels of mathematics, high expectations of the teachers that the students can learn complex mathematics, and the need for quality learning experiences. This approach has strong synergies with the productive pedagogies approach (Lingard, 2006) that has been used in the Australian context.

In the remainder of this paper, we draw on these literatures, juxtapose them with the complexities of teaching in Indigenous classrooms, and underpin them with a Bourdieuan approach to propose a way forward. The approach that we advocate is one that is grounded in considerable research

coming from the field of mathematics education and education more generally. It challenges much of current practice and moves towards an approach that draws on learning theories rather than the taken-for-granted practices of mathematics education as it is currently practiced in many classrooms. We also acknowledge at this point, that implementing reform is never easy, particularly in mathematics. Such resistance to change has been documented by many mathematics education researchers, particularly those whose work is in the area of equity (Gutierrez, 1998).

Leadership

In implementing reforms in classrooms, leadership is critical. As we have noted earlier, the leadership within Indigenous contexts may often be a devolved form where the role of leadership may be taken up by teachers as well as principals. Further, we also argue that the leadership is critical in terms of curriculum leadership. However, we also extend the notion of leadership to the students so that the pedagogy approach fosters leadership among the students.

Working as a Mathematician

We draw heavily on Burton's (Burton, 2001, 2004) work with research mathematicians and how they go about their work. Her work posed serious challenges to the pedagogies found in so many classrooms. By showing how mathematicians work, Burton proposed that the pedagogical practices of contemporary classrooms needed to be changed. Her work showed that mathematicians valued highly collaborative work; that mathematicians have emotional, aesthetic and personal responses to mathematics; that intuition and 'aha' moments were common; and that mathematicians desired to seek and see rich connections between the various branches of mathematics and between mathematics and other disciplines. The emotional aspects of working as a mathematician have also been noted by Davis and Hersh (1998, p. 169) where they lamented that "blindness to the aesthetic element in mathematics is widespread and can account for the feeling that mathematics is dry as dust, as exciting as a telephone book ...".

Group Work

From Burton's work and learning theories, the value of collaboration in learning is widely recognised and yet in most mathematics classroom the teaching of mathematics is an individual pursuit. With Indigenous students, we suggest the need for collaboration is even more important due to the strong sense of community among many Indigenous cultures. By enabling students to work in groups where each member is able to bring their own particular strengths and knowledges to the situation, there is greater opportunity for students to build on each others' thinking and so come to a richer understanding than would be possible if working alone. Furthermore, when structured well, group work has been found to enable the inclusion of students who may have cognitive or social challenges (Lewis, Trushell, & Woods, 2005). However, the group work must be well structured so that it is not the case of students sitting in a group working individually. The tasks

must be carefully chosen so that there are a range of skills needed for the resolution of the task.

Within this approach, the collective strengths within the group enable a group to complete a task that would be more difficult (if not impossible) by working alone. The group assumes responsibility for the learning of all members in the group so that if one student does not appear to understand the concept/s that are the focus of the lesson or activity, then they need to support their peer so as to enable him/her to understand the work.

There is a significant literature on group work and how best to organise the small groups. We recommend that the group work would have 3-5 children in each group. However, in many communities, the class sizes are small – in some cases, there may only be enough for 1 group in a class, and that the group may consist of family members due to the ways in which the community is formed. This creates a unique context for group work in some Indigenous communities, particularly those communities that are in remote areas of the country. However, while such constraints may create particular circumstances, the principles of group work outlined below can be adopted and would encourage interaction and deep learning – mathematically, socially and linguistically.

Roles defined

The early introduction of group work entails considerable background work to be undertaken so that students are able to make the most of collaborative learning. In part this is due to the widely held view that maths is an individual pursuit. From Cohen and Lotan's (Cohen & Lotan, 1997) work, roles within the group are defined. They argue that one of the key roles is that the group leader assumes responsibility for identifying when all members of the group seem to have developed the appropriate understandings that will be robust enough for teacher scrutiny. The group leader will make a decision as to when to call the teacher to the group.

Within the group, the roles are to enable cognitive work to be undertaken. In some group work, roles are assigned (such as notetaker, gofer, etc) that enable the students to avoid participating in the cognitive work of the group and hence withdrawing from the intellectual activity. In this approach, the roles are to enable all students to participate in the group. The roles may vary depending on the activity but could include the following:

Moderator: This role has the group member ensuring that there is a balanced participation in the group and that all students have the possibility to engage in the activity. This role ensures that one student does not dominate the conversation or activity.

Philosopher: This role is to promote and provoke discussion through the use of questions. The questions can be used to foster deeper thinking about the issues; to justify a position being taken by a member of the group; to clarify responses or comments made by members of the group and so on. This is achieved through the use of questions.

Scout: This role is a more subtle one and is to encourage the participation of the more quiet students or of students who can be excluded by their peers. In Cohen's work on Complex Instruction she focused on the importance of inclusion of socially marginalised students. This is one aspect of this role. Some students are often shy and reserved and may have significant things to offer but do not come forward easily or of their own volition. The scout listens and/or observes the group work and seeks to find subtle nuances in his/her peers and then encourages that person to offer comments. The role is different from the moderator (which is more about controlling dominant members). This role is about engaging the quieter members in the group.

Teacher as Facilitator

The teacher's locus of control is substantially different in this approach. Rather than directing the lesson, the teacher must select or design activities that will enable students to work independently of the teacher. Appropriate scaffolds need to be developed in advance so that students are able to take control of their own learning. The teacher will work around the groups, taking particular notice of discussions so as to draw on these at the end of the lesson to demonstrate the diversity across the groups. When the students are in the groups, the teacher will set the students to task, and then, when called over by the group leader, select one student to respond to her/his questions. Where a student does not understand the questions being posed by the teacher, then the teacher walks away and the students assume responsibility to enable their peers to better understand the mathematics. This shifting of control from the teacher to the students is a significant move away from the usual ways of teaching in mathematics. In this model, the main role of the teacher is to design or select tasks that will engage the group in deep mathematical learning rather than in direct teaching.

Questioning

The role of questioning is a key aspect of this approach. It has been noted in other research, that the questions posed in mathematics classrooms are often low order, recall type questions. These result in a low level of intellectual quality that has been noted in mathematics classrooms through the QSLRS study. To shift to a higher level of thinking, the posing of questions that foster deeper knowledge and access deeper understandings requires a shift to higher levels of questions being posed. A simple taxonomy of questions (Biggs & Collis, 1982) can be used to develop questions to stimulate much richer conversations – either in the group work or at other phases of a lesson. Similarly, the work that has been undertaken through approaches such as the Philosophy in Schools approach also relies on higher order questioning. Students also need to learn how to pose questions to their peers. Scaffolding students to enable them to acquire this skill may take some input, particularly in Indigenous contexts where such a process may be more difficult due to cultural and linguistic barriers to this approach. As Boaler (2008) found in her work in the US, enabling students to engage in higher levels of questioning to their peers helps to facilitate

higher levels of interactions and respect for their peers which has significant flow on effects. Questions that seek to have students justify, clarify, extend etc their thinking strongly aligns with the ways of working as a mathematician.

Rich Mathematical Tasks

Drawing heavily on the work from productive pedagogies where the intellectual quality of tasks is the focus of teaching, the selection or design of mathematical tasks becomes critical. Of primary importance is the richness and depth of the mathematics learning that is facilitated through the task. The task can vary in duration but it is a significant move away from the small lesson activity that dominates much contemporary practice. By creating learning opportunities that encourage depth of learning, it is recognised that learning takes time and cognitive energy so that the short activities that occupy significant curriculum time in mathematics (Education Queensland, 2001), there is little opportunity for depth of learning. Further, rote and skill/drill learning is very shallow learning and has little value in terms of the depth of learning that Burton advocated. Drawing on Burton's (2004) work on research mathematicians, the task should allow for students to work mathematically. By creating opportunities for the 'aha' moments; for connections among mathematical ideas; to draw on early learnings (of the group) in order to build richer conceptual learning; collaborate and share knowledge; to intuit, rationalise, conjecture, hypothesise, test ideas, justify, and challenge mathematical ideas; and to represent thinking in a range of modes are key to the selection of tasks that will enable and foster deep mathematical learning. The task should allow for multiple entry points and multiple pathways, and cater for the diversity in thinking and working mathematically.

Multi-representational

Creating opportunities and scope for students to express their mathematical thinking and reasoning in ways that suit the individual, the context, and/or the task allows for greater inclusion in activities. Learners may have preferences in terms of how they think through problems – creating mental maps; using logic and reasoning, drawing pictures, using mathematical notations and so on – so creating space in the curriculum to cater for these different ways of thinking, learning and representation opens up the learning opportunities for students. This is particularly the case when students are encouraged to share their ways of thinking with their peers. Such communications can happen within the small group work or at the end of the lesson. By sharing their representations with peers students can access other ways of thinking and representing mathematics so as to extend current modes of operating. Further it creates opportunities that enable students to create networks of thinking mathematically (Burton, 1999).

Use of Home Language

For many Indigenous students living in remote or regional areas, the speaking of English is a second language activity. Indeed, in some areas, English is spoken primarily at school with most communication outside the school being undertaken in a home language. Often this is a Kriol. In many urban settings, the students often speak a form of English that may resonate with much of everyday English but still be somewhat different from the middle-class English of formal schooling. These forms of English, often known as 'Koori English' or 'Murri English', have their own structures and nuances. The work undertaken by mathematics educators who focus on mathematical instruction being in a second language or other language (for example the work of Setati and Barwell) highlights the complexities of mathematical learning and code switching. Creating space for students to negotiate complex ideas with their peers in their home language enables the students to reduce the cognitive load created by translation of basic language and thus free up cognitive space for the mathematical learning. In her work with Railside, Boaler found that the school enabled students to negotiate mathematical meaning in their home language (in this case, Spanish) so that the students were able to debate, challenge, clarify, explain in a familiar language and in that process come to understand the mathematical concepts. Once depth of understanding is made possible, students are better able to then report back at the conclusion of the lesson.

Reporting Back

Frequently teachers use the final session of a lesson for the students to 'show and tell' but in a reform classroom, this session becomes an important aspect of the learning. Not only do students report back on their group work, but interactions between groups become a central aspect of the classroom dialogue. Students may need to be scaffolded in learning how to pose questions that will support their peers in their articulation of their thinking and working as mathematicians. At the conclusion of an activity, the group reports back to the whole class. Students in the classroom are expected to pose questions to the reporting group that will seek to clarify the processes used by the group as they came to understandings; justify the processes and/or knowledge that has been created; seek clarification about aspects that are unclear; scaffold their peers when it appears as though there may be an error or misunderstanding; and to support their peers to move towards deeper understandings about the work that has been undertaken. These questions not only help the reporting group to develop richer understandings and connections but also support the other members of the classroom to understand the work that they have done as well.

The teacher plays a critical role in this phase of the lesson or activity. As the facilitator, it is prudent that observations have been made of the groups in the working time so that groups can be targeted in this phase to elicit different responses or ways of working. This careful selection of groups, and the order of their presentations can be an important learning process for all students. It does not mean that those with simpler or incorrect

responses will go first in this phase as this would become as prescriptive as current practice. What would be sought is a process that will help student to better understand the concepts and processes that are foregrounded in the activity.

Conclusion

In this paper we have sought to identify the complexity of teaching mathematics in culturally and linguistically diverse contexts, such as Indigenous classrooms. We have drawn from an extensive review of literature to provide the contemporary context of education for Indigenous communities while recognising that there is no one Indigenous community. Like all cultural groups, there is considerable diversity within the Indigenous people of Australia. This is a salient point but a critical one. The life worlds for Indigenous people are what provide a unifying theme that separates them from non-Indigenous people. However, we recognise that many of the obstacles that Indigenous people face can be likened to other oppressed groups in Australian education – working-class families, remote communities, rural communities, linguistically diverse communities and those living in poverty. Many of these factors are compounding so that multiple disadvantage is not uncommon. Coming to develop a mathematics education that will redress some of the structural disadvantage that is now entrenched in much teaching of mathematics was a central aim of this paper. To this end, we have posed a model that draws on a wide range of literatures. The model has pedagogy at its core. The focus foregrounds learning (as opposed to teaching) as the key proposition for quality outcomes for Indigenous students. The model proposed represents a significant shift away from many of the approaches that are used in mathematics teaching, particularly for students who are most at risk of failing school mathematics.

In drawing on Bourdieu's theoretical project, we propose a significant shift in the practices of mathematics education. This shift will require strong leadership if it is to be successful as it challenges the status quo. This leadership will be from principals through to classroom teachers. The practices of school mathematics will need to undergo considerable change if the challenge to improve learning for Indigenous students is to be achieved. By building upon the habitus that the students bring to the learning environment and then creating opportunities to engage with the knowledge and processes associated with school mathematics, Indigenous students should have greater opportunities to acquire the skills, knowledges and dispositions that are central to success in this discipline. This approach is substantially different from the practices that have been so dominant in the teaching of mathematics but have been less than successful for Indigenous students. As such, a radically different approach is needed if the current situation is to be changed.

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Creating equitable practice in diverse classrooms: Developing a tool to evaluate pedagogy*

Robyn Jorgensen, Richard Niesche, Peter Grootenboer and Jo Boaler

Introduction

With Australia performing so poorly in terms of equity in mathematical achievement on the PISA scores, there is an increasing recognition for practices that may stem the inequities in education in this country. This paper explores an approach that has been found to be highly successful in the United States and links it to current issues in Australian education. Practical considerations are made regarding the application and implementation of such reform pedagogy when particular nuances of Australian issues are considered. In particular, the development of a tool to evaluate reform pedagogy is the focus of this paper.

Increasingly classrooms are becoming more diverse and with such change, new forms of pedagogy are needed to enable the greatest likelihood for success for all students but most particularly for those students who traditionally have been most at risk of not succeeding in school mathematics. Alarming, Australia performed well on international comparisons in terms of overall performance but was one of the poorest performing countries in terms of equity (Lokan, Greenwood, & Cresswell, 2001). These authors contend that the outstanding performance of some students overcompensated for the poorer performing students to allow for a good overall outcome. The concern for us is the large gap between those who perform well and those who do not. Such poor performance is not random but strongly aligned with the social, cultural and geographical location of students. In this paper we discuss these highly differentiated

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performances and propose an alternate pedagogy that has been found to be highly successful in some contexts outside Australia, but with modifications that appear to be more amenable to the unique situations of Australian education. Further, we discuss the difficulties with the implementation of such a model and the challenges to the implementation of such a successful model.

Differential Outcomes in Australian Education: The Case of Most Disadvantage

MCEETYA (2006) reported the results for students in the national testing schemes from 2005. Comparisons of these figures show that for students who come from Indigenous backgrounds and/or live in geographical remote regions are considerably more at risk of performing poorly on standardised tests than their peers in urban or regional areas, or students who are non-Indigenous. Furthermore, it can be hypothesised that some students may have their disadvantage compounded by the multiple disadvantage caused through the combination of factors. For example, Indigenous students who live in remote areas may be at increased risk of performing poorly in mathematics than their peers who are in different social/cultural or geographical locations. The differences in performance by location can be seen in Table One where there are considerable differences between students who live in Urban areas (and perform higher) than their peers who live in very remote areas (and perform lower).

State	Year 3			Year 5			Year 7		
	Metro	Very remote	diff	Metro	Very remote	diff	Metro	Very remote	diff
NSW	95.5	86.1	9.4	92.2	74.3	17.9	77.3	61.8	15.5
Vic	95.5	na		95.2	Na		87.3	Na	
Qld	93.2	76.8	16.4	89	63.1	25.9	84.5	54.3	30.2
SA	93.3	78.7	14.6	90	63.1	26.9	87	54.1	32.9
WA	91.9	67	24.9	88.2	57.3	30.9	85.9	57.9	28
Tas	92.4	86.8	5.6	89.8	83.2	6.6	82.3	na	
NT	Na	65.5		na	35.6		na	31.9	
ACT	94.6	NA		93.2	Na		88.1	na	
Aust	94.6	73.2	21.4	91.8	54.5	37.3	83.1	49.4	33.7

Table 1: Percentage of Students Performing to Benchmark by Geolocation, 2005. (Source: MCEETYA, 2005)

These data highlight the significant differences in performance by students according to their geographical location. For us, what is alarming is there is relative consistency in the data for students who live in metropolitan areas and their peers in remote areas regardless of state. Furthermore, the decline in performance of students in remote regions over time is a point for noting (and action).

In the following data, we consider the data on Indigenous students (Table Two below). A similar trend to that noted in Table One can be observed for Indigenous students. These data suggest that as Indigenous transit through formal schooling, the difference in performance with non-Indigenous students increases with duration of time. As with the students from remote areas, the gap in performance increases as students move through formal schooling by approximately 10% for each period. State performance varies which we contend may be a factor related to Table One where those states which have considerable numbers of Indigenous students living in very remote areas may have greater likelihood of poorer performance on the state-wide testing schemes.

State	Year 3			Year 5			Year 7		
	All	Indig	diff	All	Indig	diff	All	Indig	diff
NSW	95.4	87.6	7.8	91.7	75.4	16.3	75.8	44.5	31.3
Vic	95.5	91.8	3.7	95.4	89.5	5.9	86.9	66.5	20.4
Qld	92.7	78.9	13.8	88.1	65.8	22.3	83.2	54.5	28.7
SA	92.6	74.5	18.1	90.1	69.8	20.3	85.7	55.8	29.9
WA	90.2	64.8	25.4	85.9	51.6	34.3	84.3	46.8	37.5
Tas	91.2	82.4	8.8	89.1	78.7	10.4	80.5	66.4	14.1
NT	86.2	68	18.2	69.6	35.1	34.5	64.8	24.9	39.9
ACT	94.6	92.8	1.8	93.2	81.4	11.8	88.1	62.6	25.5
Aust	94.1	80.4	13.7	90.8	66.5	24.3	81.8	48.8	33

Table 2: Percentage of students achieving the numeracy benchmark by state, 2005. (Source: MCEETYA, 2005)

We acknowledge the problematic nature of state-wide tests which have some limitations in what they are able to test, the protocols around the tests, and the limitations imposed by the marking schemes and hence what can be assessed. Such limitations restrict what and how assessment can be developed. However, the tests do alert educators to the considerable differences in performance and the need to redress such performance.

Reform Pedagogy

Drawing heavily on the work of Boaler (2002) who has systematically documented the pedagogy and performance in reform classrooms in the

United States over an extended period of time, we take those characteristics that she proposed as instrumental in creating equitable outcomes for students as they come to learn school mathematics. The reform pedagogy that Boaler studied was that of Complex Instruction developed by Cohen and colleagues (Cohen & Latan, 1997). At its basis, it draws on a range of literatures to develop a pedagogy that takes a number of key ideas: group work where students assume responsibility for group learning and action; assigning status to those students who may otherwise be marginalised within a group; complex tasks that are rigorous and foster deep learning; and multidimensionality where students can represent their thinking and processes in ways at suit their unique thinking styles.

Boaler's extensive research in classrooms has highlighted the power of this approach in changing the learning outcomes for students, particularly those students from the most disadvantaged contexts. Her extensive study of Railside has illustrated how the school moved from the poorest performing school in California to 'above state average' over a period of 4 years. This radical transformation was seen to be brought about through the use of the Complex Instruction approach. Boaler (2008) noted that the outcomes of the approach are not limited to cognitive outcomes but also to social outcomes where she found that the students also learned how to resolve social and cultural conflicts outside classrooms as a consequence of their participation in the reform.

Linking Reform Pedagogy with Productive Pedagogies

Boaler's work is overlaid with the extensive research undertaken in Queensland schools through the Productive Pedagogies framework (Education Queensland, 2008). This approach has many of the features of Boaler's reform pedagogy in terms of intellectual quality and supportive learning environments but within a framework for both action and research. We do not intend to expand the Productive Pedagogies Framework in this paper as it has been taken up by most Australian states in some form or another and has been the basis of a considerable number of research papers. There are four dimensions within the framework – Intellectual Quality, Relevance, Supportive School Environment and Recognition of Difference – in which there are a number of pedagogies that are evident of that theme. In total, there are 20 identified pedagogies. These pedagogies have been used as the basis for the Queensland Schools Longitudinal Reform Study (Education Queensland, 2001) where schools across the state were studied in terms of pedagogical quality using the framework. Extensive work was undertaken to break each of the pedagogies into qualitatively different features that explicated the degree of take up so as to form the basis for observational schedules. A scaling system that recognises the degree of implementation for each pedagogy was developed using a 1 to 5 scale that, in simple terms, identified a 1 as being not an integral component of the classroom pedagogy through to 5 which identified the pedagogy being an integral feature of the classroom practice.

The model used within the Productive Pedagogies framework has been a useful tool for analysing mathematics classroom practice (Zevenbergen & Lerman, 2007). It provides a very general framework for deconstructing pedagogy as a whole. However, it also has some limitations. Most particularly for the mathematics classroom, it does not allow for the depth of analysis related to mathematical ideas. We also contend that it does not allow for the depth of analysis that Boaler's equity work has identified specifically as it applies to the teaching and learning of mathematics in diverse classrooms. To this end, we are developing a tool that incorporates the key aspects of the Productive Pedagogies framework and incorporating the aspects identified through Boaler's study of Railside.

Developing a Tool for Analysing Equity in Mathematics Classrooms

In the remainder of this paper we draw on our work where we are seeking to develop a tool for analysing classroom practice in terms of building equitable outcomes for learners. Given the data we highlighted at the commencement of this paper, we see it as critical that pedagogies be explicitly developed to redress these outcomes. To develop a tool, we have combined the work cited above – that is, the equity work of Boaler with the processes and principles used within the Productive Pedagogies framework.

To date, we have been working with a series of video tapes that were part of a previous project and that have been analysed with the Productive Pedagogies framework ((Zevenbergen & Lerman, 2006). The videos were known to the research team and were selected on the basis of their breadth in inclusive practices. Some of the videos were highly inclusive through to videos that were very traditional in their approaches to teaching mathematics. These were correlated with the initial analysis of the data (Lerman & Zevenbergen, 2006)

Using the approach adopted with the Productive Pedagogies Framework, the video data has been explored by at least 3 researchers who have negotiated each of the dimensions that were identified in Boaler's work and extended these to specifically address Australian issues. For example, one of these is the use of home language. For many of Indigenous students the language of school instruction is different from that spoken at home. In many remote communities, Indigenous students come to school speaking a Kriol. For these students negotiating meaning becomes complex when there is high demand for translating between the school and home languages, particularly when the home language is relatively "restricted" in a Bernsteinian (1990) sense and does not have the same patterns of signification found in school language.

In working through these videos, the research team has negotiated their understandings of practice in relation to the key dimensions to establish a scoring system that aligns with that of Productive Pedagogies. We have created 4 overarching categories that are then broken into smaller, more identified items. The negotiation process between the research team has

created a rich discussion that has enabled the unpacking of what is meant by each criteria and the progressive adoption of each criteria on a 5 point scale which range from 1-5.

In the following sections we provide the criteria that have developed as a consequence of the video analysis and negotiations among the research team. Preliminary application of these criteria to 5 videos indicates that the scoring rubric tends to work across the settings.

The Scoring Rubric for Equitable Pedagogy

In this section we provide the descriptors and scores for each of the identified pedagogies relevant to equitable pedagogy.

Process

Drawing on the process outlined in the University of Queensland Manual, we provide the following description of the scoring process. When scoring for each lesson, observers should carefully consider the explanations given for each dimension, using the descriptors of the scores from 1-5 for each criteria. If any difficulty is encountered in selecting between two scores, the observers should consider whether the minimum criteria for each score have been met. If these criteria have not been met, the lower score should be used. In determining the scores for each dimension, the observers should only consider the evidence seen during the specific period. The observers should complete the criteria sheet at the end of the observation period.

Equitable Pedagogies

Group Work

The group works collectively in resolving the task. People's input is drawn upon to solve the problem.

1. No group work is evident in the lesson
2. Group work is used for a brief activity over a small portion of the lesson
3. Group work is used over about half of the lesson
4. Group work is evident for almost all of the lesson
5. Group work is an essential component of the lesson in its aims and structure.

Multiple Pathways

The teaching approach and/or activity allows for students to draw on their knowledge to construct different pathways to resolving the task or problem. This may be through drawing on different forms of knowledge and knowing.

1. No multiple pathways offered by the teacher for students to solve the task or problem
2. Students given some minor variations or pathways in which to solve the task or problem
3. Students are given different starting points for the task, and some pathway variations, albeit in a limited fashion
4. Students have either different starting points or multiple pathways and some level of choice in representation
5. Students are able to use a variety of representations, multiple pathways and engage at different starting points. All three must be present.

Multiple Entry Points

The task/problem is designed so that students can draw on different entry points when starting the task/problem.

1. Tasks have only one entry point strictly controlled by the teacher
2. Teacher outlines limited variety of entry points with no student control
3. Students have some control over entry points of the task within set parameters
4. Teacher allows a variety of entry points for differing abilities
5. Teacher allows complete student discretion in the undertaking of an open ended task or problem.

Roles within the Group

The social organisation involves the clear expectations that members of a group will have particular roles within that group. The roles are followed so as to enable each person to be an active and instrumental member of the group.

1. Teacher defines roles of the group with no collective responsibility
2. Students have linked roles that are still teacher directed to complete the task
3. Students work as a collective but with predetermined roles and objectives
4. Teacher has limited responsibility in the setting up of the collective roles and responsibilities
5. All students in the group work collectively and take responsibility for each other with no direction from the teacher

Quality Interactions within the Group

The pedagogy allows for quality interactions among peers where peers can discuss and debate mathematical ideas as part of their pathway to resolving the task/problem.

1. Students are arranged in groups but have little or no interaction
2. Students have limited interaction with each other or for a brief period
3. Students are engaged in mostly low level interactions with each other for a substantial portion of the lesson
4. Students are engaged in high quality interactions for a significant portion of the lesson
5. High quality interactions with high order thinking processes evident between students for almost all the lesson.

Teacher as Facilitator

The role of the teacher is to absolve responsibility for learning to the students. Through the careful development of scaffolding techniques and task selection, the students take responsibility for their own learning and the learning of others within the group. The teachers' role is to check that students remain on task, provide quality tasks, and to provide assessment when appropriate to the group's progress.

1. Teacher takes all responsibility for the learning, task design and assessment
2. Teacher absolves very limited responsibility to the students
3. Students take some responsibility for their learning in terms of the collective learning in the group and staying on task
4. Students take responsibility for their learning with the teacher facilitating students' learning
5. Students take full responsibility for their learning with teacher facilitating students' learning through an appropriate task

Use of Home Language

Students are able to draw on their home language to negotiate meanings. When reporting back, the student/s should use standard Australian English.

1. No use of home language allowed within the classroom. Complete reliance on English
2. Teacher allows limited use of home language between students
3. Students and AEWs often use home language in the classroom
4. Teacher encourages use of home language and also attempts to learn and communicate using students' home language

5. Teacher, AEWs and students use students' home language on a regular basis to facilitate the students' understanding of mathematical concepts and learning

Multi-Representational

Catering for the diversity among learners, the tasks should foster, and allow for, various methods of representation that cater for the different skills and dispositions that learners bring to the task. Provided that the result is reasonable, the pathway and mode of representation is valued.

1. No options given by the teacher for students to represent their work
2. Some limited forms of representation allowed by the teacher but these are strictly teacher controlled
3. Teacher encourages some variance in task reporting but within guidelines set by the teacher
4. Students are given an open ended task with some brief parameters for representational options
5. Teacher supplies a broad, open ended task that allows students to fully decide on ways of reporting back and representing their work.

A Way Forward

As a tool for exploring practice, we have found the Productive Pedagogies method to be a useful but limited tool when exploring equity in mathematics education. The model that we are building towards draws on the extensive work of Boaler, extended and modified for the Australian context, appears to have application for our work in the area of equity and mathematics education. It is our intention to apply this model to a range of projects with which we are currently involved. Preliminary applications indicate that there is considerable scope for success. We anticipate that as the model is implemented it will be further refined for the particular contexts within which we work.

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Scholastic heritage and success in school mathematics: Implications for remote Aboriginal learners*

Robyn Jorgensen and Peter Sullivan

Introduction

At the cultural centre at Yulara, in the hotel rooms, and at the base of Uluru, there are signs making it clear that the rock is considered sacred by the traditional owners, the *Anangu* people, that it has spiritual significance, and is connected to the spirits of ancestors. Visitors are specifically asked not to climb on the rock as it violates the social norms and cultural beliefs of the *Anangu* people. Yet on any day there is a steady stream of climbers, so much so that there is now a track embedded in the rock face. Worse still, some choose to defecate on the top and celebrate this on websites. This abhorrent violation of a national cultural icon warrants some serious questioning. It was reported that tour operators emphasise the spiritual significance of Uluru, and they report that around 90% of visitors respect the wishes of the traditional owners. While only a small minority do climb, they are publicly and explicitly displaying a deliberate disrespect for the wishes of the *Anangu*. Our question, though, is to ask why the appropriate authorities have not prohibited climbing. It seems like a paradigmatic exemplar of the failure of government policy to respect cultural sensitivities. Unfortunately, although less obviously, governments have also failed to respect cultural differences in provision of education opportunities. This is the focus of this paper – how does education policy fail to address the cultural sensitivities of Aboriginal people and in so doing destroy the fabric of their well being. Some of these failures are in the partnerships with the

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communities, of recognising cultural sensitivities in provision of funding and resources, and in the adaptation of content and pedagogy to the cultural, linguistic, or social backgrounds of the students.

In preparing this paper, we draw on our collective experiences across two diverse Aboriginal contexts. The first is our experience in the Kimberley region where we have been working on a 4 year Australian Research Council grant across 6 communities in the Fitzroy River valley. The second experience is our work in the Central Desert region of Australia which crosses into 3 states in the Central Australia region. These experiences show the similarities and differences across Aboriginal communities. For our purposes here we draw on these experiences to argue the ways in which the practices of school mathematics exemplify the structuring of unequal access to education for many Aboriginal learners. We draw on the work of Pierre Bourdieu to understand how these practices work to exclude Aboriginal learners. However, we then argue that by gaining a better understanding of how such practices work in the reification of educational disadvantage, we are better able to understand and propose ways forward to address structural inequality.

Social Heritage and Success

For Aboriginal³ learners, coming to school represents a new social world where the rules of engagement are different from those of the community and home. For example, Anangu children from Central Australia are very strong in their cultural histories and are encouraged from a very early age to be independent and make their own choices – which includes whether or not they come to school. Anangu learners speak their home language of Pitjantjatjara in the homes and communities so the school represents a foreign language environment and yet all instruction and concepts are based in a language and culture that is unfamiliar to them. Indeed, the Northern Territory government recently announced the cessation of bilingual programs in that state for Aboriginal learners. This is despite the considerable research into bilingual education that supports a transitory period from the home language to Standard Australian English (SAE). Much of the pedagogic relay used in schools is one that is so foreign to Anangu learners that coming to learn anything through the instructional mode of classrooms is an alien process. When such factors are considered, it becomes blatantly obvious as to the limits of success that are made possible to Anangu learners. We have observed similar differences for Kimberley students who may not be strong in their original Aboriginal language or culture and now speak a Kriol. This Kriol also shapes their language, their world view and poses particular challenges to engaging with the discourse of school mathematics and SAE.

³ As we are drawing on experiences from the Central Desert region and the Kimberley region, we are concerned with Aboriginal learners. We do not intend to specifically address issues around Torres Strait Islander people in this paper but do recognise their rights and ties to Australia and indigeneity in Australia.

To better understand the processes by which the home language of Aboriginal students clashes with, and constrains their access to, school mathematics, the work of Bourdieu is used to theorise the symbolic violations that occur when the clash between school and Aboriginal learners is foregrounded. While his focus was on social class, Bourdieu explains that educators need to understand the processes around the conversion of social and cultural backgrounds into school success. He argued that:

To fully understand how students from different social backgrounds relate to the world of culture, and more precisely, to the institution of schooling, we need to recapture the logic through which the conversion of social heritage into scholastic heritage operates in different class situations (Bourdieu, Passeron, & de saint Martin, 1994, p. 53).

The notion of social heritage thus becomes a central variable in coming to understand the differential successes in school mathematics. Using a Bourdieuan framework, the lack of success for some social groups becomes a non-random event where it is a product of institutionalized practices of which participants may be totally ignorant. Participants, in this case, are more likely to be those entrenched in the school system rather than the Anangu learners. In the remote contexts of Central Desert communities of Australia, the clash between the culture of school with the culture of Anangu learners contributes significantly to the success, or lack thereof, for Aboriginal learners. Similarly, we have observed these clashes in the Kimberley region.

School mathematics represents a particular, and powerful, example of how social heritage converts to academic success. Language is an integral part of the social heritage that is brought into school mathematics and becomes reified to be seen as an innate ability that facilitates, or not, success in coming to learn the discipline knowledge within the field of school mathematics. We do not subscribe to this view of innate or ability but it is an entrenched and naïve belief within the field. The language, in very broad terms, not only conveys particular concepts but also provides a medium through which those concepts are conveyed. It is therefore important to consider not only the concepts that are being considered but also the medium of instruction.

When taking a Bourdieuan perspective, success in school mathematics is less to do with innate ability and more to do with the synergistic relationships between the culture of school mathematics and that which the learner brings to the school context. The greater the synergy between the habitus of the student and school mathematics, then there is greater probability of success. In Bourdieuan terms, the habitus thus becomes a form of capital that can be exchanged within the field of school mathematics for forms of recognition and validation that convert to symbolic forms of power. Such manifestations of this conversion can be seen in grades, awards, scholarships, and other forms of accolades. For Aboriginal learners, coming to learn school mathematics requires much more than coming to learn mathematics. Coming to learn mathematics requires a

significant cultural and linguistic shift. In the following sections we will provide some examples of how this may occur.

Variables around language and patterns of interactions must be foregrounded. Taking the communities of Central Desert lands, a common language among learners is that of Pitjantjatjara. In Pitjantjatjara there are only 6 prepositions whereas English has 64 so one can only imagine how learners make sense of the differences between terms such as near, next to, beside, adjacent, left or right when talking about the relationship between two objects placed alongside each other. Similarly, Pitjantjatjara does not have a comparative language so terms used for comparison – such as larger, smaller, taller and tallest – are not present in the home language. Whorfian theory would suggest that the language and context shape the need for particular terms. As such Pitjantjatjara learners not only have to learn the language of prepositions and comparisons but also the deeply embedded concepts associated with such terminology. This is often difficult for those who have grown up in a language and have accepted the terms and concepts as a normal part of that language and culture. In this context, coming to learn such concepts requires a reconstruction of fundamental learnings. For Bourdieu, this would require a reconstruction of the habitus. In Bourdieu's theory, the habitus is the internalization of culture and provides a medium through which people interpret their worlds. The complexity of these relationships can be better understood when living in temperate zones, how difficult it would be to imagine 32 different forms of snow. Yet, such challenges are what is being imposed upon Aboriginal learners as they enter mathematics (and other) classroom settings.

The ways of interacting and communicating also need to be considered. One of the major aspects of classroom interactions is questioning. In Western schooling, the role of questioning is significant but it violates the everyday use of questioning. The teacher uses questioning to elicit responses from the students even though he/she may know the answer. In everyday life, the function of questions is to elicit responses for an unknown problem. From a Bourdieuan perspective, the notion of 'game' becomes useful to theorise the role of questioning in classrooms. Bourdieu has employed the metaphor of a game to theorise how social practices enable some participants to be winners and others to be losers. The games metaphor is an apt one as it enables a theorisation of how the practices within the teaching of mathematics enable some students greater access to mathematical knowledge while excluding others. Bourdieu (1990) explains it in the following way:

The earlier a player enters the game and the less he is aware of the associated learning, the greater his ignorance of all that is tacitly granted through his investment in the field and his interest in its very existence and perpetuation and in everything that is played for it, and his unawareness of the unthought presuppositions the game produces and endlessly reproduces, thereby reproducing the conditions of its own existence. (Bourdieu, 1990, p. 67)

The game which, in this case, is questioning often revolves around the students having to guess what the teacher wants or what is in the teacher's

head. The purpose of the question is not to find out an unknown piece of information. So, when the teacher poses a question such as "what is the sum of 16 and 35?" the game being played is not one where the answer is unknown but rather for the students to elicit responses whereby the teacher may be seeking to identify which students have grasped the concept, which students may be experiencing difficulties with this type of addition, or which students have been able to transpose learning from one addition process to this process. However, what happens in many Aboriginal classrooms is that the students appear to engage in a different game. Their game is one where they are seeking to please the teacher by offering responses, or offering responses to help the teacher work out the response since clearly the initial (correct) response was incorrect as she kept seeking to find other responses. We have observed this game in the Cape and Strait schools of far north Queensland, in our Kimberley project and in the Central Desert area of Northern Territory. We suggest that in these contexts, the mode for eliciting responses has been misinterpreted by the students. We contend that the students have engaged in a parallel game from that which the teachers intended. The students' responses are counter the goal of the teacher and as such can be misinterpreted

From these examples, it begins to emerge that the social background of the students shapes their ways of seeing and interacting in the social world of the classroom. In other words, the habitus of the students provides a lens for seeing, interpreting and interacting in the classroom. However, for many Aboriginal learners that habitus is one which is not aligned with the field of school or school mathematics. In conceptualizing this within Bourdieu's framework, what can be seen is that the social heritage of the students is combating with the implicit rules of the classroom thus making success in mathematics challenging. The (in)ability to morph from the habitus of the Aboriginal students to that of a learner of school mathematics demands significant reconceptualisation of the social background of the learner. Not only learning the language with all of its nuances of English and mathematical concepts and processes, the Aboriginal learner must also come to understand, participate in and be successful with the dialogic interactions of the classroom banter. These are not insignificant challenges.

The fundamental assumption that underpins this chapter is that the social heritage of the learner is a critical factor in the success of the student. Where that social heritage becomes a strong feature of the habitus that remains impermeable to change, then there is a greater risk of failure within the school setting for students whose habitus is not which is aligned to the field. Using this as a principle, there is now a significant challenge to views about innate ability and its relationship to success in school mathematics or schooling in general. We contend that Aboriginal learners are highly intelligent and that their lack of success in schooling is not due to innate ability but rather a clash between the practices of schooling and the social heritage of the students.

Scholastic Mortality

To this point, our argument has been to highlight the processes through which the field of school mathematics constructs and constrains access for particular learners. These are very subtle and often remain hidden to both learners and teachers who have come to see school mathematics as an apolitical practice. However, we contend that this is the exact process through which hegemony is realised. For Aboriginal learners (along with other marginalised learners) the field of school mathematics remains relatively impermeable. This is not due to the innate abilities of learners but as a social marginalisation whereby the social heritage of the learner is at loggerheads with the objective and subjective structuring practices of the field. Consider the Aboriginal learner who comes to school without the comparative signifiers and signifieds in their home language. The instructional discourse of the early years where comparisons are an integral part of that discourse are non-sensical – which number is bigger than; how many more is 4 than 5; and so on. These types of questions fail to make sense to those whose home language does not have such comparative terms.

Some Aboriginal activists such as Sarra (2007) and Pearson (2009) have strong views about the ways in which education provision needs to be provided for Aboriginal (and Torres Strait Islander) students. These will align with the views expressed in the volume by Mick Dodson. We concur with their views of having high expectations of students (and teachers) and placing the best teachers with Aboriginal students. However, we suggest that even with high expectations and great teachers, what is missing from these views is the understanding of the symbolic violence that can occur to Aboriginal learners when educators are not cognisant of the cultural norms and language nuances impacting on learning. While the climbing of Uluru at the start of this paper is a blatant violation of the culture of traditional owners of Uluru, education can be far more subtle and pervasive. What we have attempted to show in this paper is how coercive this process can be. Educators need to be astutely aware of how culture is implicated in learning and how this can be addressed so as to reduce the possibility of scholastic mortality among Aboriginal and Torres Strait learners.

Scholastic Mortality and NAPLAN Testing

Within the Australian context, a national testing regime has been implemented. The tests are administered across most Australian schools. The examples have been challenged (Zevenbergen,) and shown to have quite a language and cultural bias. This bias significantly disadvantages Aboriginal learners, but most particularly those who live in remote areas. Not only does the language and sociology of the testing process violate the cultural and linguistic norms for these students, the examples provided within the format fail to account for the contexts of these students. Imagine the ludicrousness of asking questions about in-line skates to students who live in Central desert regions or conversions between English and Brunei currencies yet such examples appeared in the 2008 tests. These may be challenging for urban students due to the context but even more profound for English-as-Foreign-Language learners such as the students in the Kimberley or Central Desert regions.

Funding models and reporting schemes (such as those on the ACARA site) show the results of NAPLAN tests against schools. The normalising processes associated with this 'objective' and standardised testing scheme is highly problematic. It is well documented that students from economically-deprived families; students living in rural or remote regions; students whose first language is not SAE and 1st Australians are most at risk of poor performance on these tests. When Aboriginal students from Central Australian or Kimberley regions are considered, their levels of educational disadvantage are multiplied and thus creating greater levels of educational disadvantage. Testing students does not make students smarter, but appropriate intervention can help to address the gross inequalities in education in this nation.

The Structuring Practices of School Mathematics

In this section we draw on some practical examples drawn from our work across Aboriginal contexts to highlight the problematic nature of school mathematics for Aboriginal learners, particularly those in remote areas of Australia. These are the students who are at most risk of scholastic mortality and whom are the scapegoats for much of current educational policy – such as the national testing regimes of Australia. Bourdieu differentiates between the objective and subjective structuring practices. Zevenbergen (2005) has drawn on this framing for understanding the processes of streaming in mainstream schools. This same streaming is currently endemic in Aboriginal schools where the 'cream' of the remote schools is being sent away to elite boarding schools in major urban areas. Despite decades of research into streaming, the highest achieving Aboriginal (and Torres Strait Islander) students are being sent to out-of-country sites to learn western ways of being. Aside from pragmatic issues around support for students out of country and being immersed in upper-class value systems, there remains the challenge of the circumstances for those who remain behind as well as what happens to those students who leave country and acquire the taste of Western life. This 'brain drain' from Aboriginal communities represents a challenge to those who remain in-country⁴ in so many ways. However, our point here is not to question this objective structuring practice but to focus on the practices of school mathematics.

Similarly the subjective structuring practices need to be considered alongside the objective structuring practices. Practices such as streaming produce effects on learners who come to see themselves as successful learners (or not). In doing this, they internalize the outcomes in an insidious way so the outcomes are unquestioned and the internalization of success or failure becomes the lens through which the learners see themselves. This subjective structuring practice now shapes how the learner interacts with mathematics – for example as an engaged or disengaged learner –

⁴ Country is very strong to Aboriginal learners. Nyangatjatjara College was founded on the principle of providing Anangu learners with an education that kept them in country and thus tied to their people, their families, their beliefs and their culture.

which comes to influence how they interact with mathematics and education.

The status quo: Doing maths as it has always been done

In terms of curriculum, available text and other resources, assessment and system monitoring tools, and even learning programs, there is an implicit assumption by governments that mathematics will be taught the same way in Indigenous schools as in other schools. Indeed, there have been pushes for school curriculum to remain as it has always been and that anything less is an impoverished curriculum. However, there have been excellent examples of 'two way strong' curriculum that has rigorous western knowledge systems but also embeds traditional modes of learning and knowledge so that students get the best of both worlds (Harris, 1990). A curriculum focused only on Western values fails to recognize the obvious disconnect between "the culture of school mathematics and that which the learner brings to the school context" (Jorgensen (Zevenbergen), 2009, p.3), and that the chances of learning the conventional curriculum are limited by "linguistic, social and cultural habitus" (p.5). It also fails to recognize and celebrate the strengths of the indigenous culture of the groups. In this way, the death Aboriginal culture is almost certain. It should not be an either-or curriculum but a curriculum with high expectations of learning in and about both cultures.

In exploring the habitus of teachers and how they framed mathematics learning, we asked teachers at Nyangatjatjara College to reflect on the challenges they are experiencing in teaching mathematics to Anangu learners, particularly the challenges they faced in attempting to teach the students mathematical concepts and processes. Their responses included that students:

- tend to see mathematics learning as memorization, and doing mathematics as remembering rather than reasoning;
- give up quickly when confronted with ideas with which they are not familiar;
- are unfamiliar with many fundamental concepts even those that have practical significance such as comparative measurements, and names and properties of plane shapes;
- experienced a curriculum that was not age appropriate, and spent much time being taught material that they have previously encountered but not necessarily mastered;
- had difficulty in transferring skills learned in one context to another context; and
- found it difficult to work with large numbers and more abstract ideas such as fractions and decimals.

While such difficulties are by no means unique to Indigenous learners, programs seeking to engage Indigenous learners with school mathematics need to find ways to connect the mathematics to be learnt to the students'

social, cultural and linguistic backgrounds. The comments made by the teachers were framed in deficit models of thinking and failed to account for the differences between the two cultural systems. What remains clear to us is the need to work with teachers to move away from deficit models towards both-ways models.

As a further exploration of the disjunction between students' habitus and the curriculum with which the students are expected to engage, we examined the assessment items on the Year 7 calculator-free 2008 Australian numeracy assessment based on the context of money. It is noted that the government uses the results of these assessments to report on educational progress, and various compliance mechanisms are in place to ensure schools prioritise the content assessed by these tests.

There were four items on money. The first asked "What is \$10 as a percentage of \$40?" offering students four choices. Even though adults would more frequently find a given percentage of a money amount, this is a reasonable question. The second question presented drawings of a pair of inline roller skates, a cricket bat, and a tennis racquet, labeled respectively at \$42, \$26 and \$98. The question asked "what is the best way to estimate the total cost of these three objects?" and presented four choices the correct one being "\$40 + \$30 + \$100". Even ignoring the unrealistic prices for these objects, the items seem a somewhat unusual collection for a national assessment that is presumably intended to be inclusive, and the form of the question is dependent on students having had experience with the notion of rounding as a way of progressively estimating money totals. The third item presented a two way table of data, 3 rows by 3 columns, related to mobile phone costs, with a question that required reading and synthesizing data from two columns. To answer the question students needed to interpret text involving over 50 words and symbols, but the mathematical demand was that they merely add 12 and 28. The question assumes familiarity with mobile phone bills, tabulated data, and sorting relevant from superfluous information. The fourth question required students to interpret two straight line graphs, and convert British pounds to Brunei dollars. There was a similar complexity to the text of the question, and for those students who are not familiar with the notion of three way currency conversions, they would have to infer what the task was asking them to do.

The latter three of these items can hardly be considered to be culturally inclusive, and the quite obvious reliance of the items on school content rather than realistic situations is an obvious example of how the social heritage of Aboriginal students is not considered in the design of these questions thus creating greater opportunities for scholastic mortality. Imagine a question that was embedded in desert knowledge – the backlash from city and non-Aboriginal educators, parents and communities would have been challenging but when the relationships are reversed, the challenge is silent as if there is not real challenge at all. It is also worth noting that the assessments not only communicate to students that school knowledge is not connected to what they know, but also reinforces to them that they are failing. Thus the objective and subjective structuring practices become obvious.

Finding ways to connect mathematics learning and student experience

In terms of exploring what might be the characteristics of a relevant curriculum, the following draws on a series of teaching explorations at an Indigenous Community School in a remote region of Western Australia, that was part of the *Maths in the Kimberley* research project, and conducted on the invitation of the *Association of Independent Schools of Western Australia*.

There are two obvious dimensions to connecting prospective learning with retrospective experience: the first is to identify ideas with which students are familiar and build on those; the second is to create connections between ideas that are fundamental to a modern mathematics curriculum and students' prior experience. In exploring the former of these, it is possible, for example, to examine Indigenous languages to check mathematical ideas that are present in the culture. For example, in a publication that is both a language guide and dictionary for the *Nyikina* language (*Jalmadangah Burru* Aboriginal Corporation, 2003), one of the languages in the Kimberley region, there is a developed lexicon for place and direction words. For example, there are 18 different words for describing location, as well as four different expressions for each of the four compass directions, making a total of 34 distinct terms that can be used. It would be possible to use this language as a starting point for an exploration of modern mathematical concepts associated with location, direction, map reading, networks, and possibly even co-ordinate geometry.

In considering the latter dimension, it seems that both traditionally, as reflected in the language, and currently, in terms of the limited use of quantities in their everyday lives, number activities all tend to be remote from students' experience. To overcome this, we are exploring ways of building connections between money, with which the students have some familiarity, and more abstract number ideas. This has its own challenges.

One of the products of this project is a set of recommendations to teachers that addresses both planning and pedagogy, and which encourages them to accommodate cultural, social and linguistic backgrounds of the students. We are conscious that it seems that inexperienced teachers sometimes err by underestimating the potential of the students and set expectations that are too low. Indeed some structured programs also seem to adopt a deficit approach. Our perspective is that students benefit when teachers set high expectations, and expect that students engage in the full range of mathematical actions such as understanding, problem solving and reasoning and not just fluency. On this point we concur with many Aboriginal educators that having expectations of students (and teachers) is paramount to success in Aboriginal (and Torres Strait) education. In summary, our recommendations to teachers are that they:

- Identify big ideas that underpin the concepts you are seeking to teach, and communicate to students that these are the goals of the teaching;

- Build on what the students know, both mathematically and experientially, including creating and connecting students with stories that both contextualise and establish a rationale for the learning;
- Engage students by utilising a variety of rich and challenging tasks, that allow students opportunities to make decisions, and which use a variety of forms of representation;
- Interact with students while they engage in the experiences, encourage students to interact with each other including asking and answering questions, and specifically planning to support students who need it, and challenge those who are ready;
- Adopt pedagogies that foster communication, mutual responsibilities, and encourage students to work in small groups, use home language when communicating with each other, and using reporting to the class by students as a learning opportunity.

Each of these recommendations is further elaborated for teachers. To see how these recommendations might apply, consider the following activity, adapted from the well known and well publicised work of the Shell Centre in the UK.

The task involves a set of cards consisting of a number of rows like the following (which addresses subtraction), with each row consisting of four ways of presenting a particular operation.

I collect groceries worth \$17.85 at the store and give the sales person \$20. How much change do I expect to get?	Subtract 17.85 from 20	20.00 – 17.85	\$2.15
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The task involves connecting representations, and being able to see that the mathematics needed to solve the problem in the first box is represented on the other cards. The activity addresses an important mathematical idea, it uses the notion of story, it is a variation on the conventional pen and paper form of representation, it is challenging, and it provides the content that can form the basis of later reporting back by students.

There is a variety of ways that the cards overall can be used. The teacher can, for example, invite students to discuss similarities and differences in the cards, to sort them into groups, to arrange the cards into order of difficulty, and so on. Certainly it is intended that students are given opportunities to make their own decisions. There are, though, still substantial challenges in using such a task.

Even though the task is designed to connect to a shopping context, with which it is hoped that the students would be familiar, it can be anticipated that specific actions would be needed by the teacher to ensure that the task

can be connected to the students' social, cultural and linguistic backgrounds. For example it might be necessary that the teachers do what the *Accelerated Literacy* program (unknown, 2009) term as "putting the language through their system" or what Munro (2003) calls "getting knowledge ready". This might involve role plays of shopping including giving change, or particular strategies such as chunking the key phrases in the text and deciding which phrases make a difference to the task and which are irrelevant to the mathematics, and searching for the words that identify the mathematical operation. This means that, after the activity, the reviews not only focus on revising such ideas, but also the similarities and differences in the mathematical cards, the connections between the cards, and ways of performing the operation on the cards.

Our experience with the MiTK project indicates that students at all levels can engage effectively with tasks such as these, so long as the teachers anticipate pedagogical pitfalls, and that with appropriate choice of task and pedagogical support such tasks help form the bridge between the habitus of the students and the demands of school mathematics. We contend that by acknowledging the social heritage of the student, realising that this shapes their knowledge and ways of thinking and learning that they bring to the formal school context, and that ALL students can learn mathematics if they are provided with the right learning environments, then scholastic mortality will be reduced, and we would hope, eradicated. But much of this will depend on reshaping the habitus of teachers working in these regions.

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Redressing marginalisation: A study of pedagogies for teaching mathematics in a remote Australian Indigenous community

Peter Sullivan, Robyn Jorgensen and Rebecca Youdale

Introduction

This discussion in this Chapter draws on a series of teaching explorations at an Indigenous Community School in a remote region of Western Australia that was part of the *Maths in the Kimberley* research project, led by Robyn Jorgensen, and conducted on the invitation of the *Association of Independent Schools of Western Australia*. The project is seeking ways to support the teaching of mathematics in small community-run schools. We see the learning of mathematics as directly connected to modernisation of communities, and that an important focus of support is to enhance the capacity of teachers to engage all students in effective mathematics learning.

The project design recognises the complexity of the educational challenges in such small communities, acknowledges those who have addressed these issues previously, and emphasises collaboration with the respective communities at each stage. The Chapter outlines the context of the research, some challenges with teaching and learning mathematics for Indigenous students, the pedagogical model that we are researching, some classroom explorations that exemplify aspects of the pedagogical model, and some reflections on the opportunities and challenges with the model.

The research context

The schools serve communities that are focussed on modernisation, they foster commitment to the community, and there is active involvement in

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most schools. Most of the communities served by these schools are alcohol free, there is a mix of traditional activities, such as hunting and fishing, and some access to aspects of modern living such as sporting opportunities and health care. School attendance is very good. It appears that the basic conditions for effective schools with high proportions of Indigenous students, as described by Frigo, Corrigan, Adams, Hughes, Stephens, and Woods (2003), are being met. In particular, Frigo et al. noted that key features of schools that supported positive outcomes were strong school leadership in partnership with local Indigenous leaders, specific actions to support regular attendance and active engagement, good teaching, and Indigenous presence in the school.

The schools conduct a well supported and highly structured program, termed *Accelerated Literacy*, that aims to set high standards for students, and revolves around allocating significant time for literacy, and structured, even scripted, actions by teachers. This support for literacy is clearly a prerequisite for educational and community development, although we note that this program, given the allocated resources, has only mixed success.

While both the leadership and the teachers are active and committed, they are inexperienced, there is a high attrition rate (although substantially less than in similar communities elsewhere), and there is limited induction to the schools, the communities, and the challenges the teachers encounter.

Challenges in and approaches to teaching mathematics

Our project is exploring ways to teach the mathematics that is needed for participation in modern societies. We endorse the call by Sarra (2009) that "Aborigines ... be afforded the capacity and freedom to engage in whatever economies in whatever part of the world they choose" (*The Australian*, August 8th). We argue that success at mathematics is a prerequisite to access to opportunities for this engagement.

Yet it seems that performance overall of Indigenous students is not preparing students for these opportunities. Lokan, Greenwood, and Cresswell (2001) note that, while some Indigenous students are performing at the highest levels (indeed, the recent PISA results reported that the proportion of Indigenous students at the highest level was the international average), most are well below the overall means on most aspects of numeracy. Frigo et al. (2003) noted that, while Indigenous students performed well in assessments when commencing school, by the third year of school growth had "slowed considerably" (p. xi), and that much of the variation in students' scores was a function of the school. Zevenbergen explored this further by analysing differences between all students and Indigenous students in the means on Year 3, 5 and 7 systemic numeracy assessments, and found that the gap between Indigenous and non-Indigenous Australians increases with each assessment. She noted:

The national differences indicate a trend where the percentage of non-Indigenous performances remains at or above the set benchmark but the performance of Indigenous students declines with an increasing difference of almost 10% each two years so that by Year 7 less than half of the Indigenous students are reaching the national benchmarks.

In other words, the challenges of improving access to opportunities include finding ways to improve the overall performance of Indigenous students, and arresting the apparent decline in comparison with non-Indigenous students over time. There have been a number of studies that have sought to address this decline. The theme in all of the studies, as articulated by Perso (2006), is that students improve when teachers recognise differences in background and learning styles, and that failing to do so can lead to teachers adopting a deficit approach, perpetuating marginalisation of these students. Frigo et al. (2003) listed key elements of effective numeracy teaching from across schools serving high proportions of Indigenous students as teaching skills in real life contexts, developing sound number skills, reinforcing concepts through structured activities and semi-structured play, offering low risk opportunities to develop confidence, exploring the language of mathematics, and building on what the students know.

Several studies have been carried out to attempt to explain why policies and initiatives aimed at improving Aboriginal students' mathematics achievement have often failed (see for example, Baturu, Cooper et al. (2004). Howard (1997) argues that the imposition of a 'Western' curriculum has meant that "for many Aboriginal children ... the mathematics classroom becomes an alien place characterised by tensions and conflicts about relationships and the value of what they are being taught" (p. 17).

There have been attempts to adapt conventional Western pedagogies to Indigenous contexts. For example, the *Garma Living Maths* program (Perso, 2006) describes an approach termed 'two way learning' indicating acceptance of a mixing of Western and Indigenous knowledge and likens the meeting of these knowledge systems to the meeting of two bodies of water in a lagoon where salt and fresh water come together. A key element in this approach is the notion of not only incorporating community values into teaching approaches, but actively engaging the community in all aspects of the curriculum and pedagogies that are adopted.

An alternate approach, termed *QuickSmart* (Pegg, Graham, & Bellert, 2005) is a four phase process for addressing the needs of low achieving students. The approach involves initial teaching, subsequent attempts to address difficulties experienced by some students, collaborative support for teaching by a specialist, and ultimately withdrawal from class. The approach emphasises automaticity of skills in both reading and computation, and their measures were of the extent to which the improved automaticity enhanced higher order processing.

Our pedagogical model draws on these various approaches, and also on our understandings of mathematics learning generally. For example, we see mathematics learning as more than the development of low level skills, and that the strategies that have been successful with learning mathematics elsewhere in the world should also be utilised in such community schools. These include creating opportunities for students to investigate mathematically rich situations, to identify patterns and seek commonalities, and to explain reasoning and justify choices. Our approach seeks to create such opportunities.

Interactive pedagogies

Our approach, termed *interactive pedagogies*, draws on the extensive work from Boaler (2008), and has also been informed by the work of Burton (2004) for working mathematically, William, Lee et al. (2004) on assessment for learning, and the productive pedagogies (Gore, Griffiths, et al. 2004). Our approach challenges deficit models of teaching Indigenous students and seeks to promote a rich and deep mathematical learning. The approach is founded on a strong belief that all students can learn mathematics when the pedagogy is appropriate (see Jorgensen, 2009, Grootenboer, 2009; Sullivan, 2009, for more detailed elaboration). The key elements of the interactive pedagogies are:

Group Work: We see group work as foundational to processes of social learning. By incorporating group work with which students are familiar in out-of-school learning, it becomes possible to draw on the skills and knowledge within a group to solve problems. The roles of the group members create inter-dependent learning opportunities that are not possible within parallel learning.

Home Language: Students are allowed to draw on their home language (in this case, *Kriol*) to negotiate meanings. When reporting back, the students are encouraged to use standard Australian English.

High Interactivity: There is a strong focus on quality interactions – within the group work and the reporting back stage. Good questioning is critical to this approach. Teachers develop good questions to promote learning opportunities for the students as well as students learning to pose good questions to each other.

Multi-representational: Recognising the diversity among learners, we encourage use of tasks that foster, and allow for, various methods of representation that cater for the different skills and dispositions that learners bring to the task. Provided that the result is reasonable, the pathway and mode of representation is valued.

Reporting back: This is a critical part of the lesson where students report to the class on their approach to solving the task and the responses they have developed. Ideally, students within the classroom pose questions to the reporting group so that there is a quality dialogue among peers that ultimately promotes aspects of working mathematically such as justifying, clarifying, generalising, conjecturing and so on. The purpose is to encourage dialogue among peers that promotes rich mathematical learning.

Tasks and activities: Our focus in this Chapter is on the choice of the task for which there are three complementary elements:

- the teachers should be clear about what they are intending to teach;
- the lessons should build on what the students know (as distinct from what they do not know);
- tasks should be mathematically rich and draw on the “working as a mathematician” approach in which there should be multiple pathways and entry points for learners, and multiple ways of representing thinking and learning that incorporate different learning styles and approaches.

These aspects are each elaborated in the following discussion of the exploration in Rebecca’s classroom.

The classroom explorations

The project overall involved regular professional learning sessions with teachers on aspects of the interactive pedagogies, supported by occasional school visits by the research team, data collection via the video recording of lessons by the teachers, and telephone interviews with the principals and teachers.

The following discussion focuses on just one aspect of the interactive pedagogies, and elaborates considerations about the selection and use of tasks and activities. It draws on observations from a set of 10 lessons, spread over three separate research visits. The lessons were planned collaboratively with Peter and taught by Rebecca in one of the community schools. The purpose of the observations was to examine the implementation of the interactive pedagogies in real time in a classroom. Rebecca was willing to explore all aspects of the pedagogies, and these observations provide a realistic indication of what is possible. Peter observed the lessons, made video and audio recordings of key moments, gathered student work samples, and interviewed Rebecca before and after the lessons. The following is a discussion of the three elements of the *tasks and activities* aspect of the interactive pedagogies: the importance of having clear goals; building on what students know; and mathematical richness.

The importance of having clear goals

The importance of teacher clarity is supported by Hattie and Timperley (2007) who reviewed a range of studies on the characteristics of effective classrooms. They found that feedback was among the main influences on student achievement, the key elements of which are “where am I going?”, “how am I going?”, and “where am I going to next?” The implication is that it is best if that the teacher formulates specific goals for student learning, can make decisions on expectations for performance, and has some sense of where the experiences are leading subsequently. It is therefore important that the teacher establishes clear goals, so that the many interactive classroom decisions, questions and comments are made with a clear purpose in mind.

To help make the focus of teaching clear, in each of the three sets of lessons some key ideas were extracted and elaborated at the first stage of planning. The planning was interactive and occurred by email some weeks prior to the teaching. To illustrate what is meant by identifying key ideas, the following were the ideas suggested after Rebecca has proposed the topic and level (Grades 3 and 4, student ages 8 or 9) which was the focus of instruction.

The first sequence of lessons was on subtraction. It was proposed that the key ideas were: stating the number 1 and 2 before a given number; modelling numbers in terms of their parts; mental strategies that are useful for subtraction; and connecting different representations of subtraction (see Sullivan, Youdale, and Jorgensen, 2009a, for further elaboration of this). As an indication of the success of the planning and teaching, all students were individually interviewed at the end of the lesson sequence. Nearly all grade

4 students and most grade 3 students were able to answer the questions: “I have 8 biscuits, and I eat 3. How many do I have left?” and “What is $10 - 7$?” While these are not complex tasks, the results indicate that the lesson sequence has included the weaker students effectively.

Rebecca suggested that the second sequence of lessons focus on partitioning numbers, the key stages of which were proposed to be: patterns in numbers to 10 and 100; breaking numbers into parts (e.g., 65 is $60 + 5$ as well as $50 + 10 + 5$, etc); and regrouping numbers (e.g., $98 + 35 = 100 + ?$) (see Sullivan, Youdale, and Jorgensen, 2009b, for further elaboration of this). Again students were interviewed to gain a sense of their learning. Nearly all of the 15 students were able to: Count by 10s past 100; Count by 5s to 90; Calculate $9 + 4$, where the 9 objects were covered, requiring counting on; Stating the answer to $2 + 19$; and most answered $27 + 10$. This is evidence of learning and growth.

The third sequence was about division. The key ideas were suggested to be: using models to represent multiplicative situations; working multiplicatively with numbers; solving problems without using models; and moving to larger numbers.

It is argued that these represent key ideas within each of these topics, and that having a clear idea of the focus of instruction is better than merely working on a collection of loosely related activities that vaguely address the topic for instruction. This clarity is helpful for choosing tasks, for explanations, for emphasising the purpose to students, for interacting with students, for interpreting their responses and for assessing their achievements. The interview assessments were not intended to measure the ceiling of learning but the extent to which students generally had learned the desired content. In this, the lesson sequences were successful.

Building on what they know

The second element also draws on Hattie and Timperley who argued that learning is more effective when teachers identify what the students already know, so that both the activity on the task, and the feedback to students can build on these. The confidence that students derive from working on familiar concepts can then be used as the springboard for the subsequent challenges that teachers set that lead to real learning. Perhaps paradoxically, this is an aspect that many educators find difficult.

As part of teacher learning sessions we have proposed the use of contexts with which the students are familiar. These might include linking to modern ideas such as sports, or traditional ideas such as time marking systems or the language of directions and location.

Since the development of understanding and fluency with numbers is an essential element in education for participation in modern society, a particular challenge is to identify aspects of number with which students are familiar. After observing students at a school fete, Rebecca commented that the students seemed to be familiar with money. The second and third sequences were developed to build on this familiarity. The following two activities show how this was enacted.

The first activity sought to build on perceptual (as distinct from conceptual) recognition of money amounts. Using various combinations of \$1, \$2, and \$5, amount were shown for a short time and then covered. Students first whispered their answer to the person sitting next to them and then declared their answer. The observer (Peter) noted:

The students seemed to be extraordinarily adept at doing this accurately. Given that this involves a number of key skills in combining and partitioning numbers, it created the sense of the strong foundation on which the lesson sequence could build.

This was repeated using 10, 20 cents first, and then adding in 50 cents. Many of the students seemed to do this readily, and it created the excitement that goes with successful completion with challenging questions. We have video records of 8 year old students accurately identifying money amounts as quickly as adults who have been familiar with money all their lives.

Another activity, indicating the move away from using the actual coins, was based on a well known game *Race to \$10* where students, starting at 0, in turn add \$1 or \$2, and the one who makes the total \$10 is the winner. There is a winning strategy. This was then played as *Race to \$1*, adding on 10c or 20c. The observer noted:

The students were able to play the game easily, and were energetically engaged. As a review of the activity, Rebecca played this for some time with individuals to see whether they would see the pattern, and recognise a winning strategy. Only one student did, and he was asked to report on this, but there was an emerging awareness in the others.

Again the success at the game, presumably derived from the familiarity with the money amounts created an opportunity for engaging with the mathematical ideas. The money provided the springboard.

Using the money tasks, with which many students were familiar, created a sense of enthusiasm and success, and seemed to allow extension to straight number tasks, which was Rebecca’s intent in the first place. In individual interviews after the lessons, nearly all students could recognise the total of two \$2 coins and two \$1 coins, shown for two seconds, and over half of the students could recognise the total of three 20c coins and one 10c coin, shown for two seconds. This both confirms the initial observations that some students were fluent with this, and also indicates that the lessons allowed other students to attain this fluency.

Choosing rich tasks

The third element is the choice of tasks that are mathematically rich and challenging. The nature of the tasks and associated teachers actions are summarised in a set of recommendations for teachers (see Jorgensen & Sullivan, this volume). To illustrate the nature of these tasks, the following are three examples that were used as part of the observed teaching. The first task was posed as follows:

I am thinking of two numbers. The difference between the numbers is 2. What might be the numbers?

This can be recorded symbolically as $\square - \square = 2$

The point is that pupils can explore aspects of 2 difference, and even recognise the patterns of differences that appear. We want students, for example, to be able to calculate $19 - 17$ as readily as they calculate $19 - 2$. This type of task gives pupils the opportunity to make active decisions on the numbers they use and the way they record their results. It is important to emphasise that there is more than one possible answer, and that it helps if the answers are written systematically. The observer noted:

The pupils worked productively on the task, and most groups were willing and able to produce multiple solutions, some of which were systematically organised. Making choices seemed to be engaging. In this case there was a need for extended explanations of how this would work. Perhaps in the future it will be easier to pose such tasks. The students worked in groups with particular roles. Rebecca encouraged the reporter from each group to explain the process whereby the group found their particular set of answers. Again this reflects the focus on students explaining their strategies, supported by the teacher.

The success of the groups is indicated in the diversity of responses given by one of the groups as shown in Figure 1. Note that this group, at least, has developed a range of possible solutions, appears to have identified a pattern in the solutions, and has laid the groundwork for knowing the answer readily to questions such as $19 - 17$.

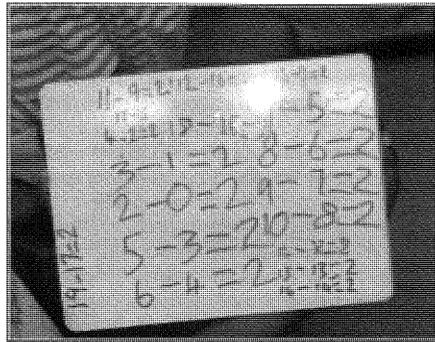


Figure 1: One group's responses to "difference is 2".

The pedagogies associated with this task are illustrative of the approach we are advocating. The task had a variety of entry levels, it could be answered in different ways, it involved group work with roles, and it allowed a detailed and focused class discussion of strategies and patterns. The concluding review allowed the teacher to highlight particular student insights.

Another task was posed, using \$1, \$2, and \$5, in Rebecca's words, "your job is to work out as many ways as you can to make \$10". The observer noted:

This seems to be an example of the type of task that can be successful. It is complex enough to allow for multiple answers, some reasoning and

problem solving is required, and it is practising a core skill toward the goal, that of ways of building to 10.

The students wrote their answers on a small whiteboard. The students seemed to understand the task and worked productively, with many students producing multiple correct answers such as those shown in Figure 2.

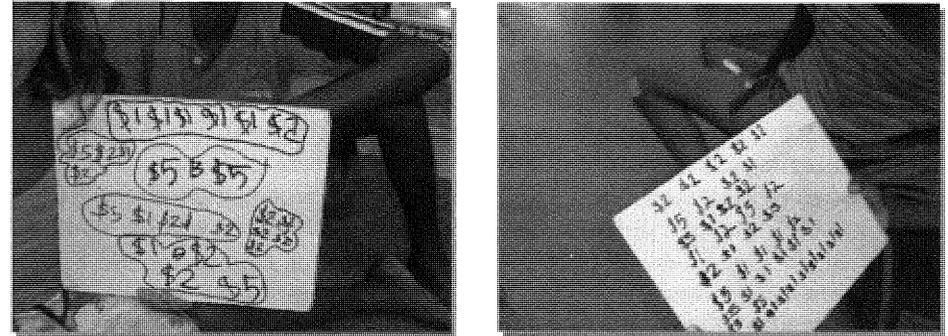


Figure 2: Sample responses to the "Make to \$10" task.

The purpose of including discussion of the third task here is slightly different. This task was presented as "I have 3 silver coins, how much money might I have?" It allows a similar diversity of responses as do the previous tasks, but there was an interesting twist. The observer noted:

This again is the sort of task that should work. It has a range of answers, it prompts communication, it is challenging mathematics, and it is addressing the overall theme. It did not work as intended, with many students including \$1 and \$2 coins in their total, making it more complex. Yet Rebecca had explained the task well. The reason for not mixing the dollars and cents is that it makes the calculation more difficult.

Only later it emerged that the local word for coins or change is "silver" (in Australia, there are coins for \$2, and \$1 and these are gold), which highlights the need to consider alternate interpretations of events and language at all times. This highlights the importance of the interactivity implied by the pedagogical model, as well as sensitivity by the teacher to the interpretations of the students.

These three tasks illustrate that the students are willing and able to engage with such number and money investigations, they are able to identify a range of possible responses and record them systematically, which presumably lays the groundwork for developing mathematical connections.

Reflecting on opportunities and challenges with the interactive pedagogies approach

The goal of the research is to investigate the challenges and opportunities afforded by this pedagogical approach.

From the lesson observations overall, it can be concluded that being clear about the goals of teaching is helpful both to the teacher and to the students. In the lessons observed the clarity meant that the activities could be thoughtfully sequenced, each activity could build on a previous experience, and the students were clear about the teacher's goals and her expectations for them.

It also appears that "building on what the students know" was an effective strategy. In the sequence of activities that drew on the apparent familiarity and fluency of students with money, the class was extraordinarily energised and engaged, the students participated actively, and the experience seemed to lead to other learning. Rebecca was able to extend some of the students toward formulating some potentially powerful generalisations.

In these observations, it also appeared that the students were both willing and able to engage with rich tasks that required decision making by them and which allowed the construction of mathematical ideas. It seems useful to use such rich tasks with the students, and to encourage the students to create mathematical ideas based on those tasks.

In these examples, and the other lessons observed, there were many instances that would be judged outstanding teaching and learning in any school, and certainly demonstrated that students in remote schools can learn as well as their metropolitan counterparts.

There were three challenges that emerged from these observations. The first challenge is that care needs to be taken when making inferences about the extent of student engagement. In the sequence of activities that based on the money the class seemed highly engaged. Yet in subsequent interviews (see Sullivan and Grootenboer, in preparation) in the class observed while most students were highly fluent with the money and equivalent number questions, there were also two students who were not able to identify the value of any coins. This emphasises that there is a diversity of achievement within each class, and a diversity of readiness, and specific actions must be taken to accommodate this diversity. While we have not researched the potential in this, it seems that the Aboriginal Education Workers who are available in some schools could be better utilised.

A second issue relates to the conduct of class reviews after rich explorations. Rebecca patiently probed the student thinking, and invited them to explain their reasoning. Yet this was not often successful from a whole class perspective. One example was the student who explained his strategy for winning the *Race to \$10* game. He gave an extended explanation, and if you knew what he was trying to say, his explanation was insightful, and illustrated clear conditional thinking and argument. Yet his explanation would not have informed other listeners. There were a number of other instances where an individual gave an excellent explanation that elaborated on the desired type of thinking, but not in a way that would engage the other children. The other students were not interested in such explanations, which may be partly a function of this lack of clarity. Rebecca is energetic and committed to this approach, and had worked with the class on her expectations for participation. It is suspected that specific actions will be necessary so that this aspect of the approach can realise its potential.

One strategy that seemed to work was for the teacher to restate the explanations given by students, and to provide additional diagrammatic support for their explanations.

A further issue is the intensity of the interactivity. In many of the observations the students became tired. Noting that these classes are quite small, students are constantly under scrutiny. Clearly, in the above, there were mathematically rich and challenging experiences in which the students participated well, even beyond expectations. But it is perhaps unreasonable to expect the students to do this for the full 90 minutes of each mathematics class. It is suggested that teachers could plan some experiences that are less intensive and less interactive and these could be used to buffer shorter and more intensive parts of the lessons. These less intensive experiences could include competitive games, including card games, or some aspect of physical activity combined with a mathematical experience, or drawing, or story telling.

The interactive pedagogies model clearly has potential to engage students in doing significant mathematics. Our project is now seeking to elaborate on the aspects that worked well, and revising those that did not.

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The link between planning and teaching mathematics: An exploration in an Indigenous community school*

Peter Sullivan, Rebecca Youdale and Robyn Jorgensen

Abstract. This workshop reports on a teaching exploration at an Indigenous Community School in the Kimberley region of Western Australia that sought to use a specific way of thinking about particular content domain, partitioning, to develop focused mathematically rich learning experiences. A set of four 90 minute lessons was planned and taught by Rebecca, building on activities suggested by Rebecca and Peter, and incorporating the pedagogical approach being advocated by the project. The successes and challenges are reported below.

Introduction

This is a report of a teaching exploration at an Indigenous Community School in the Kimberley region of Western Australia. Peter was at the school as part of the *Maths in the Kimberley* project, which is led by Robyn Jorgensen (Zevenbergen) from Griffith University, and is an Australian Research Council project in partnership with the Association of Independent Schools of Western Australia.

A set of four 90 minute lessons was planned and taught by Rebecca Youdale, building on activities suggested by Rebecca and Peter Sullivan, and incorporating the pedagogical approach being advocated

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by the project. There was an interview assessment of student learning after the lessons. A report of an earlier set of lessons with a focus of the topic of subtraction is also available (see Sullivan, Youdale, & Jorgensen, under review).

The purpose of the visit was to spend time in classrooms investigating which aspects of the pedagogies model are able to be implemented readily, and which are proving challenging. A subsidiary goal was to explore the strengths of the students, and any challenges in implementing a planned teaching sequence addressing a specific aspect of content.

Rebecca had suggested partitioning numbers as the focus of the teaching. Rebecca had also suggested that the students seemed to be adept at money. In response Peter suggested the following as the focus ideas, with each key idea growing out of the money experience, and some suggested activities many of which are presented below:

- Patterns in numbers to 10, 100. etc
- Breaking numbers into parts
- Building up numbers

In an email response, Rebecca replied:

Your assumption about the purpose of us thinking about partitioning is spot on. I'd especially like to develop the understanding that 19-16 is the same as 19-3.

The Grade 4s have lots of experience with standard place value decomposition in 3 and 4 digit numbers and also partitioning small numbers (up to about 15). I'd say their understanding and skill ranges from sound to excellent.

The Grade 3s have just started to learn about place value in 2 digit numbers and are consolidating their friends of 10. Some have caught on very quickly, and are demonstrating a keenness and good understanding of number patterns and small number partitions.

In the earlier report, one of the arguments made was that teaching has more chance of success if the focus is clear. It seems that Rebecca had a clear idea of the key stages in an important topic. Recognising that an explicit intention was to build on what the students know and can do, the overall goal was agreed as being to lead students towards calculating change, and to partition numbers as a way of manipulating numbers easily.

Report on the activities

The following presents a brief indication of the activities that formed part of the lesson sequence, presented in the days they were taught. Each activity is described, and there is a reflection of the activity presented as well.

Day 1: Patterns in numbers to 10 and 100, emphasising money

The goal of this day was to establish building to 10 and 100.

Subitising with money to \$10 (and later to \$1)

Using various combinations of \$1, \$2, and \$5, amount were shown for a short time and then covered. Students first whispered their answer to the person sitting next to them and then declared their answer.

The students seemed to be extraordinarily adept at doing this accurately. Given that this involves a number of key skills in combining and partitioning numbers, it created the sense of the strong foundation on which the lesson sequence could build.

This was repeated using 10 and 20 cent pieces first, and later adding in 50 cents as well.

The students also seemed very good with this. There were some students who could recognise \$1 but could not say how many cents there are in a dollar.

Race to \$10

There is a well known game where students, starting at 0, in turn add 1 or 2, and the one who makes the total 10 is the winner. There is a winning strategy. The students played a variation, where they could add either \$1 or \$2.

The students were able to play the game easily. As a review of the activity, Rebecca played this for some time with individuals to see whether they would see the pattern, and recognise a winning strategy. Only one student did, and he was asked to report on this, but there was an emerging awareness in the others.

The reporting phase raised an interesting challenge. The student who did identify the winning strategy was asked to explain his reasoning. If the listener already knows the strategy it would be possible to recognise the key milestones, but the student used many incorrect words, and it was sufficiently garbled that not much could be taken from it by an uninformed listener. Of course there are many advantages in students being encouraged to explain their reasoning. There seems to be a challenge, though, in using such explanations as part of the learning of others. Not only are such explanations not instructive, but the other students seemed uninterested, thereby creating potential management problems.

Race to \$1

The students then played a further variation to the game, this time adding on either 10c or 20c, the person to make the total \$1 is the winner.

This also worked well, in that the students engaged in playing the game and followed the rules, thereby (theoretically) getting valuable practice at building up to \$1. In retrospect, it would be useful to play the game the other way, starting at \$1, and racing to 0 in that it would show the breaking up aspect of the \$1, which is part of the challenge in calculating change, and especially the aspect counting back 90, 80, 70, etc.

How many ways to make \$10

The task was posed, using \$1, \$2, and \$5, in Rebecca's words, "your job is to work out as many ways as you can to make \$10".

The students wrote their answers on a small whiteboard. The students seemed to understand the task and worked productively, with many students producing multiple correct answers.

This seems to be an example of the type of task that can be successful. It is complex enough to allow for multiple answers, some reasoning and problem solving is required, and it is practising a core skill toward the goal, that of ways of building to 10.

It was, though, another example where the review of the discussion is problematic. The type of question "how did you get that" is too abstract, at least for students at this level. One possibility could be to ask students to describe one answer, then another, then ask how did they get from one to the other.

We met at the end of day 1 to review the activities, and to consider possible options for day 2. The outstanding part of the day was the subitising with money, but they also played the games well and completed the open-ended activity. It seems like they are confident and skilled at building to 10 and 100.

Day 2: Further emphasis on building to \$1

The overall emphasis on day 2 was on building to \$1 (100).

Making \$1

There were further activities subitising with money as were described above.

There was more subitising to \$1, this time 50c and 5c were added. Whereas it seemed that all students were fluent, even with the addition of the 50c, some started to be confused by the 5c.

Rebecca even did some combinations such as \$3.85 which 3 or 4 of the students were able to do, but this was difficult for the others. This confirms the importance of building up, especially to totals other than 10 and 100.

3 silver coins

The task is "I have 3 silver coins, how much money might I have?"

This again is the sort of task that should work. It has a range of answers, it prompts communication, it is challenging mathematics, and it is addressing the overall theme. It did not work as intended, with many students including \$1 and \$2 in their total, making it more complex. Rebecca had explained this well. The reason for not mixing the dollars and cents is that it seems to make the calculation more difficult. It turns out that the local word for coins or change is "silver", which highlights the need to consider alternate interpretations of events and language at all times.

Making \$1

The task "Using coins, how many different ways can you make \$1" was then posed.

The students were given a clipboard and worksheet and worked on the question in pairs. It is suitable for the students in that it is somewhat challenging, it has multiple possible answers, therefore requiring discussion and explanation. In this case the review worked well. On later inspection of their sheets, it was noted that all students got at least 5 correct responses and some more. In the review of strategies, some of the first answers were $50 + 50$, $20 + 20$ etc, "count by 5s". One student had worked out that there were 20 five cent coins in \$1, and explained how she did it.

It seems that such open-ended explorations work, and even the reporting back has some value for the teacher and the individual reporting. It is the value for the others that could be considered.

Missing addends to \$10, \$1

Using actual money jingling in a pocket, and modelling the actions, questions such as the following were posed: "I have \$10 in my pocket. If I pay \$2 for something, how much do I have left?"

This provides another take on the "building to 10s" strategy, and directly addresses the theme of giving change. The students found this straightforward and nearly all students could answer the various questions.

Questions such as the following were then posed: "I have \$1 in my pocket. If I pay 30c for something, how much do I have left?"

Some students had more difficulty with these questions, but others could do it. The purpose and intent of the question was clear.

Ping Pong

In the easy version, the teacher says 4 and the students called out the number (6) that is needed to make it up to 10. In the more challenging version, the teacher says 30c and the students call out the response to make it up to \$1, occasionally the teacher says *ping* to which the students respond *pong*.

The students could do the easy version, and it looks like they do this regularly. They found the version to \$1 much more difficult.

Again there was a meeting to review the teaching and to consider options for the following day. It was agreed that while these tasks were challenging, the students were engaging with the ideas, and were laying the foundation of future learning of this type.

Day 3: Further partitioning, including subtraction

The third day built on the experience of the other days to consider subtraction in various forms, more on building to 10, and introducing empty number lines as a way to record and describe intuitive strategies.

Missing addends – other than to \$10

This was a repeat of the earlier activity except rather than making amounts to \$10, other amounts were used such as “I have \$5 in my pocket and give you \$1, how much do I have left?”

This was clearly much harder for them than the breaking up \$10 that we did earlier.

1 difference, 1 more, 1 less

Rebecca posed problems like the following, actively and explicitly modelling each one.

“What is the difference between \$9 and \$10?”

“Peter has \$7, and I give him \$1 more”,....

“Peter has \$67, and I give him \$1 more”,....

“Peter has \$7, and \$1 fell out of his pocket. How much did he have left in his pocket?”

“Peter has \$67, and \$1 fell out of his pocket. How much did he have left in his pocket?”

The students were able to answer the questions well. It would also have been possible to introduce the word “less”.

One more, one less on the hundreds board

Using a hundreds board, with rotating numbers, a set of numbers were shown, and students asked to call out, rhythmically, the set of numbers that were, in turn, one more, one less, 10 more, etc.

The students did this well.

Make to 10 card game

Played in groups, students deal out 10 cards, then in turn collect sets of cards that add to 10. They score points for each card so there are advantages in getting, for example, 3 cards that add to 10.

Rebecca modelled the game and then allocated the students to play in pairs with one pair against another. The students I sat with coped with the mathematical demands of the game easily, although only one tried to find more than 2 cards to make 10. There were significant social tensions between them. Rebecca reported that other students she had watched experienced difficulty with the game. It is a valuable game, and worth repeating.

Empty number lines

The empty number line provides a good additional representation, of number calculations, has a spatial element, and especially should be useful for giving change. In this case Rebecca, after modelling how the empty number lines works, posed the task $8 + 5$, and asked the students to show this on the small whiteboard.

The students did not understand the process for doing this and only 1 or 2 students produced appropriate responses. It is suspected that it would be worth persevering with this representation. It seems that the students have all the skills that are needed to, for example, break 25c into 20 and 5, and count down first by the tens (\$1, 90c, 80c) and then the five. We have a photo of the work of a grade 3 student who is an irregular attendee, who did this accurately, and who erased the answer before Rebecca could see it.

Again there was a review of the activities and consideration of options for the following day. This day had included more abstract ideas, and the students experienced more difficulty with these than with the previous days' suggestions. Further development of these ideas is needed.

Day 4: Emphasising that the two parts make a whole

The fourth day continued the theme of partitioning.

Something out of a \$1

Problems such as the following were posed: "I have \$1. I give (student name) 30c. How much do I have left?"

The students performed better at this than previously, and this was even extended to including 5c pieces. There was a wonderful exchange where the task "I spend 65c. How much did I have left?" which was reviewed and agreement on 35c as the answer. The task "I spent 35c, how much did I have left?" was posed and one of the students gave a nice explanation how these two tasks were related.

Split a number 2 ways, split a number 3 ways

Find a way to select a number. Rolling 2 ten sided dice can do this. Then have the students split the number in two parts, and split it into 3 parts (e.g., 48 can be $40 + 8$, or $40 + 7 + 1$). The students can be asked to produce multiple solutions.

The task was initially modelled by Rebecca. The students appeared to understand how to break 48 into two parts, 40 and 8. There was an interesting response from a student who when asked to suggest how 48 might be broken into 3 parts said 4 and 0 and 8.

The students had a worksheet on which to record their answers. Some students did this well but most students found it difficult. It seems like this is getting to the core of the challenge with partitioning, that of finding a way to split a number. Of course later they need to split it in particular ways, but this seems like a good first start.

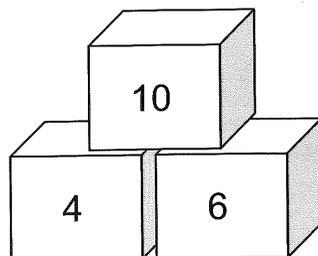
It was noted that while the students were still engaged in these challenging tasks, there were also additional distractions. The day extended the earlier concept development.

Some further suggestions

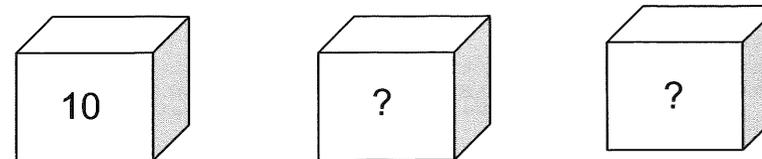
The following activities were not done, but would be reasonable suggestions for the next steps.

Splitting a number many ways using number building blocks

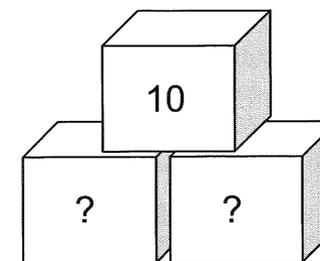
In Europe it is common to use "building blocks" to represent combining and partitioning numbers, as follows.



So different versions of the task can be presented such as the following:



The following can also be posed with the possibility of many possible answers being an important element.



Find the missing number

Equations such as the following are posed. The intention is to allow students to focus on breaking up the numbers in a way which makes the calculation easier.

$$8 + 2 = 7 + \underline{\quad}$$

$$88 + 12 = 89 + \underline{\quad}$$

$$7 + \underline{\quad} = 5 + \underline{\quad}$$

(note that there are many possible answers to this question)

Changing the numbers around

Pose questions such as "What is the best way to add ..."

$$1 + 23 + 9$$

$$1 + 9 + 1 + 9 + 1 + 9$$

$$7 + 35 + 3$$

Pose questions such as:

How can you show 57 on a calculator if the 5 button is broken?

Student achievement

To gain a sense of the learning of these aspects of partitioning, the students were interviewed individually using one section of the Victorian *Early Numeracy Research Project* interview (Clarke et al., 2001), supplemented by some substitising with money items.

The focus of the interview was on whether or not students had mastered particular levels within the number domains: counting and addition/subtraction were used in this case.

If we define *strong* achievement as where 11 or more of the 15 students answered the particular question correctly, then there was strong achievement in:

- Recognising the total of two \$2 coins and two \$1 coins, shown for two seconds
- Counting forwards by 1s
- Counting from 52 to 63
- Counting from 24 back to 15
- Stating the number after 56
- Stating the number before 56
- Counting by 10s past 100
- Counting by 5s to 90
- Counting by 2s to 40
- Calculating $9 + 4$, where the 9 objects were covered, requiring counting on
- Stating the answer to $4 + 4$
- Stating the answer to $2 + 19$
- Stating the answer to $4 + 6$

If we define *satisfactory* achievement as where from 7 to 10 of the 15 students answered correctly, then there was satisfactory achievement in:

- Recognising the total of three 20c coins and one 10c coins, shown for two seconds
- Stating the answer to $8 - 3$
- Stating the answer to $27 + 10$
- Stating the answer to $10 - 7$

Two questions at which the group overall were unsuccessful, with 3 or less correct were:

- Counting from 84 to 113 (most faltering at 109)
- $12 - 9$

It is noted that the *strong* and *satisfactory* sets of items represent excellent achievement by the class, at least comparable with the reference school classes in the ENRP results, and are perhaps indicative that the activities presented above were broadly successful with these students.

Reflecting on some pedagogical issues

It is relevant to use the experience to reflect on aspects of the pedagogies used. While there were some very successful activities during the week, such as the open-ended tasks, the games, the challenging and mathematically rich activities, the use of home language for student-to-student discussion, there were clearly also difficulties. The following are some of the pedagogical issues identified.

Rebecca patiently probes the student thinking, and invites them to explain their reasoning. Yet this was not often successful from a whole class perspective. One example was the student who explained his strategy for winning the *Race to \$10* game. He gave an extended explanation, and if you knew what he was trying to say, he was correct. But his explanation would not have informed other listeners. There were a number of other instances where an individual gave an excellent explanation that elaborated on the desired type of thinking, but not in a way that would engage the other children. The other students were not interested in such explanations, which may be partly a function of the lack of clarity of the explanations. There is a need to reflect on the best ways to conduct such whole class reviews of student work.

There seemed also to be some latent tension between students, with niggling between some children, some of whom respond violently on occasion. The reviews of work, in which the students are not engaged, seem to exacerbate the tension.

The use of *Kriol* for communication between the students enhances student to student dialog and allows the students to articulate their thinking. There is a challenge, though, in moving this towards a need to communicate using mathematical terminology. To a short term observer, it seems that over the years only some students are moving towards greater proficiency in spoken English, even though it seems that they comprehend English well.

Another challenge is the posing of the tasks, especially the more open-ended ones. Some students seem not to listen to instructions so it is necessary to communicate the desired activity through modelling. There is a clear tension between avoiding telling the students how to do the task, on one hand, and communicate expectations clearly on the other.

A further issue is the extent to which the students' thinking is challenged. Clearly, in the above, there were mathematically rich and challenging experiences in which the students participated well, even beyond expectations. But it is perhaps unreasonable to expect the students to do this for the full 90 minutes of each mathematics class. It seems reasonable to plan some activities that are reinforcing known mathematics, where the goal is engagement. It seems that activities that draw on two senses are

suitable for this. These can be competitive games, including card games, or some aspect of physical activity, combined with a mathematical experience, or drawing, or story telling.

At all levels of the school it seems that students have an orientation to calling out answers. Yet this has the effect of minimising the requirement for all students to be thinking. Rebecca had an excellent strategy of asking students to whisper their answer to a neighbour, recognising the need for the students to say the answer, while still preserving the possibility of thinking for all.

Conclusion

The learning associated with this sequence of lessons suggests that there are real advantages in planning coherent sets of experiences with the key ideas clearly articulated, and activities chosen to allow students to engage with those ideas. The notion of using the students' strength, in this case subitising with money, as the basis of the learning was also successful. There were a number of highly successful experiences, as described above, some of which were open-ended explorations. Some pedagogical challenges were identified, and finding ways of addressing those challenges will be a key focus for subsequent investigations.

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Knowing where you are going helps you know how to get there*

Peter Sullivan, Rebecca Youdale and Robyn Jorgensen

Introduction

The following is a report on a teaching exploration at Kulkurriya Community School in June 2008. The lessons were taught by Rebecca Youdale, and the activities were suggested by Rebecca and Peter Sullivan.

The report focuses on the topic suggested by Rebecca, subtraction, to middle primary students. Rebecca reported that while the students had had a range of experiences at counting and addition, their experience was limited.

An aspect of this approach is a principle that teaching is more likely to be effective if the specific goals are clear to the teacher and to the students. To do this, it is important to describe the goals succinctly and clearly. In this case, the teaching was based on an assumption that the five key initial stages in learning subtraction are:

- backwards counting
- modelling situations in which one part of the whole is unknown
- number strategies that are useful for subtraction
- solving subtraction word problems.
- using formal processes for solving 2 digit subtraction.

Another principle is that teaching involves structuring and supporting experiences for students in which they can actively engage in their own learning. Some key aspects are that experiences should be challenging, experiential, requiring decisions and choices by students, and fostering talking about mathematics. It was also assumed that activities would be more successful if they:

- were in a game format;
- had simple and easily communicated rules;
- allowed opportunities for pupils to make decisions;
- provided a variety of representations of the one concept;
- allowed opportunities for extension of the better students, and
- offered support for students experiencing difficulty.

The later sections of this report contain a range of suggestions for activities that adhere to these principles. Many of the activities were trialled, and there is a reflection on the success of those that were.

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Structuring lessons

One of the key steps for teachers is to convert activities such as the ones below to lessons. While the lessons for each activity will be different, there is also substantial commonality in structure for the lessons. To illustrate this structure, the following table indicates how a lesson might be structured that builds on one of the activities presented below. The activity is described in brief as follows:

Unifix tower

Make a tower using, say, 15 *Unifix*, making sure they are aware that there are 15 in the tower. Put the tower behind a barrier, but where the top can still be seen, but the lower blocks cannot. Take part of the tower away, say a set of 3 blocks. They can see the 3 blocks but not the 12 that are left. Ask them to work out how many are still in the tower.

This is intended to prompt counting back from a given number. Hiding the initial tower makes it clear that they have to operate on the blocks removed. This is important for later subtraction tasks where the objects have to be imagined, rather than seen.

The left hand column of the following table presents the teacher actions that would apply in most similar lessons. The right hand column shows the specific details for the *Unifix tower* activity.

Key teacher actions	For <i>Unifix tower</i>
Teacher explains the purpose of the activity, and demonstrates the activity to the class.	<p>The teacher explains that this activity involves working out the answer to a question about the number of cubes without needing to see all the cubes. Teacher explains that sometimes we have to solve problems like this in our lives.</p> <p>Teacher makes one tower of 15 cubes (use a smaller number of cubes if appropriate), counting the cubes with the students. Teacher invites one student to remove some of the cubes, but to keep them hidden. Teacher invites students to suggest what how many cubes have been taken (without seeing them), including explaining how they worked out their answer. Teacher invites other students to explain how they would work out the answer.</p>

Students engage in the activity for a short while, after which there is a teacher-led class discussion of the strategies and/or mathematical point of the activity (also rules and possibilities may need to be clarified)	<p>This step can be repeated until students appreciate what is required.</p> <p>The students can be grouping into 3s: one student making the tower with everyone counting; another taking and hiding some cubes; and the third working out how many have been taken. They take turns at the particular roles.</p> <p>After the students have worked for a while on the activity, there can be a further class discussion of the strategies for working out the number of cubes hidden.</p>
The students are then offered further opportunity to engage with the activity. The teacher can suggest variations, such as making the activity more challenging for some, or less complex for others.	The groups continue with the activity. The teacher monitors the students' work and suggests additional strategies. Some groups might be invited to make a tower of 20 cubes, others to work with 8 cubes.
The teacher leads a discussion of the strategies and mathematics of the activity.	Teacher poses further problems using the unifix towers, with different numbers in the totals, and invites students to explain their solutions.
The teacher summarises the main mathematical ideas.	<p>The teacher can ask students to suggest which strategy they find is most effective.</p> <p>The teacher gives a summary of the point of the lesson, and explains what the students have learned.</p>

Getting started: Counting backwards

The focus at this stage is on activities that help students develop facility with counting back from (as the opposite of counting on), with the aim of connecting this to later more formal subtraction activities. The first level of activities is to reinforce counting back.

Sit Down Zero

The pupils stand. They count, in turn, from 10 to 0. The person who says "zero" must sit down, then the next person starts again at ten. The game continues until everyone has sat down.

The main purpose of the game is to practise counting back, and to focus on counting down from a given number.

The pupils played the game eagerly. One advantage of this game is that there is an element of expectation, of having to say 0, which therefore generates interest. Another advantage is that all students get to attend to all the numbers being counted, and to say a variety of numbers over the course of the game. The pupils were engaged in the game, and while they played boisterously, they were interested throughout.

Sit Down 25

This was a variation of the above game, except starting at 35 and count down to 25. The purpose was to practice counting backwards through the 10s.

This game was harder, and prompts were necessary for some students. Most of the class were able to do this readily. The same game (count from 25 to 15) was used the next day as an introduction, and all students played this fluently. Rebecca had spent some time to outline rules for behaviour (stay in the circle, etc) and this helped.

The next step: Subtracting when one part of the whole is hidden

This set of activities models the essence of subtraction: that of using the total number of objects and the number in one part or subset of the whole to work out the number in the other part.

Unifix tower

Make a tower using 15 unifix (you can use a smaller number to start if appropriate), ensuring students are aware that there are 15 in the tower. Put the tower behind a barrier, but where the top can still be seen, but the lower blocks cannot. Take part of the tower away, say a set of 3 blocks. They can see the 3 blocks but not the 12 that are left. Ask them to work out how many are still in the tower.

This is intended to prompt counting back from a given number. Hiding the initial tower makes it clear that they have to operate on the blocks removed. This is important for later subtraction tasks where the objects have to be imagined, rather than seen.

This was played initially as a whole group. This was harder for some pupils. Some students were able to calculate the number left in the tower easily, but generally they had difficulty articulating the strategy they used, even though Rebecca was both patient and persistent. Rebecca did at times try to "fill in the gaps", but it is possible that this creates an interesting tension. While it is intended that listening to pupils explain their strategies can offer models for other pupils, it may be that the teacher simply inferring the strategy used by the student and explaining it to the class may create confusion.

Unifix tower with patterns

This is a variation on the previous activity. Even though this has advantages over the previous activity in that it has inbuilt prompts, it is better to do this second so that the strategy can be seen as a special case.

Make a tower using 15 unifix, but have 5 of each of three different colours. Put the tower behind a barrier, but where the top can still be seen, but the lower blocks cannot. Take part of the tower away, say a set of 7 blocks.

They can see the 7 blocks that will be 5 of one colour and two of another. Ask them to work out how many are still in the tower.

The purpose of this is to prompt strategies that focus on bridging over the 10.

More students seemed able to respond to this task, and it seemed that it was more possible to infer the strategy they had used, although they did not articulate their strategy well. Encouraging pupils to explain their thinking takes substantial skill and patience.

Unifix tower, with the other part hidden

This time do the same activity, but after showing the total in the tower, show the number of blocks left in the tower. The task is to work out how many unifix cubes have been taken away. Note that while the first activities model the calculation $12 - 3 = ?$, this is modelling $12 - ? = 3$.

The purpose is to illustrate that these are essentially the same task.

One handful

Two students with one bag of counters. Have a bag that has say 15 unifix in it. One student takes a handful out and counts the counters. Without looking, the other student has to say how many are left in the bag. They can then count them together (they can get points).

This is a variation on the Unifix tower activity, with the purpose again being for the pupils to work on the removed group (the handful) and use this to calculate what is left.

This was also done as a whole class activity, with similar results. It seemed that most students were engaged, they understood the purpose of the task, and they were prepared to persist to find an answer. As with other activities, there is a strong sense of guessing, with the teacher's reaction being a clue to correctness.

Two handfuls

Students sit, in threes. They have a bag with about 15 counters. In turn two students grab a handful of blocks. The third student has to work out (or guess) how many are left in the bag.

They then check.

This is basically the same activity, with an addition step contributing to the

complexity.

Again this was done as a whole group activity. The additional step was manageable by the students, and they were able to answer correctly a number of the problems posed.

Saying numbers together

Using the 100s board, random numbers are shown and the others hidden. Together the class can say the numbers shown, or one less, one more, ten more, ten less, and so on.

While not exactly fluent, the activity gave the pupils practice at these key aspects of number recognition, and saying the numbers together gives both opportunities for participation and immediate corrective feedback. It also gives teachers active formative assessment of pupils facility with particular number tasks.

Race to 0

Starting at 10, players take turns to take away either 1 or 2 from the previous total. The winner is the person who says 0. The following is an illustrative game.

Player One	10	7	3	0
Player Two		8	5	2

This can be played starting at any number, and counting down to any other number. If the students get good you can count down using 1, 2 and 3, starting at, say, 20.

This game emphasises counting down. Another aspect of the game relates to the existence of a winning strategy. Rather than detracting from its effectiveness, the existence of the strategy enhances the search for mathematical connections.

After some illustrative games, the pupils paired off and played together. The games provided further practice at counting down. Again not all students were fluent, but there was plenty of opportunity for practice.

2 difference snap

Play snap with playing cards from 1 (ace) to 9, but rather than snapping when the numbers are the same, snap when they are different by 2.

The rules were explained, and then we broke into groups to play. The pupils found this game difficult. This was partly due to the challenge of

playing snap, and partly due to the unfamiliarity of sight recognising a difference of 2. Some students began to recognise particular combinations, but many other possible snaps were missed. It might be preferable to play 1 difference snap first. The rules of snap also may need reinforcement. Even so, the game provides useful practice and alerts pupils to the need to develop this particular skill.

Step three: Moving toward subtraction using numbers, emphasising fluency

At this stage, the students start to work with numbers that they are imagining, and not necessarily connected to specific objects. This works best if the students have some fluency with the numbers they are operating on, and perhaps confidence that they can devise a solution path.

The activities are based on the understanding that some number facts are more important than others. The key number facts are:

- taking away 1 and taking away 2
- building to 10 (6 + 4, etc)
- doubles
- adding and subtracting 0
- adding 10 and subtracting 10
- adding 9 and subtracting 9
- near doubles.

The next set of activities focus on aspects of this.

Ping pong

The class and the teacher play a game where the teacher says a number and the class says the number that would make it up to 10. From time to time the teacher says “ping” and the class responds “pong”.

This is another example whether the focus is important (the 10s families), and the emphasis is on practice to fluency in a low risk group setting.

The class responded accurately and moderately fluently to this. They were familiar with the ping pong game, and some students were also fluent with the facts to 10. It was a strongly communal activity. Even though some students were not able to respond immediately, this was neither an embarrassment nor a threat to self esteem. It complements some of the other related activities.

Tens facts: Fingers up and down

Ask children to show different ways to make ten using their fingers. For example, three fingers ‘up’ means that seven fingers are ‘down’. This represents $3 + 7$ or $10 - 3$ (or $10 - 7$). This is one way of making ten, or a ‘tens fact’.

Challenge children to find and record all the different tens facts using their fingers. Ask children how to record the example when all fingers are up (10 + 0; 10 - 0), and the example when all fingers are down (0 + 10).

The 10s facts

Children work in pairs to practise knowing the tens facts. One child puts some fingers up, for example 4. The other child has to say the number that completes the tens fact. Ensure both partners practise completing the facts. In the case of subtraction they can emphasise subtraction (10 take away 4).

Once they understood the goal, the activity went well. Various pupils were invited to take turns at representing the situation. The pupils were invited to write the subtractions on the board (e.g., 10 - 4 = 6).

Doubles bunnies

The doubles facts to ten can be practised using fingers. Children can show 1 + 1, 2 + 2, 3 + 3, 4 + 4, and 5 + 5 using both hands.

Once they are confident in modelling these and saying the totals, children can be asked to do this with hands held up at either side of the head, like 'bunny ears'.

Give quick directions to children, such as "Make 3 + 3 bunny," or "Make bunny ears that show double 5."

First, Rebecca led the pupils through some set of doubles from 1 to 5. Then she explained the ways that pairs could represent doubles from 5 to 10. The students then created doubles in their pairs. This seemed a useful additional representation, and there were some students who were very involved with the task. Some remained a little uncertain about the word "doubles".



Doubles bunnies to 20

The previous activity can be extended to 20, by having the children working in pairs. "Each pair shows 6 + 6 bunny ears. How many ears altogether?"

Brainy fish

Taken from CMIT, this consists of a board (in the shape of a fish) on which there is a set of numbers, a dice to get the starting number, and a hexagon with a spinner choose from one of four operations: make up to 10, double; double add 1; double subtract 1. In groups students take turns to roll the dice, then spin the spinner and place the counter. The winner is ???

The instructions were explained to the group, and then the pupils did the activity in groups. Some students experienced difficulty in reading the operations instruction ("double then minus 1"), and also in completing the operation, but others were able to help. Redina, Rebecca and Peter each worked with a group. It is suspected that some groups would be better unsupervised since there would be less need to prompt each other with the answer. This introduces the difficulty of monitoring the accuracy of what they were doing. Perhaps the group could take responsibility for this. On the other hand, as it was played it was an excellent way to diagnose the students' strengths. For example, one pupil who otherwise did not seem to stand out, completed every calculation accurately and even assisted others. Even though the 2 step instructions seemed complex, this was not a barrier to any of the pupils. It also emphasises the need for ongoing attention to transferring skills from one context to another.

The difference is 2: An open-ended investigation

The problem is posed: I am thinking of two numbers. The difference between the numbers is 2. This can be recorded symbolically as:

$$\square - \square = 2$$

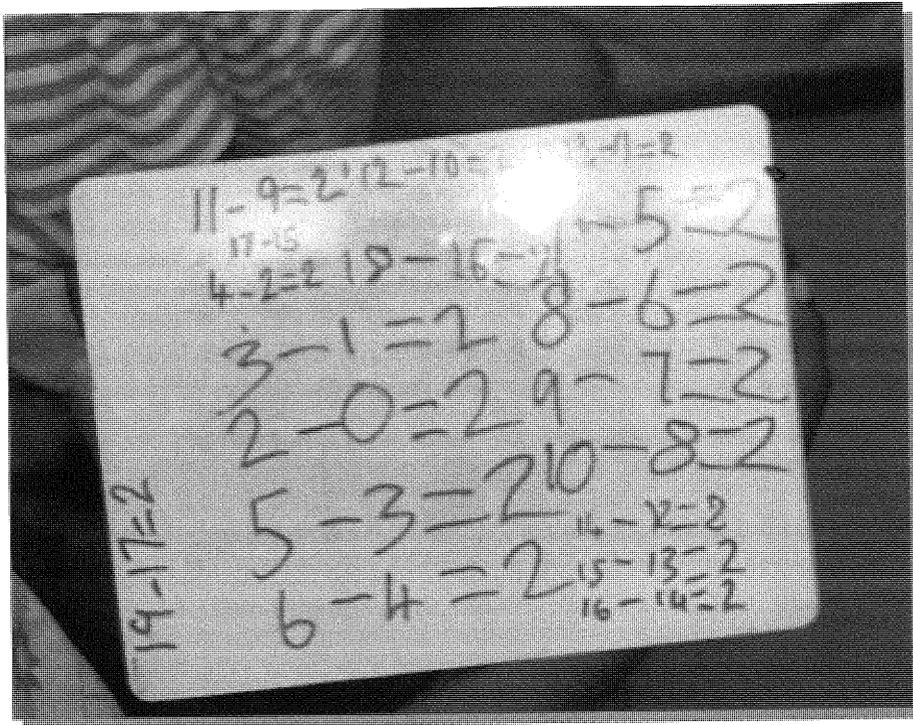
Variations that follow on from this are like:

$$\square - \square = 5$$

$$1\square - \square = 5$$

The point is that pupils can explore different aspects of 2 difference, and even recognise the patterns of difference that appear. It gives pupils the opportunity to make active decision on the numbers they use and the way they record their results. It is important to emphasise that there is more than one possible answer, and that it will help if the answers are written neatly.

The pupils worked productively on the task, and most groups were willing and able to produce multiple solutions, some of which were systematically organised. Making choice seemed to be engaging. In this case there was a need for extended explanations to the students of how this would work. Perhaps in the future it will be easier to pose such tasks. Students worked in groups and had particular roles which contributed to the success of the activity.



Tens facts: Ten frames

On a large ten frame, fill eight cells with counters, and leave two cells empty. Explain to the children that this shows a way to make ten, or a tens fact ($8 + 2$; or $10 - 2$). Point out that the counters show one number, and the empty cells show the other number. You might ask: "How many here? (8) How many more to make to ten? (2)"

Give each child a small ten frame and ten beans. Ask them to find and record all the different tens facts (ways to make 10). Encourage children to try to remember some of the pairs of numbers that make to ten. They can do this in pairs.

Doubles facts: Doubles investigation beyond 10

Challenge children to continue to list 'doubles facts' from $11 + 11$ onwards. Encourage them to use the 'twos' counting pattern to generate the answers. Although it is not expected that children will memorise these facts, this allows a further exploration of doubling as 'two lots of the same number', and the fact that answers will always be even numbers.

Tens facts: Make to ten concentration

This is a game for two players. Use a pack of playing cards for each pair of children. Remove the picture and tens cards so the card values 1-9 remain. Aces count as ones.

All cards are placed face up in an array (4×9). Player 1 takes two cards that add to 10 and say the number fact. If the two cards add to ten, the player keeps the pair. If the cards do not add to ten they are placed down again. Player 2 has a turn.

When children can play with the cards 'face up', play with the cards 'face down'.

Subtracting 10: Calculators

Children could subtract a series of tens using the constant function ($85 -$, $10 =$, $=$, $=$, $=$, ...). Ask them to record each number if doing this, e.g. 85, 75, 65, 55, 45,

Draw their attention to the pattern. Ask children to try out other numbers. Does this pattern 'work' every time ten is subtracted?

100s jigsaw

The instructions for the 100s jigsaw are written up elsewhere on this site.

Subtracting ten: 100 grid

Use the large 100 grid. Point to a two digit number and have the children identify this. Challenge them to find the number that is ten less. Allow children time to do this, and establish the answer. Ask children to tell their ways of finding the answer. Lead the children through a check of each method.

Have pairs of children use a 100 grid to check if this 'works' for other two digit numbers. Encourage them to record each number they tried, and the number that is ten more.

Use the large 100 grid. Point to a two digit number and have the children identify this. Challenge them to find the number that is 9 less. Allow children time to do this, and establish the answer. Ask children to tell their ways of finding the answer. Lead the children through a check of each method.

Step four: Solving subtraction word problems

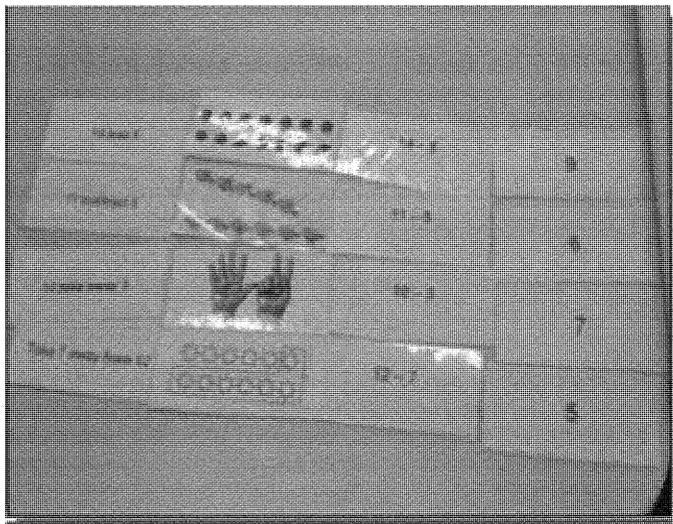
The next stage is solving word problems. We did not do many activities at this stage, but one that we did do was as follows.

Focus on words

Four representations

Each group has a set of 16 cards, with four different subtraction calculations represented, and 4 representations of each calculation, such as “12 – 7”, “5”, “take 7 away from 12”, and a drawing such as 12 objects with 7 leaving.

The cards can be used for structured games such as concentration, snap, or placed on a prepared board. In this case, the students in pairs were asked to group the cards however they liked. There was a diversity in their responses, but it seemed that the students were able to decode the representations, and most of the group, unsupervised were able to suggest some possible groupings. One only group by themselves, and another with help, grouped all four representations together. The set that was used highlight the need for care with the representations and the words. For example, even though the students could match “take 7 away from 12” with an appropriate card, the term “subtract” on another card created difficulties.



Rich mathematical tasks in the *Maths in the Kimberley* (MITK) project*

Peter Grootenboer

Rich mathematical tasks are central to the pedagogy that underpins the MITK project. In this paper I present and discuss the characteristics of rich tasks as we have defined them in the project. Activities that have the qualities outlined here can provide the ‘tools’ for teachers to develop their pedagogy so that deep mathematical learning is promoted for all.

Overview

In this symposium we will discuss four aspects of the pedagogy that underpins the MITK project. The project is based in six schools in the remote Kimberley region with the express intention of enhancing the mathematical learning for Indigenous students in these communities. Over three years, the project will investigate, implement and evaluate particular strategies that are likely to enhance the learning of mathematics. The four papers in this symposium each focus on one aspect of the range of pedagogical components of the MITK project (for further details see Zevenbergen, Niesche, Grootenboer, & Boaler, 2008).

Introduction

A central and critical component of the pedagogy that underpins the MITK project are the tasks and activities that make-up the mathematics lessons. The importance of rich mathematical tasks is not new, as was highlighted, for example, many years ago by Afzal Ahmed (1987) in his ground-breaking work in the UK. Furthermore, the ideas about what constitutes a rich mathematical task here are not radically new, but rather we have drawn on the wealth of research-based knowledge that already exists, in particular aspects of Boaler’s work at Railside (2008; Boaler & Staples, 2008) and the *productive pedagogies*

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that were developed from the Queensland study of schooling (Lingard, et al., 2001). We have rested upon these projects because they had a strong emphasis on pedagogy that caters for diversity and promotes equity. The development and use of rich mathematical tasks is pivotal to the pedagogy of the project, but we are aware that they can only “provide a set of constraints and affordances”, and it is in the implementation “that the learning opportunities [are] realised” (Boaler & Staples, 2008, p. 627-628).

In this paper I will briefly outline and discuss the characteristics of rich mathematical tasks as we have defined them in the MITK project pedagogy.

Characteristics of Rich Mathematical Tasks

The term ‘rich task’ was employed as a central platform in the *New Basics* program that emerged from the Queensland longitudinal study (Lingard, et al., 2001). In the *New Basics*, a rich task was seen as a substantive, transdisciplinary problem that would “require students to analyse, theorise and engage intellectually with the world” (Education Queensland, 2001, p. 5). Such a task would have intellectual depth and educational value, and it would require a significant amount of time to complete. In the *New Basics* program the Rich Tasks were largely used for assessment purposes and they were not limited to mathematical learning. Boaler’s work at Railside School had a particular focus on mathematics education, and in this project there was a strong emphasis on mathematical problems that were “groupworthy” (Boaler & Staples, 2008, p. 627), meaning that they not only had to be substantially mathematical, but they also had to have opportunities for multiple representations, multiple solution pathways, and require the shared resources of the collective. Drawing upon these two seminal works, the key aspects of rich mathematical tasks in the MITK pedagogy include:

- Academic and intellectual quality
- Group work
- Extended engagement
- Catering for diversity through multiple entry points, multiple solution pathways
- Connectedness
- Multi-representational

Academic and intellectual quality

Rich mathematical tasks will have academic and intellectual quality because they facilitate deep mathematical learning (Zevenbergen & Niesche, 2008). These sorts of tasks require students to work mathematically by inviting them to rationalise and make conjectures, to hypothesize and then test their ideas, and to justify their findings and represent them in meaningful ways. In short, these are the activities of mathematicians that are central to mathematical practice, and as such, are essential for a task to be deemed appropriate for mathematical pedagogy (Burton, 2004).

Boaler and Staples (2008) noted that students in their Railside study, whose mathematical program largely consisted of tasks with academic and intellectual integrity;

regarded mathematical success much more broadly than students in ... traditional classes, and instead of viewing mathematics as a set of methods that they needed to observe and remember, they regarded mathematics as a way of working with many different dimensions. (p. 629)

By employing rich tasks that are dense with mathematical knowledge and processes, the students at Railside not only performed well in standard formal assessments, but they also developed a robust mathematical identity that would engender a positive attitude towards continued mathematical participation and engagement.

It is worth noting that Freedman, Delp, and Crawford (2005) found in their study into issues of equity in teaching English, that having culturally sensitive materials was not a prerequisite quality of appropriate tasks. However, they also noted that it is important that tasks that were challenging academically for the students.

Group work

Opportunities for students to work collaboratively in groups are integral to rich mathematical tasks in the MITK pedagogy. Effective group work allows students opportunities for students to develop deep understanding through substantive conversations. (Group work is discussed in more detail by Jorgensen later in this symposium).

Extended engagement

If students are going to develop deep and robust mathematical knowledge by engaging in tasks that have academic and intellectual integrity, then the tasks need to be prolonged in nature. In both the productive pedagogies and the Railside project, the tasks required extended time and energy, and students were required to persevere on a task. Indeed, at Railside class periods were 90-minutes so extended engagement could be facilitated. Schoenfeld (1992) noted the folly of trying to develop mathematical thinking by giving students multiple questions to complete in a brief period of time (e.g., 30 exercises in 60 minutes). The unspoken, but pervasive message is that each question should take you no more than a minute or two, and the task is to finish them as quickly as possible. Extended engagement not only allows for richer mathematical outcomes for the students, but it also promotes the development of personal qualities such as resilience and perseverance.

Connectedness

In the *New Basics* program the rich tasks were required to be transdisciplinary, and while our focus is primarily on mathematics, we also see connectedness

as important. In the pedagogy of the MITK project, the mathematical activities should first of all, link and build upon students' background knowledge and experience – both mathematical and more generally. To this end, it is important that teachers know and understand their students (Grootenboer & Zevenbergen, 2008). Further, the tasks should connect with other mathematical concepts and ideas, and again, this allows students to build robust mathematical knowledge thus adding intellectual and academic quality. In this way students avoid building siloed and disconnected connected mathematical knowledge. Tasks that are problem-based can also link in meaningful ways to other discipline areas and the 'real world'. This sort of connection allows learners to see the ubiquitous and utilitarian value of mathematics and build enabling numeracy practices.

Cater for diversity

A rich mathematical task must cater for a range of students in terms of previous mathematical achievement and interest, and different ways of thinking, learning and working mathematically. This means that tasks must have multiple entry points and multiple solution pathways (Freedman, et al., 2005). Tasks with these qualities not only cater for a range of students, but they also enhance the intellectual quality of the afforded learning by requiring students to analyse and evaluate the alternatives presented in their group.

Multi-representational

Finally, rich tasks also need to be multi-representational so students can express their mathematical ideas in ways that are appropriate for their solution path and context, and that suit the individual and/or the group. As was pre-empted in the discussion of diversity, students can extend and enrich their mathematical understanding by experiencing a range of representations of the mathematical ideas that are embedded in a rich task. In the Railside project tasks that allowed for multiple representations were seen as critical by the participating teachers and the researchers.

At Railside, the teachers created multidimensional classes by valuing many dimensions of mathematical work. This was achieved, in part, by implementing open problems that students could solve in different ways. The teachers valued different methods and solution paths and this enabled more students to contribute ideas and feel valued. (Boaler & Staples, 2008, p. 629)

The desire for multiple representations does not imply that all are equal in value, but when they are shared there are opportunities for discussions about the limitations, merit, and elegance of each representation.

Concluding Comments

The sourcing and/or development of rich mathematical tasks are essential to the development of the pedagogical approach employed in the MITK project. However, they are not alone sufficient, as the teacher is the key

critical component (Hayes, Mills, Christie, & Lingard, 2006). Therefore, while attention is paid to the nature of the mathematical tasks in the project, the central focus is on teacher professional development.

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Cooperative learning environments*

Robyn Jorgensen (Zevenbergen)

Learning is a social activity but mathematics classrooms are often sites for solitary work or at best, parallel work where students may sit in groups but do not interact. For the engagement of learners, working collaboratively in mathematics represents a significant shift in practice. This paper explores the principles of cooperative learning environments and with the roles that learners need to undertake to ensure group participation and membership. Working in Indigenous environments, there are considerable challenges to implementing a collaborative learning environment despite its synergies with Indigenous ways of knowing.

Introduction

Initially the *Maths in the Kimberley* (MITK) project drew on Complex Instruction (Cohen & Latan, 1997) processes as outlined through Boaler's (2008) work with *Railside*. In this reform approach to mathematics, group work was seen as a key feature of the learning environment. At *Railside*, Boaler found that group work, when accompanied by well designed tasks, fostered deep learning among students. The quality interactions among learners in groups as they worked collaboratively on well-designed tasks facilitated deep learning. In this approach, group work was structured so as to enable learners to talk, debate, contest, clarify, etc their understandings as they engaged with mathematical tasks that were cognitively demanding. These two constructs were central to engaging learners in mathematics. As will be discussed in Grootenboer's paper in this symposium, quality tasks are central to the learning as they provide the entrée into the mathematics while enabling good discussion among peers. The ideas that Niesche also proposes are critical to the language backgrounds of the learners and how they can use home language to negotiate meanings in group work. The culmination of learning through engagement in group work, with shared responsibility for reporting back is discussed in Sullivan's paper.

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Collectively, these elements of the Kimberley Mathematics project are outlined in this symposium.

Within the Complex Instruction model, students are expected to act as resources for each other within a group. Cohen and Latan (1997) state the fundamental premise of the grouped activity work is that students "have the right to ask for help, and you have the duty to assist when asked" (p.21). This approach encourages students to justify their arguments; explain their processes or rationales for actions; seek clarification for action and so on. This encourages the development of rich thinking among students.

Cooperative Learning and Indigenous Education

The use of cooperative learning appears to be a useful strategy, at least at a theoretical level, when working with Indigenous learners. As cultures that rely on oral traditions, being able to talk with peers would seem to resonate with these cultures. However, as has been noted in earlier research (Zevenbergen, Mousley, & Sullivan, 2004) there are often expectations held about the teaching of mathematics that are held by learners of particular cultures. Mathematics is frequently seen as a curriculum area where individual learning is the norm so shifting this approach to one of collaboration demands a shift in culture that needs to be made explicit to learners so that they can understand and engage with the changed environment. It would appear that collaborative learning augers well with many Indigenous ways of knowing and working.

Constitution of Groups

Drawing on heterogeneous grouping research, within the approach there is a strong recognition that groups should be multi-ability. This approach represents the usual practices beyond school. In out-of-school settings, there is a broad range of skills, strengths, dispositions in most workplaces that collectively enable the successful completion of problems or tasks. Similarly, ensuring a diversity of strengths within a group enables a more comprehensive team that is more likely to be able to solve the problems/tasks being posed. Studies have consistently shown that heterogeneous grouping benefits all learners so that mixing students offers greater potential for learning than homogeneous groupings. However, Gillies and Ashman (1995) argue that for the most gain from heterogeneous grouping, students need to be skilled in interpersonal skills and know how to work in groups.

Gillies (2005) summarises collaborative group work as being most effective when the size of the group is around 4 members; where there is a gender balance and a mix of abilities; where tasks are clearly defined (such as open and discovery based as found in the rich-task format) and with explicit criteria and scaffolding; and where students receive appropriate training/scaffolding to provide and ask for assistance.

Group Task

It is not the intention to elucidate on this aspect of group work in this paper as it will be addressed in greater detail by Grootenboer in this selection of papers. However, it is worthy to note that most mathematics tasks given to students, such as find the area of a particular shape, only require minimal interaction among peers. These tasks are often clearly outlined, have a well defined process for resolution; have a clear prescription in process and produce and in so doing have little need for interaction among peers. With this in mind, the effectiveness of collaborative learning is highly contingent upon the provision of good tasks that enable dialogue among peers.

Maximising Participation in Small Groups

To ensure that students gain most learning, the teacher needs to ensure maximum participation in small groups. This is achieved by the teacher delegating authority to students so that the teacher is able to monitor classroom behaviour by making students responsible for their own and their peers' learning. Students are expected to monitor their own on-task behaviour as well as their peers.

The students assume responsibility within the group to support each other. Gillies (2005, p. 107) referred to the concept of 'promotive interaction' which she argued enabled student to provide support to each other; facilitated the sharing of resources; providing constructive feedback to peers in order to enhance performance on a task; provoke challenges to the conclusions provided by groups in order to gain improved insights into the tasks and solutions; enabled students to encourage the engagement of their peers; demonstrating positive dispositions towards peers; and for mutual gains for all participants.

Roles within Cooperative Learning

In the traditional group work models, particular roles have been identified such as reporter, gopher, time keeper, and material manager processes. These traditional roles tend to allow learners to take on particular roles but where there is no interdependence among members. For example, the time keeper can keep an eye on the time but not engage in the substantive learning. As such, those roles can foster more opting out of the learning than engaging with the learning. In contrast the roles advocated in the Complex Instruction model are ones where students are encouraged to be proactive in the learning process. For example, one person may be assigned encourager where the role is to listen to the contribution of members and where a member makes a contribution to the discussion but this may be ignored or skipped over, the encourager brings the discussion around to include this contribution. Some of the specific roles that Cohen and Lotan (1997) identify are:

Facilitator: ensures that all members understand the instructions and expectations of the task; that all students have opportunities to participate in

activities and discussion; and acts as the conduit between the teacher and group members

Reporter: undertakes the reporting back on the learning of the group; and often evaluates how the group worked.

Materials manager: ensures all equipment is collected for the activities; oversees any tidy up at the end of the lesson

Harmonizer: facilitates communication among the group; encourages students to participate (or not participate if someone dominates).

McInerney & McInerney (1998) also advocate for similar roles to Cohen and Lotan but extend this to include:

Motivator: to ensure the group moves with the tasks

Contributor: ensures that self makes a contribution and models this to other members so as to ensure all members contribute

Summariser: keeps a record of key points raised by the group to enable a recapitulation at the end of the activity

Collectively this range of roles ensures that the group self-monitors as they work through the tasks and keeps all members actively engaged with the task and its resolution

Group Accountability

Aligned strongly with the Chinese approach to education and learning, the approach adopted within this project is one where the group is accountable for the learning of others within that group. The Complex Instruction model has the students working within the group and when it appears that all members understand the underlying mathematics and could individually explain their learning to the teacher, the member responsible for the group, calls the teacher over. The teacher's role is now one of asking members to explain his/her learning or understandings. If a member does not appear to understand the expectations of the task, then the teacher passes responsibility back to the group, and walks away, leaving the group members to support their peer in coming to understand. The teacher may pose questions to provoke a learning episode but the responsibility remains with the group.

Teacher Roles

The approach requires the teacher to progressively remove him/herself from a direct teaching role. Initially time is spent on developing the classroom culture but as this becomes embedded, the teachers' role is less intrusive and becomes more engaging. Cohen and Lotan's (1997) research indicates that at first this may be threatening to teachers to absolve responsibility for direct teaching but as the practices becomes more entrenched, the role of the teacher shifts to a more enjoyable one where

they are able to take a greater responsibility for fostering deep learning over behaviour management.

One of the most critical roles for the teacher is the assigning of status to students. As the role becomes more about observations of students, the teacher is able to observe students interactions. As a goal of the approach is to increase participation rates for all students, the teacher assumes responsibility for enabling the inclusion of students who are often peripheral to groups. This is achieved by assigning status to students who may not be included by peers. In her work, Boaler noted the teacher hearing student input but which was ignored by her peers so the teacher casually drew attention to the student's input thus making her input critical to the resolution of the task. This process assigned recognition (or status) to the student.

Enacting Collaboratively Learning in Remote Indigenous Communities

The rhetoric around collaborative learning through structured group work that has been centred on quality tasks suggests that there would be very positive gains – cognitively and socially. As noted, such a process is often quite different from the traditional approaches found in school mathematics – namely solitary and competitive work. As such, implementing this change requires considerable input and support from teachers as it represents a cultural shift in the classroom organisation.

Within the remote communities, working in small groups posed particular challenges in some schools. For small communities where the class size is often small, that is, where there may be less than 10 students in a class, and in some cases, only 4-6 students in a class, the small group is the class. Further compounding the small class size is the issue that many of the students are from the same family thus making for the group to be a family grouping with the dynamics from the family in operation. For the teachers, group work posed challenges that are not evident in larger classes. However, from a project perspective, we would contend that the principles of collaborative learning can be enacted within these small classes when the teacher is able to scaffold student learning of the principles that underpin this form of classroom organisation.

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The use of home language in the mathematics classroom*

Richard Niesche

In this symposium, I argue that the use of home language needs to be viewed as a valuable resource for teachers in Indigenous schools in the Kimberley region of Western Australia. For students to be able to negotiate meaning and mathematical concepts in Kriol can help facilitate their mathematical learning as well as demonstrate an explicit valuing of indigenous cultures and heritage.

Introduction

The continual underachievement of Indigenous students in this country has been well documented (MCEETYA, 2006). As a part of an overall reform pedagogy to address the poor performance of Indigenous students' outcomes in mathematics in the Kimberley region in Western Australia (Zevenbergen & Niesche, 2008), this paper examines the issue of home language use in the classroom. The issue of language in the classroom has long been recognised as an important one in Indigenous education in Australia (Malcolm, Kessariss & Hunter, 2003). With the use of Standard Australian English (SAE) as the dominant mode of communication in the classroom, this places those students who speak English as a second language, including Indigenous students who speak Kriol or Aboriginal English, in the difficult position of having to 'catch up' with those students who have grown up only knowing English. When Aboriginal students from regions such as the Kimberley come to the classroom, they come equipped with a language and form of communication that is based on an Indigenous world view (Christie, 1985) with particular cultural histories and ways of being. Harris (1984) has argued that the Aboriginal public speaking 'rule' of the right for speakers to speak and the right of listeners not to listen, coupled with the increased level of movement and physical activity within the classroom places these students at odds with the mainstream way of 'doing' school. Walsh (1997) also claims that communication in Aboriginal

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society is largely communal rather than the more dyadic and contained interaction of non-Aboriginal groups.

While such differences need to be recognised, it is equally important that such cultural aspects are valued in both rhetoric and in practice. The aim of this paper is to therefore argue for the use of students' home language within the mathematics classroom to negotiate meaning and to place an important emphasis on valuing their cultural heritage. This latter point is particularly important with the loss of large numbers of Indigenous languages throughout this country. It is important for these communities' cultures to be acknowledged and preserved. The use and encouragement of students to use their home languages can also be a powerful resource for teaching and learning. Such a model moves away from deficit discourses that have so plagued Indigenous education in this country to one of viewing such a cultural heritage as a valuable resource.

Languages in the Kimberley

There are a large number of diverse languages in the Kimberley region. However, the relatively small group of speakers means that many of these languages are under threat (Berry & Hudson, 1997). Languages spoken in the Kimberley are both a Kriol and Aboriginal English (AE) which adds to the complexity for classroom teachers. The difference between these two terms is the extent to which the language is influenced by English. However, both terms are often used interchangeably. Kriol is largely a mixture of local Aboriginal languages and English, however words typically have a new Kriol meaning and pronunciation. For the students who speak Kriol and learn English at school, they quickly adapt to using Kriol amongst their peers and family, and English with English speakers such as classroom teachers. The knowledge of Kriol is a sign of identity with their community. In some cases children speak Kriol while their parents' main language is a traditional one (Berry & Hudson, 1997).

Approaches in the Mathematics Classroom

It has been recognised that the issue of language is a crucial one in the process of constructing mathematical knowledge within the classroom (Gorgorio & Planas, 2001). In order to improve their educational outcomes and performance in school mathematics, these Indigenous students will need to be able to negotiate the fundamental and linguistic assumptions that underpin school mathematics. In addition, they need to be able to fully participate and engage in other aspects of this research project, such as group work, intellectually challenging tasks, and reporting back. All of these activities place an enormous strain on the students' capacity to fully engage with these aspects of classroom learning. As a result, I believe that students be encouraged to use their 'home language' or Kriol in the classroom for the purposes of negotiating mathematical concepts to enable them to better understand and negotiate these mathematical problems.

Research into approaches such as 'code switching' and multilingual classrooms has been conducted extensively in South Africa (Setati & Adler, 2001) and Canada (Epstein & Xu, 2003). The notion of code switching refers to the practice that enables learners to harness their main language as a learning resource. The work of Boaler and Staples (2008), for instance also highlights the power of such an approach in raising the outcomes for non native English speakers. In Boaler's study of Railside, the students were able to negotiate meaning in their home language (Spanish), however, they were required to also use the appropriate mathematical terms when discussing their ideas to the class. Setati & Adler (2001) also point out the importance of contextual diversity, and the issue of moving between languages is only part of the process of learning mathematics. They point out that moving between languages and distinct mathematical discourses is where the main challenge lies. It is not just a matter of switching languages but also negotiating the mathematical language and articulating the meaning of mathematical concepts. This is certainly a challenge for teachers in Indigenous communities such as those in the Kimberley for meaning is derived from context. The lack of immersion in number within regions such as the Kimberley compounds the problem. There is very little use of numbers within these communities. For example, in the local store, there are no prices on items, nor are there numbers on houses etc. As a result these contexts offer little in ways of preparing students for the world of schooling.

One of the aspects of this research project is for the teachers to encourage the students to report back on their learning in their group activities. It is expected that while the students can negotiate meaning within their groups in their home language, they are required to report back to the rest of the class using the appropriate mathematical terms in SAE.

Facilitating the use of Home Language

The teachers participating in this project have so far been hesitant to encourage the use of home language by the students. Of the 26 lessons that have been observed during 2008, none of the lessons have made explicit mention of students using their home language. One reason for this may be that so far, the emphasis has been on developing mathematically rich tasks for the students and this has been the teachers' focus. Some teachers have also commented that in fact, the students do use their language all the time in the classroom and therefore they feel there is little point in mentioning it. However, as a part of this project we feel it is an issue that needs further exploration and finding ways to facilitate students' understanding is necessary. Other reasons for the lack of 'take up' of this notion could be reasons such as teacher inexperience (many teachers are first or second year out teachers); lack of knowledge of local languages (a number of teachers are also new to the region); a harsh and isolating physical environment in which to teach, where teachers are in remote areas a long way from families and friends; and complex and often problematic relationships with the local communities. For success in this project, it is

vital that the students' home language or Kriol is viewed as a resource to the students' learning rather than a barrier.

There are two issues that are important in facilitating teachers to enable the students to use their home language within the classroom. These are the importance of school leadership, and the use of Aboriginal Education Workers (AEWs) from the local communities. With such a valuable resource as AEWs on the schools' doorsteps, these community members can provide the necessary link between the teachers and the students in the negotiation of home language. However, the facilitation of these links requires leadership from the school to make those links productive and beneficial. Of the six schools participating in this project, five of these use AEWs in the classroom. However, from our observations of these classroom interactions, the AEWs are largely functioning in the role of managing and observing student behaviour rather than taking an active role in the classroom activities and facilitating the students' learning. It is common for AEWs to be heard 'growling' at students when they are misbehaving, yet their participation in classroom learning can be of great benefit to not only the students' learning but also to help school community relations. In discussions with the AEWs at one school concerning their role in the classroom, they responded that they would like to play a more active role in the learning activities. In order to facilitate such involvement, the principals and teachers need to actively work with the AEWs to help them contribute to the teaching and learning in these schools. There have been some complaints that the AEWs can be unreliable, not turn up on time or regularly, and not have the required expertise to adequately help the teachers. It is therefore the role of the school leadership to move away from existing deficit models of the contributions of local community members to one of actively seeing these AEWs as potentially valuable resource that can benefit the children and their communities. In response, we have encouraged the attendance and participation of AEWs in the twice yearly workshops run by the project research team.

Concluding Comments

In this paper I have put forward the argument that the use of home language in the classroom for the students involved in this project can be of benefit to both the students and communities. This has largely been a proposal rather than a report based on empirical evidence. The challenge is now up to the teachers to design appropriate tasks that allow the students to collaborate in their home language on rich mathematical investigations. These collaborative efforts can need to be facilitated by an AEW from the local community for any chance of success. Only then can we evaluate the effectiveness of this approach for this particular context, and if necessary, tailor the approach to suit the contexts in which these students live. The model which is proposed here represents a significant shift away from existing approaches to teaching mathematics in these areas. If we are serious about improving the continual underachievement of Indigenous students in this country, then this approach, as a part of a larger

pedagogical reform, can play an important part in redressing this imbalance.

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Describing teacher actions after student learning from rich experiences*

Peter Sullivan

This contribution to the Maths in the Kimberley project symposium focuses on teachers' actions around the review of student work. Recognising that teacher actions at each phase of a lesson are connected, it is argued that there are two different but complementary rationales for effective reviews of student work, and two phases at which such reviews occur. The following uses a vignette from a lesson observed as part of the project to elaborate some of these actions.

Introduction

The pedagogies associated with directed teaching are clear and obvious (see, for example, Good, Grouws, & Ebmeier, 1983). On the other hand, if the teacher aims to facilitate the learning that arises from engagement of children with rich mathematical experiences, the pedagogies are more complex. The *Maths in the Kimberley* (MITK) project is examining some of these complex pedagogies, one aspect of which relates to the actions teachers take after students have engaged with such activities.

The following presents some actions that contribute to effective lessons, outlines two rationales for effective reviews of students work, and elaborates two phases at which such reviews occur.

The nature of the teaching we advocate

The complexity of the pedagogies associated with organising rich learning experiences have been well documented. Sullivan, Mousley, and Zevenbergen (2006), for example, when describing lessons that have

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potential to address diversity of student readiness, proposed the following as lesson elements:

The tasks and their sequence: Open-ended tasks create opportunities for personal constructive activity by students, and appropriate sequencing of tasks contributes to their effectiveness.

Enabling prompts to support students experiencing difficulty: Teachers offer *enabling prompts* to allow those experiencing difficulty to engage in active experiences related to the initial goal task, rather than requiring them to listen to additional explanations or having them pursue substantially different goals.

Extending prompts for students who complete the initial task readily: Students who complete the planned tasks quickly are posed supplementary tasks that extend their thinking on that task.

Explicit pedagogies: Teachers make explicit the usual practices, organisational routines, and modes of communication that impact on approaches to learning, types of responses valued, views about legitimacy of knowledge produced, and responsibilities of individual learners.

Learning community: All students progress through learning experiences in ways that allow them to feel part of the class community and contribute to it, including being able to participate in reviews and class discussions about the work. (p. 497)

Similarly, the MITK project proposes that lessons should include: rich tasks and activities, drawing on a “working as a mathematician” approach; group work to prioritise social learning; use of home language for student-student communication; high interactivity between students within the group work and the reporting back stage; and use and recognition of multiple representations allowing accommodation of diversity of approaches among learners.

The focus in this contribution is on the reporting back phase of lessons. To clarify aspects of the following discussion, an example that was used as part of a within class study as part of the project is presented. When teaching a class in a community school in the Kimberleys having initial experiences in learning subtraction, a problem was posed as follows:

I am thinking of two numbers. The difference between the numbers is 2. What might be the numbers?

This was recorded symbolically as $_ - _ = 2$. The point was that pupils could explore different aspects of a difference of two, and even recognise the patterns of difference that appear. In this class pupils had opportunity to make active decisions on the numbers they used and the way they recorded their results. The teacher emphasised to the students that there is more than one possible answer, and asked the students to search for patterns in their answers. The pupils worked productively on the task, and most groups were willing and able to produce multiple solutions, some of which were systematically organised. Making choices seemed to be engaging. Students worked in groups and had particular roles which contributed to the success of the activity. So far, this lesson had all of the

elements of a successful experience. To realise the potential of this initial learning, the key was how the students' work was reviewed by the teacher.

There are two aspects: mathematical and social

All students had participated in common activities that could form the basis of common discussions and shared experience, both social and mathematical. These two aspects are reflected in Wood's (2002) emphasis on the interplay between children's developing cognition and the “unfolding structure that underlies mathematics” (p. 61) and “rich social interactions with others substantially contribut(ing) to children's opportunities for learning” (p. 61).

For the mathematical aspects, it is argued that students can benefit from either giving or listening to explanations of strategies or results, and that this can best be done along with the rest of the class with the teacher participating, especially facilitating and emphasising mathematical communication and justification. A key in such tasks such as this example is students having the opportunity to see the variability in responses (Watson & Sullivan, 2008). Cheeseman (2003) similarly argued:

the critical issue is to think about drawing mathematics lessons to a close in the most effective and interesting manner. It is difficult to do so well and quite complicated because it involves much more than simply restating the mathematics. It encourages children to reflect on their learning and to explain or describe their strategic thinking. The end of the session give the opportunity for teaching after children have had some experience with mathematical concept. (p. 24)

The second aspect of reviews at the end of lessons is the contribution they make to social learning. The second aspect is related to a sense of belonging, but is also connected to building awareness of differences between students and acceptance of these differences. Such differences can be a product of the students' prior mathematical experiences, their familiarity with classroom processes (e.g., Delpit, 1988), social, cultural and linguistic backgrounds (e.g., Zevenbergen, 2000), the nature of their motivation (e.g., Middleton, 1995), persistence and efficacy (e.g., Dweck, 2000), and a range of other factors.

In the case of the subtraction experience, the teacher invited, in turn, each of the groups to report on their exploration. Note that the openness of the task gave students something to report on. One of these feedback instances was videotaped, reviewed and studied. This particular group produced 17 separate responses to the difference 2 question, although these were presented on a small whiteboard somewhat haphazardly.

In this group there were four students, and there were two reporters. The teacher first affirmed one of the responses, and asked the students how they found the answer to $19 - 17$. One of the reporters said “thinks”. To seek to draw out a more extended explanation, the teacher commented that she had noticed that the group did not use their fingers. In response, this

reporter said that they did, indicating that one student had put up 10 fingers, and the other had put up 9, at which stage this student then fell over (perhaps not liking being pointed at). This meant that the teacher was not able to solicit the key piece of information, which is how the students knew that the other number was 17.

The two aspects of lesson reviews were evident in the lesson. There was clearly a mathematical aspect to this review, which was that there are various ways of finding a difference of two, and having a strategy for doing this is helpful for students. Note that the teacher had intended this when choosing to use this activity. There is also a social dimension, in that students had worked in groups, and the group sharing emphasised the ways that the groups had negotiated the activity, and the reporting on an activity in which they had all participated highlighted the community that was represented by the classroom.

There are two phases to lesson reviews

It is helpful for teachers to think about the lesson review as consisting of two phases. The first is where the teachers solicit explanations from the students. In general terms, a possible approach is for some students with simple strategies to be invited to demonstrate those responses to the class. Next, the teacher might choose a student who had produced an organised response to summarise their answers to the whole group. Students who have different responses can be invited to contribute their answers. Cheeseman (2003) described the purposes as: gathering evidence; summarising; reviewing the focus; sharing common discoveries, celebrating learning; learning from each other; encouraging students to reflect on what they had learned; extending thinking; and building positive attitudes. Some of these are illustrated in the above discussion of the subtraction example.

The second phase involves specific actions by the teacher to ensure that the key findings from the explorations reported are sufficiently emphasised. One appropriate action is for the teacher to summarise successful strategies and the collective responses. The teacher can also seek to draw out patterns, identify commonalities, and promote the forming of generalisations. Cheeseman (2003) listed some of the key actions for teachers as providing evaluative feedback to students, flagging possible future activities, and reiterating the purpose of learning.

In the case of the subtraction lesson, a number of the groups reported of significant insights that could assist with aspects of subtraction in the future. While it was possible to experienced observers to infer the key insights and to extrapolate from the brief descriptions given, it was unlikely that the other groups of students would have seen those insights, or even have been alerted to their existence through the group reports. In this case, the teacher spent some time seeking to develop the pattern 19 - 17, 18 - 16, 17 - 15, ... that the group whose responses were recorded used. Of course, if all goes well with the first phase of the review then the second phase may not be necessary, but the teacher still needs to be aware of the possibility of the need for the second phase.

Summary

The MITK project is working with teachers on various aspects of the mathematics teaching, and one of the key guiding frameworks is the pedagogical approach. It is recognised that the pedagogical elements are complimentary, and all are necessary. This contribution has focused on just one aspect of these pedagogies: that of lesson reviews.

It is argued that there are two purposes for lesson reviews: mathematical; and social. It is also argued that there are two phases of lesson reviews: students reporting; and teacher synthesising. Teachers will be better able to cope with the complexity of student centred pedagogies if they are aware of the nature of each of the elements.

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Challenges for teacher education: the mismatch between beliefs and practice in remote Indigenous contexts*

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The poor performance of Australian Indigenous students in mathematics is a complex and enduring issue that needs a range of strategies to enable success in schooling for these students. Importantly, large numbers of teachers in remote Indigenous contexts are new graduates who, while full of enthusiasm, lack experience. Similarly, many of them are unfamiliar with the demands and nuances of teaching in remote and/or Indigenous contexts. This paper explores the nexus between the beliefs and practices of teachers working in a remote, Indigenous region of Australia. In particular, it proposes that the discrepancy between beliefs and practices found in the reconnaissance phase of a design study is due to the teachers realising that they need to implement changed practices to enable students to learn but having little knowledge of what such practices may look like. This finding has implications for pre-service and in-service teacher education.

Introduction

The underperformance of Indigenous students in Australia continues to be nothing short of alarming. Recent data (Ministerial Council on Education, Employment, Training and Youth Affairs (MCEETYA), 2006) indicate that Indigenous students are performing at a much lower level than their non-Indigenous peers, and also that the difference between Indigenous and non-Indigenous students has increased in recent years. Furthermore, these

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data indicate that the longer Indigenous students remain in school, the wider the gap becomes. Many factors contribute to this enduring educational concern. The one that we consider in this paper is the role of the teacher in bringing about reform practices that may help to redress inequities in terms of access to, and performance in, school mathematics. Our focus stems from recent studies indicating that the most critical variable in the provision of quality learning is the teacher (Hayes, Mills, Christie, & Lingard, 2006; Hill & Rowe, 1998; Lingard et al., 2001).

In the Australian context, there is recognition that many teachers who work in remote, Indigenous communities are new or recent graduates (Cape York Institute, 2007; Heslop, 2003). Furthermore, most are from white, middle class, urban environments and have had little interaction with people of other ethnicities and social class (Allard & Santoro, 2004; Causey, Thomas, & Armento, 2000), and no experience of life in isolated rural or remote settings. Teacher turnover is very high in rural and remote communities (Heslop, 2003). Further, the tyranny of distance compounds the difficulty of professional conversations among teachers in remote communities. Collectively, these challenges can create difficulties for beginning teachers in their adjustment to life in this context, and barriers to their professional learning opportunities.

Through empirical survey data and by video recording of classroom teaching, we demonstrate the disjunction between teacher beliefs and classroom pedagogies in remote contexts. We contend that the teachers, most of whom are very early in their careers, understand the need for inclusive practices in the communities but do not have the skills to enact their preferred strategies. We discuss and explain these outcomes using the data and field notes compiled when working with teachers in their schools and professional development workshops. These data highlight several issues: the need to support teachers to be able to enact their preferred pedagogies; the shortcomings of pre-service education of beginning mathematics teachers in remote indigenous communities; and the need for on-going in-service work for these teachers.

Background

A note on the term "Indigenous Australian"

Before commencing this paper, we highlight an important issue related to our use of the term 'Indigenous Australians'. Diversity is as great among Indigenous people as it is among many other groups of people. For this paper, we need to be able to express the focus of our writing in ways that will help support the coherence of the text. To enable this, we adopt the protocol of referring to 'Indigenous Australians' but are cognisant that this is a shorthand term that reflects a multitude of people, cultures, and languages. Our use of this term is not meant to devalue the diversity of Australian Indigenous people. We propose that those aspects which unite Indigenous people and make them different from non-Indigenous people help to make a construct from which to talk about the issues raised in this paper.

Teaching mathematics in remote Indigenous communities

There is recognition within the field of mathematics education that primary pre-service teachers are often fearful regarding their study of mathematics education. Frequently their content knowledge and pedagogical content knowledge are quite weak. The vision for pre-service education programs is to redress this situation so that teachers enter the workforce with a strong preparation to work effectively with learners of mathematics. Those who teach in remote communities are often fresh graduates who are highly motivated and enthusiastic with their appointments but lack the experience of the longer serving teacher. The schools often consist of only a handful of teachers hence there is little scope for mentoring by older, more experienced staff. Further, the schools are often remote, so the opportunities for professional, face-to-face interactions are limited (Beresford & Partington, 2003). Collectively these issues compound the challenges faced by teachers in remote communities.

Cultural approaches to teaching Indigenous mathematics

Recognising the limitations in what can be presented in the following sections, we seek to propose that there are three main approaches to teaching mathematics in remote Indigenous communities. Each approach is premised on some notions of what it is to learn mathematics; what mathematics is; and what the key elements are that should be learned. The differences in approach can vary according to the location of the people – the experiences of those who live in urban areas can be quite different from those who live in remote, isolated areas. Ways of living and thinking vary considerably according to students' cultural backgrounds, which influence how students engage with mathematics (de Abreu, Bishop & Presmeg, 2006; Kaleva, 2003; Matang & Owens, 2004; Owens & Kaleva, 2007). This paper is focusing on those students in remote contexts.

Deficit models

According to a deficit model of culture and mathematics, Indigenous students bring little mathematical understandings or knowledge to the school context. In part, Indigenous students' limited contribution is thought to be due to their impoverished numeracy environments in which number and other mathematical ideas, as expressed through a Western curriculum, are not evident. Without the immersion in a numerate culture, coming to learn mathematics is a much more difficult process as it requires a considerable investment in (Western) mathematical ideas.

Many of the pedagogical approaches that stem from deficit models are premised on skill-and-drill activities, which require students to learn, and demonstrate some knowledge of, a body of facts reified in a curriculum document. Often the knowledge of value to the communities is not questioned, for example Pegg, Graham, and Bellert's (2005) suggestion

that speed learning enables quick recitation of number facts is representative of the skill-and-drill approach. In their work in Queensland schools, Warren, Baturu and Cooper (In press) observed teaching approaches that could be seen to be of this form and that were informed by narrow views of appropriate knowledge and ways of teaching for Indigenous students. Adding to this, Howard and Perry (2005) reported that teachers failed to take into account the particular cultural needs of Indigenous students.

Other researchers have shown that Indigenous students can learn mathematics, and that poor performance on test items is due not to a deficit in capacity but rather to educational and social factors (Boulton-Lewis, 1990). Such findings de-bunk the myth of inherently flawed cognitive skills for Indigenous learners.

Ethnomathematical approaches

Some approaches have fostered attempts to identify the activities of Indigenous people and then to seek to extract the mathematics from that activity, and use the mathematics as the basis of curriculum activity (Harris, 1990, 1992). These approaches are in line with ethnomathematical perspectives (Bishop, 1988; D'Ambrosio, 1991; Matang & Owens, 2004). In her comprehensive study of Indigenous communities in the Northern Territory, Harris (1992) reported that Indigenous people represented many spatial concepts in their art. These included concentric circles, parallelism, and symmetry. Similarly, in his early work searching for mathematical universals, Bishop (1978, 1988) argued that there are a number of mathematical activities found in every culture. However, this work was framed by a Western perspective and thus rendered some forms of knowledge to a Western mathematical standpoint. An example of this type of work can be seen in the popularity of card games (Baturu, Norton, & Cooper, 2004) played in a number of Indigenous communities.

Collectively, ethnomathematical approaches take the Indigenous activity and search for the Western mathematics within that activity. Dowling (1991) has convincingly argued that such approaches reinforce the (high) status of Western mathematics while subjugating the Indigenous activity. These ethnomathematical approaches suggest a different kind of deficit model, albeit one that still recognises differences among cultural groups (Gale & Densmore, 2000).

Bicultural mathematics

Bicultural mathematical approaches have been premised on a Western view of mathematics, the central aim of which is to induct Indigenous people into school mathematics. It is seen to be an approach whereby the mathematics to be learnt is set and the task of the teacher is to somehow enable people to learn this knowledge. In contrast to these approaches is a both-ways education program developed by Watson (1987) in conjunction with the Yolgnu people in Arnhem Land. This program recognised both Western and Indigenous ways of knowing as legitimate. For example, activities of mapping the landscape were undertaken through both school

mathematics and Indigenous approaches. Such approaches seek to develop border crossings between one culture and another, and to ensure, through promoting recognition of each culture's strengths, that neither culture is foregrounded. Indeed, one could also argue that, in some contexts, the Indigenous culture should remain dominant for Indigenous students. For instance, land mapping the Yolgnu way is more important for Yolgnu students than Western mapping and, in fact, non-Indigenous people could learn a new approach to mapping in context from the Yolgnu approach. In an international context, others have approached border crossings in this way. For example, Ezeife (2002) illustrated the power of building bridges between the culture of the students and that of school mathematics.

Factors that build success in learning

In this paper, we move towards a model of reforming teaching in complex classrooms where the goal is to enable Indigenous students to learn and perform well in school mathematics. While school mathematics has been quite outside the realms of many Indigenous life worlds, over 70% of Indigenous people live in urban settings and consequently have exposure to Western numerate cultures (Steering Committee, 2007). This exposure is less likely for Indigenous people living in isolated and remote communities, in many of which houses are not numbered, there may be only one telephone in the school, birthdates are not recorded, and the local store does not display prices. The main exposure to Western number systems is on the highway where distances to local towns are displayed, as well as the playing of card games mentioned earlier. As a result, coming to learn number in school is more challenging for students in remote rural schools than for students in other schools.

While there may be little exposure to Western number systems, Indigenous students in remote settings are likely to have strong spatial experiences. However, as these are not integral to the curriculum in the early years of schooling, the resulting mismatch between the formal curriculum and the knowledges learners bring to school can often lead to an alienation from school. Such feelings of alienation are a rational reaction to the 'symbolic violence' enacted through school such processes (Bourdieu, 1998). We use the term 'symbolic violence' to refer to approaches of teaching mathematics that reproduce dominant forms of knowledge to the detriment of marginalised groups.

Expectations held of learners are also critical to success. Perhaps one of the most pervasive factors that hinder success is the belief espoused by the linear model of mathematics. Frequently, Indigenous students have absences from schooling for a multitude of reasons, and there is a perception that such absences lead to considerable gaps in their learning. The linear model suggests that teaching needs to 'fill these gaps' and that students are not exposed to more complex ideas until such gaps are filled. However, this linear model has been significantly challenged by O'Toole (2006), who suggested that mathematics learning should be seen as a network and that learners have many paths through the maze of

mathematical concepts. These pathways will be influenced by many factors but, as O'Toole has shown, the linear model is not appropriate for mapping student learning.

Both-ways education models have acknowledged that there is a significant possibility of providing curriculum that legitimated Western and Indigenous models of learning and knowledge (Watson & Chambers, 1989). Integrating Indigenous knowledges into the school curriculum legitimates Indigenous ways of knowing. Such an approach helps to ameliorate differences between the two forms of knowledge and may build bridges between Indigenous and Western ontologies.

Research from literacy education has found that quality pedagogy and appropriate scaffolding along with high expectations of learners results in significant gains for Indigenous students (Gray, Scott, Ah Chee, Wyatt, & Bourke, 1999). Gray et al.'s work has shown that Indigenous students can be literate when the pedagogy adopted by teachers meets the needs of learners. As such, pedagogy and teachers become the lynchpin to quality learning (Hayes et al., 2006).

Currently many mathematics programs that have been implemented for Indigenous (and other) students have been founded on deficit models – of learners and of the curriculum. Most of these models are acknowledged within the mathematics education literature as having little impact or success (Clements, 1989). What most students learn from exposure to school mathematics is that they cannot do it. This raises questions of why such models still pervade, and, even more so, why such models are transported into Indigenous education contexts and expected to work. The transposition of new graduates into remote Indigenous contexts with little support or mentoring raises the issue of how the graduates will enact their learning, and what might be the effect.

Beliefs and practice

The importance of teachers' beliefs about mathematics teaching and learning is a critical factor in reforming mathematics education (Ernest, 1989). A study in Indigenous communities (Zevenbergen, Mousley, & Sullivan, 2004) demonstrated that when teachers' beliefs about inclusion and their practice align, then inclusive practice that enables Indigenous students to access mathematical ideas and concepts is made possible. While we argue for the need for beliefs and practices to align (Stipek & Gralinski, 1991), we do recognise that this may be difficult for teachers for whom work in remote communities is a new experience. As such, research findings need to recognise that teachers' beliefs are contextualised: to the data-gathering situation; to the interviewer/interviewee relationship; to the location of classroom, laboratory or other setting; to the particular group of students, and so forth. Teachers' beliefs are related to practice and beliefs about practice, but they are not simply able to be mapped one to the other (Lerman, 2003).

Evaluating classroom practice

In this paper we draw upon the productive pedagogies framework (Lingard et al., 2001) in conjunction with Boaler's elements of reform pedagogy in order to examine classroom practices.

Productive pedagogies

The notion of productive pedagogies arose out of a longitudinal study into schooling in Queensland, Australia (Lingard et al., 2001). Since its inception, significant research has examined and used the productive pedagogies framework (e.g., Allen, 2003; Hayes et al. 2006; Keddie, 2006; Keddie & Mills, 2007; Lingard, Hayes, Mills, & Christie, 2003; Munns, 2007). Based on the work of Newmann and Associates (1996) and Newmann, Secada, and Wehlage (1995) on authentic pedagogy, productive pedagogies refer to classroom practices that were considered to be most likely to lead to 'productive performance' (Lingard et al., 2003), that is, to make a difference to the academic and social learning of students. Productive pedagogies consist of four dimensions – intellectual quality, connectedness, supportive classroom environment, and working with and valuing difference. Intellectual quality emphasises that all students need to be provided with intellectually challenging classrooms, and findings demonstrate that when students from marginalised backgrounds engage with intellectually challenging work, their outcomes are likely to improve (Boaler, 1997a, 1997b; Hayes et al., 2006; Newmann & Associates, 1996). Similarly, an attempt to make schooling more connected to the lives of students can provide them with more meaningful experiences that may help to alleviate the alienation students from disadvantaged backgrounds often feel when presented with de-contextualised school knowledge. The supportive classroom dimension is concerned with creating a classroom environment in which students are able to 'take risks' and not be ridiculed if they make mistakes. The concept of working with and valuing difference emphasises the need to recognise and value the cultural backgrounds of students for them to achieve better outcomes (Hayes et al., 2006).

Since the initial conception of the productive pedagogies framework, some criticisms have been raised in terms of the lack of agreement regarding what to look for in classroom observations (Hayes et al., 2006); an over focus on the outcomes of pedagogy (Sellar & Cormack, 2006); a lack of empirical evidence for the inclusion of the valuing of difference dimension (Ladwig, 2007); a lack of student voices; and issues concerning observers taking part in classroom observations with unfamiliar subject areas (Mills & Goos, 2007). While we recognise these limitations of the productive pedagogies approach, in particular for the teaching of mathematics, we still feel it is an extremely important and useful approach to analysing classroom pedagogy.

Reform pedagogy

The reform pedagogy elements we use come from the work of Boaler (2002, 2008; Boaler & Staples, 2008), in which she documented the reforming of classrooms in the United States to create more equitable outcomes for students learning mathematics. Boaler's work rests within a larger movement of reform pedagogy based on the work of Newmann and Associates (1996) and Cohen and Lotan's notion of complex instruction (Cohen & Lotan, 1997). Complex instruction is premised on pedagogies that can have a powerful impact on the learning outcomes for disadvantaged students. Concepts such as group work, assigning status, complex tasks, and multidimensionality (Boaler & Staples, 2008) are some of the ideas with which we have worked to build a framework that is suitable and culturally relevant for remote Indigenous students. We have extended Boaler's complex instruction to include the dimensions of multiple entry points and multiple pathways in order to cater for the extensive diversity in mathematical understandings among Indigenous learners. We also recognise the importance of language, story telling, and 'yarning' among Indigenous peoples, so we have also included a dimension that focuses on quality interactions. We agree with Boaler (2008), who argues that the outcomes of such a reform pedagogy approach are not limited to academic outcomes but extend to social outcomes whereby students actively seek to work with and resolve social and cultural conflicts in their communities. The key aspects of our reform pedagogy approach are:

Group Work – Students work in groups to solve a problem or task that could not have been solved individually.

Multiple Pathways – The task is designed so that students can seek different pathways to solve the problem. There is no one particular answer or pathway.

Multiple Entry Points – In classes of very mixed age and ability it is necessary that each student has a suitable entry point to the task so they do not feel alienated.

Roles within the Group – Each member of the group is to be assigned a specific role so that all members can actively participate in the task. It is also advisable that the students rotate roles.

Quality Interactions within the Group – This designates the extent to which there is significant discussion amongst the students in the solving of the task or problem. Students should be encouraged to engage with, discuss, and debate rich mathematical concepts as a part of the task.

Teacher as Facilitator – The teacher scaffolds the students but absolves responsibility for learning to the students. The teacher checks to see that the group is on task and raise open ended, deep questions rather than standard Initiate Respond Evaluate (IRE) teaching processes.

Use of Home Language – Students are to be encouraged to negotiate meaning in their home language, but must still report their findings to the class in Standard Australian English.

Multi-representational – Various methods of representation for the students' work need to be encouraged to embrace the diversity of learners within the classroom.

This reform pedagogy approach, in conjunction with the productive pedagogies approach, should provide a comprehensive model for analysing the classroom teaching practices of teachers working in remote, Indigenous contexts. While this work is still in a preliminary stage, and future refinements may be needed, we believe there is considerable scope for successful pedagogies to be implemented within the classrooms to promote the mathematical learning of remote Indigenous students.

Data collection

This article draws on data that were collected in the early stages of a 3-year project that focuses on mathematics education in six remote Indigenous schools in Western Australia. For our current purpose, data were drawn from two sources: an initial questionnaire that was distributed to all the teachers in the participating schools, and video-taped mathematics lessons. While the data are numerical in nature, we have not undertaken a rigorous statistical analysis because the sample size is limited. Rather, we have used the data to highlight apparent discrepancies between the teachers' espoused and enacted beliefs, and features are described more qualitatively.

As teachers commence the project, a questionnaire is used to establish baseline measures. The survey has 125 items and uses a 7-point Likert scale. It is divided into 8 sections on teacher attitudes; planning for teaching mathematics; assessment as a practice; the students; task design and planning; lesson design and planning; and assessment, engagement, and learning. Participants indicated the degree to which they agreed that the items represented their beliefs or goals for pedagogical practice. In addition, an open-ended section includes questions about teachers' beliefs and feelings, the students in their classrooms, and the challenges teachers face. In late 2007, surveys were sent to 26 teachers in the participating schools and by early 2008 25 surveys were returned. The responses were condensed into 5 response categories for ease of comparison with the video data (which is based on a 5-point scale). Specifically, responses indicating very strong disagreement and responses indicating strong disagreement were combined; these responses were coded as indicating strong disagreement. Similarly, responses indicating very strong agreement and responses indicating strong agreement were combined; these responses were coded as indicating strong agreement. According to this recoding, possible scores range from 1 (strong disagreement) to 5 (strong agreement).

The video data consist of video-taped lessons from 14 of the 25 teachers who completed the questionnaire. Each of the video-taped lessons was

analysed by at least three researchers using a framework that incorporated both the productive pedagogies and reform pedagogy frameworks (for more details of the framework see Zevenbergen, Niesche, Grootenboer & Boaler, 2008). The linking of the productive pedagogies framework to the reform pedagogy of complex instruction, while not explicitly mentioned by Cohen and Lotan, has occurred in previous work (Lerman, 2004). The video-taped lessons were scored on a 5-point scale, where a score of 1 designates that a particular pedagogy was not observed, and a score of 5 signals that that pedagogy was an integral part of the lesson or activity. Each researcher scored each video individually, and then the researchers collectively engaged in a process of negotiation and consultation to determine an agreed score, which was recorded. The negotiation process among the research team has created a rich discussion that has enabled the unpacking and refinement of the criteria. It should be noted that the final score is an agreed score and not just the average of the scores. For this reason, the negotiation was crucial.

While the two data collection processes were not specifically designed to examine exactly the same practice details, they had many common foci. This enabled comparison of the data that centred on similar themes. For example, the questionnaire contained items about inclusivity in terms of culture and location, and the video data were analysed for pedagogical aspects that acknowledged culture or geography. To facilitate comparison, the questionnaire data and the lesson video data were grouped around common themes and placed side-by-side. Through this process, four areas of discrepancy emerged. There were other contradictions apparent in the data (e.g., aspects of intellectual quality), yet in these cases some dimensions were evident in one data set but not the other (e.g., there were a number of items on assessment in the questionnaire, but little formal assessment was observed in any of the video-taped lessons). In general, a discrepancy was deemed to exist when one set of data indicated agreement or use and the other data set indicated the opposite. As was mentioned previously, it would be inappropriate to use statistical procedures to compare these two sets of data because they have been collected in different ways and in different contexts, but they do indicate inconsistencies between the espoused or aspirational beliefs expressed in the questionnaire and the beliefs that were evident in teachers' classroom practice.

Examining beliefs and practice

The survey data and the video data were compared and Table 1 shows the mean scores for the two sets of data around the common themes. Again, we acknowledge the limited statistical value of the data and, while averages are becoming widely used in the analysis of ranked data, we also understand that this practice is statistically problematic. Therefore, the results in Table 1 should be seen as a concise way to present some broad issues that we will discuss in a more qualitative manner in the rest of the article.

Table 1

Mean Scores for the Two Data Sets in Common Themes

Theme	Questionnaire Items	Lesson Video Criteria
Inclusiveness	<ul style="list-style-type: none"> Consideration of the students' culture is essential for planning to teach quality mathematics. 4.5 	<ul style="list-style-type: none"> Connectedness beyond school 1.0
	<ul style="list-style-type: none"> The context is suitable culturally. 4.0 	<ul style="list-style-type: none"> Inclusivity 1.0 Narrative 1.0
	<ul style="list-style-type: none"> I use the culture and/or geography productively. 3.5 	<ul style="list-style-type: none"> Use of home language 1.0
Group Work	<ul style="list-style-type: none"> Small group work is a very good strategy for teaching maths. 4.6 	<ul style="list-style-type: none"> Group work 2.6 Roles defined 1.7
	<ul style="list-style-type: none"> Working in groups allows students to learn from each other. 4.6 	<ul style="list-style-type: none"> Quality interactions 2.7 Teacher as facilitator 2.3
	<ul style="list-style-type: none"> Group work does not work well in my classroom. 2.6 	
Intellectual Quality	<ul style="list-style-type: none"> Problem-based learning is a very good strategy for teaching maths. 4.3 	<ul style="list-style-type: none"> Higher order thinking 2.5 Depth of knowledge 2.4
	<ul style="list-style-type: none"> It is important that maths activities are challenging for the students. 3.8 	<ul style="list-style-type: none"> Depth of understanding.

The Learning Environment	• It is important that students offer help to others.	4.0	• Social support	3.0
	• It is important that students seek help from others.	4.1	• Academic engagement	3.0
	• Tasks should engage students.	4.3		
Connectedness	• Students engage more when there is an applied context to their mathematical learning.	4.5	• Knowledge integration	1.1
		4.2	• Background knowledge	2.3
	• Students should be able to transfer learning to different situations.	4.1	• Problem-based curriculum	1.9
		4.1	• Connectedness to other mathematics	1.1
	• Students should be able to apply what they have learnt.		• Connectedness to other subjects	1.0
			• Connectedness beyond school	1.0
Multiple Pathways	• Students have options to choose their own pathways in how they solve the task.	4.3	• Multiple entry points	1.6
	• There are a range of possible pathways to solve the task.	4.3	• Multiple pathways	1.9

Four areas of mismatch were identified: inclusiveness, or the importance of culture; group work; connectedness, or applied context; and multiple pathways.

Inclusiveness

It has been recognised that valuing and working with difference is good in and of itself in education (Delpit, 2006; Lingard & Mills, 2007; Lingard, 2007). Consistent with this recognition are the survey responses showing that teachers value cultural inclusivity (see Table 1). These data indicate that the participating teachers not only believe that culture is important in the teaching of mathematics, but also acknowledge culture in their planning and implementation. However, this acknowledgement was not evident in the video-taped lessons (i.e., each of the four dimensions of inclusivity had an average score of 1; see Table 1). These dimensions of inclusivity may not have been relevant for the particular observed lesson, or they may have been attended to in another lesson. However, the teacher may also have lacked understanding of the importance of that pedagogy; this possibility is alarming considering the survey responses. It is important to note that the video data set is quite small; however, to not have observed any reference to these dimensions in any of the lessons indicates a mismatch between what the teachers' espoused beliefs indicate and what the teachers practise in the classroom.

The use of narrative (one of the inclusivity pedagogy dimensions) has been a contentious issue, particularly when issues of Indigeneity and the curriculum area of mathematics come into play. The storytelling heritage of Indigenous cultures has led to the assumption that narrative would be useful for Indigenous students. However, one must acknowledge that not only are there differences between Indigenous groups in their forms and styles of storytelling, but also that some researchers (e.g., Nakata, 2001) have emphasised the importance of Indigenous students acquiring Western knowledge systems in order to effectively participate in Australian society (Mills & Goos, 2007). There needs to be further research into this uneasy juxtaposition between the valuing of traditional storytelling and the acquisition of skills to participate in Australian mainstream society. In this research project we have tried to bridge this issue by encouraging students to use their own language when negotiating meaning and undertaking activities but asking that students report to the class and teacher using Standard Australian English (SAE). In addition, we recognise that cultural recognition in and of itself is not a sufficient criterion by which to critique the role that schools play in eliminating differential academic achievement (Gale & Densmore, 2002), and in this way we agree with Mills (2008) that we need to move beyond a superficial treatment of diversity in pre-service teacher education.

Group work

The participants indicated in their survey responses that they saw pedagogies related to group work as important (see Table 1). However, in the video-taped lessons there were very few instances of group work pedagogy in practice. While the results regarding the first two dimensions of group work (group work and roles defined) are somewhat self-evident, the

findings regarding the second two (quality interactions and teacher as facilitator) require some unpacking.

While these data do not reveal the same degree of mismatch as the data concerning recognition of culture, there is still a sizeable variation between teacher beliefs and practices. The teachers clearly demonstrate an acknowledgement of the importance of group work in the learning of mathematics, but the video data show that group work in class lacks effectiveness. The low score for the effectiveness of group work in the classroom may indicate challenges arising from the student context. For example, in remote Indigenous communities the class sizes are small – in some cases, there may only be enough for one group in a class, and the group may consist of family members due to the ways in which the community is formed. However, while such constraints may create particular circumstances, we believe the principles of group work outlined by those such as Burton (2001, 2004) can be adopted and would encourage interaction and deep learning – mathematically, socially, and linguistically.

The notion of specific assigned roles within the group, according to Cohen and Lotan (1997), plays an important role in ensuring that all students participate and are involved in the cognitive labour. This aspect of group work received a low score in the pedagogies analysis, perhaps as a result of class size and make up as discussed above.

Connectedness/applied context

We have divided the *drawing on the connectedness to the world* concept, developed by Newman and Associates (1996) and Lingard et al. (2001), into three new items: connectedness to other areas of mathematics, connectedness to other areas of the curriculum, and connectedness beyond school. In analysing and scoring the video-taped lessons we explicitly focussed on these pedagogical aspects along with the other items within this dimension. The video data indicated limited or no evidence (i.e., low scores, see Table 1) of 'connectedness' in classroom practice. As with the previous pedagogical themes, the relative absence of pedagogical practices that promote connectedness contrasts with the strong support for it in the related questionnaire items.

The low connectedness scores in Table 1 were surprising as we considered this dimension easy to implement. With the contexts in which these students live full of rich examples to draw upon for their lessons, this dimension should have scored much higher. We have been working with the teachers since to provide examples of how they can incorporate local culture and contexts into their lessons and teaching, so we expect to see the scores for this dimension improve in the future.

Multiple pathways

The multiple pathways dimension refers to the notion of students working in various ways to solve mathematical tasks or problems. This practice aims to allow the students to draw upon a variety of skills, and is similar to Boaler and Staples's (2008) notion of multidimensionality, whereby task

expectations value a range of ways to solve the problem. Mean survey scores, shown in Table 1, indicated that teachers agreed that multiple pathways should be catered for in their mathematics lessons. However, the video scores indicated that there was very little evidence of this dimension in the teachers' practice. Given the lower scores across the range of video data compared to the survey data, the low scores on this dimension are not surprising. Teachers' incorporation of different dimensions to their tasks is perhaps one of the more challenging aspects of our reform pedagogy, as it involves the development of rich and often complex tasks by the teacher. While we see this as a difficult aspect to implement it is also one of the most important as "when there are many ways to be successful, many more students are successful" (Boaler & Staples, 2008, p. 630).

Conclusion

In this study the translation of teacher beliefs into observable pedagogies and practices in the classroom is clearly problematic. We acknowledge that the acquisition of data from a survey and classroom video data will inevitably draw out some contradictions due to different contexts and the environments in which the data have been collected. Indeed, it is accepted that beliefs are contextual (Green, 1971) and the beliefs outlined in the questionnaire can be seen as somewhat idealistic or aspirational, whereas the beliefs enacted through teachers' pedagogy are more 'real life' and significantly affected by other pressing concerns of the classroom (for a more detailed discussion see Grootenboer, in press). Nevertheless, the differences between the two data sets reveal that there may be a range of intermediary factors. The remote context and teachers' lack of confidence in teaching mathematics (evident in the survey data and informal conversations), may create an environment in which it is difficult for these teachers to put into practice the aspirational beliefs they expressed through the initial questionnaire. Participants in the study have explicitly asked for resources and input that will enable them to adopt more inclusive practices, and they acknowledge that their understandings are limited by their knowledge and experience.

The isolation and difficulties of working in these remote, Indigenous communities present challenges for teacher educators and policy makers, and more research needs to be conducted to evaluate how best to prepare teachers for these difficulties. Research suggests that the productive and reform pedagogies can have a significant benefit to students' academic and social outcomes, and certainly the survey responses show that the teachers believe such approaches to have great benefit. The challenge therefore is to translate these beliefs into concrete classroom practices. We are now working with the teachers and principals to align their teaching practices with elements of the productive and reform pedagogies, and it would be fair to assume that if a number of these teachers have already made a mind shift in support of these frameworks, we would likely see an improvement in the scores of productive and reform pedagogies. Such an improvement can only be for the betterment of the students.

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The Maths in the Kimberley Project: Evaluating the pedagogical model*

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The poor mathematical achievement of remote Indigenous students continues to be a significant educational issue. The Maths in the Kimberley project seeks to implement an innovative pedagogical reform in six remote Indigenous schools to explore reforms that may lead to improved outcomes for Indigenous students in mathematics. This paper reports on the data collection phase of the project and identifies key areas of success and others of concern.

Introduction

The Maths in the Kimberley project is now in its final year of implementation. This symposium paper reports on the data collected so far and provides a brief overview of the data analysis in the two following papers. The aim of the project is to trial an innovative pedagogical model in mathematics education in six remote Indigenous communities in the Kimberley region of Western Australia. The classroom teacher has been identified as the critical factor in addressing educational reforms (Boaler & Staples; Hayes et al., 2006) so this project has its focus on the teaching practices in the remote schools as the basis for reforming the teaching of mathematics. The pedagogical models used are based on the work of Boaler (Boaler, 2008; Boaler & Staples, 2008), Burton (2004) and the Productive Pedagogies model developed in Queensland (Lingard et al., 2001). These models and the approach used in the Maths in the Kimberley project have been detailed elsewhere so will not be discussed here (for example, see Jorgensen, Grootenboer, Niesche, & Lerman, 2010; Jorgensen, Sullivan, Grootenboer & Niesche, 2009; Zevenbergen & Niesche, 2008).

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Data Collection

Members of the research team have visited the Kimberley region regularly to provide support and professional development sessions, and to collect data. However, the great distance of the research site from the researchers meant that support and data collection was also undertaken remotely. A mixed method approach was employed, but the small sample size limited the scope for quantitative analysis. Five modes of data collection were employed: (1) a questionnaire; (2) video-tapes of classroom lessons; (3) interviews with teachers and principals; (4) field notes; and (5) student testing and interviews.

The focus of this paper is the results from the lesson video tapes scored against the productive pedagogies model. The following papers in this symposium use the same data and also qualitative data to further discuss elements that have and have not been working from the model.

Results

The following table demonstrates the mean scores from the classroom lesson observations. These comprised of mostly videotapes sent in by teachers and also some tapes made by members of the research team while visiting schools. Lessons are scored from 1-5 based on the productive and reform pedagogies models.

Table 1: Video data mean scores

Inclusive Pedagogy Dimension	2008 (n=16)	2009 (n=16)	Change 2008-2009
Higher order thinking	2.6	3.4	+0.8
Depth of knowledge	2.4	3.5	+1.1
Depth of understanding	2.3	3.4	+1.1
Substantive conversation	1.9	2.5	+0.6
Problematic knowledge	1.4	3.0	+1.6
Metalanguage	2.3	3.0	+0.7
Knowledge integration	1.3	1.6	+0.3
Background knowledge	2.3	2.9	+0.6
Problem based curriculum	2.1	3.6	+1.5
Connectedness other maths	1.4	1.3	-0.1

Connectedness other curriculum areas	1.1	1.1	0.0
Connectedness beyond school	1.4	2.8	+1.4
Student direction	1.3	1.4	+0.1
Social support	3.0	3.2	+0.2
Academic engagement	3.0	3.6	+0.6
Explicit criteria	2.7	3.1	+0.4
Student self-regulation	3.6	3.5	-0.1
Inclusivity	1.0	1.6	+0.6
Narrative	1.3	2.8	+1.5
Active citizenship	1.1	1.3	+0.2
Assessment for learning	1.9	2.8	+0.9
Multiple pathways	2.0	2.5	+0.5
Multiple entry points	1.6	1.8	+0.2
Quality interactions	2.6	2.5	-0.1
Roles defined	1.7	1.8	+0.1
Group work	2.5	2.5	0.0
Teacher as facilitator	2.4	3.0	+0.6
Use of home language	1.0	1.0	0.0
Multi-representational	2.1	2.6	+0.5
OVERALL	1.9	2.5	+0.6

To further investigate the video data, the pedagogical dimensions were categorised in two ways based on their overall mean score and how much their mean scores improved over the two years. Dimensions with a mean score greater than 2.8 were noted as relatively high, and those with a mean score less than 1.8 were noted as relatively low. A score above 2.8 indicates that the pedagogical dimension was fairly regularly a significant part of the lesson, and a score below 1.8 means the dimensions was rarely observed and/or not a significant feature of the teaching. If the mean score for a pedagogical dimension increased by 0.9 or more over the two years, then it was categorised as 'improving', and if it increased by less than 0.2 then it was noted as 'not improving' (see Table 1). The results of this data analysis are shown in Figure 1 below:

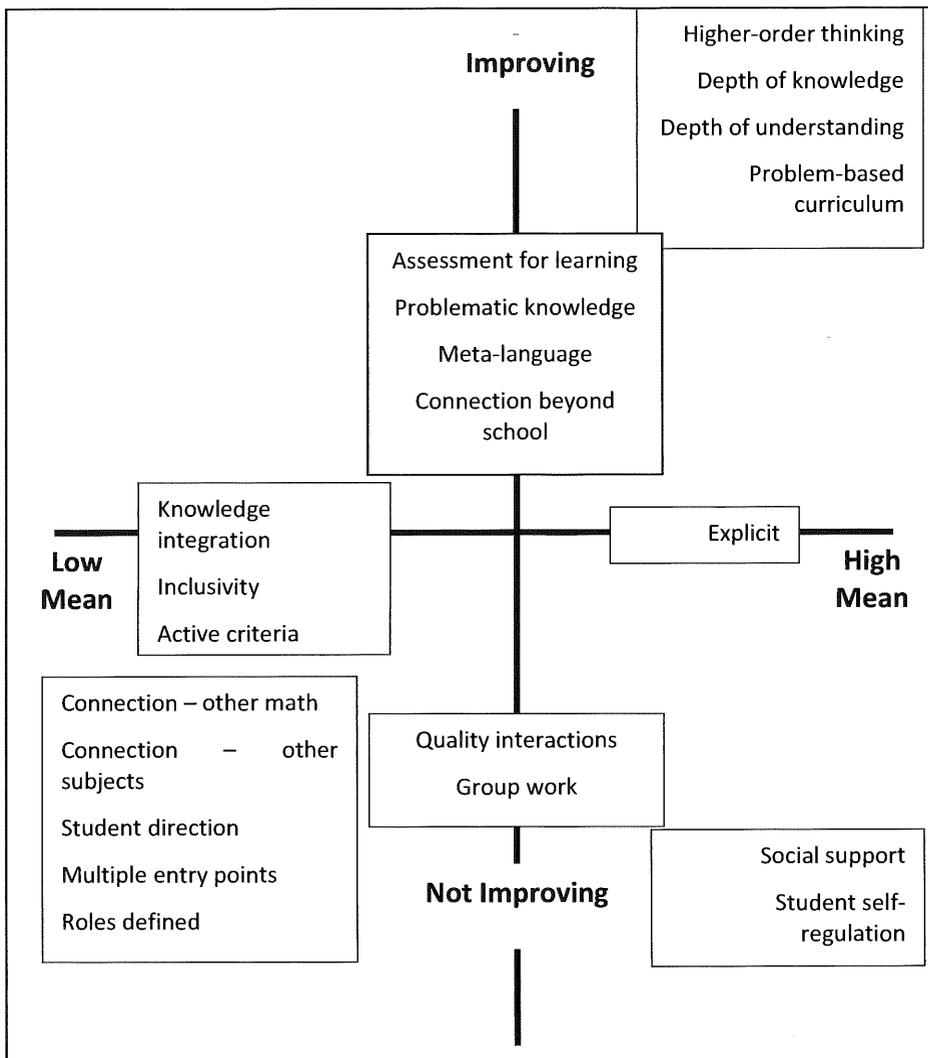


Figure 1: Analysis of Pedagogical Dimensions

Summary

The data represented in Table 1 and the analysis in Figure 1 indicate that there are aspects of the model that have been readily adopted by the teachers as well as some elements that have not been taken up. The research team were pleased to see that the intellectual quality dimensions scored highly and also improved over time. Of significant concern, however, are the group work and use of home language elements that scored low on the scale as well as not improving. One of the aspects that has been emphasised by the research team was the notion of group work. As is discussed in the following symposium paper, this element has particular contextual and cultural issues that may need further examination. The use

of home language in the classroom also warrants further exploration as a number of teachers have remarked that the students are already using their home language in the class. The inclusive pedagogy model used in this project involves the students reporting back to the class their findings and this is done in Standard Australian English. The teachers have been encouraged to explicitly allow the students to discuss the mathematical reasoning in their home language but this has met with resistance from some teachers. While elements of this model have proved successful in other contexts, there are clearly spaces for re-examination of the model in this remote Indigenous context.

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Effective Features of the Maths in the Kimberley Inclusive Pedagogy Model*

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The Maths in the Kimberley (MitK) project has been progressing for two years and so it was timely to evaluate the Inclusive Pedagogy model that underpinned the study. The data presented in the first paper in this symposium indicated that some aspects of the model worked well. Primarily the areas of improvement were related to the intellectual quality of the lessons. These pedagogical dimensions are outlined and discussed here by drawing on the broader data set of the project.

Introduction

Sullivan and Niesche presented an analysis of the lesson-video data earlier in this symposium, and the results indicated that some of the pedagogical dimensions of the Inclusive Pedagogy model worked well. These were aspects of the new approach to mathematics that were readily adopted by the teachers and seemed to be effective with the learners in the participating schools. In general these aspects related to the intellectual quality of the lessons and features of the learning environment.

In this paper I will outline and discuss these aspects of the model that improved over the first two years of the project. These are generally in the upper right-hand section of Figure 1 (Sullivan & Niesche, this symposium).

Intellectual Quality

The analysis of the video-taped lessons indicated that pedagogical aspects related to the intellectual quality of the classes (e.g., *higher order thinking*, *problem-based curriculum*) were scored relatively highly. Furthermore, the mean scores for these dimensions increased as the project progressed.

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This indicates that in the lesson reviewed the pedagogy was characterised by intellectual quality and high expectations, and, these qualities were more evident and in increasing depth as the project progressed. Apart from the lesson video data, these features have also been observed by the research team in the course of their visits to the classrooms during the first two years of the study. At the start of the project the mathematics lessons were largely characterised by rote learning and regular 'drill and practice'. However, towards the end of 2009 (the second year of the project), the teachers employed more tasks that are rich and relatively complex.

For example, in the first year of the project one of the teachers video-taped one of his mathematics lessons and sent it into the research team for analysis. The lesson he sent in involved a hangman-type game where the students were trying to guess the teacher's "secret number". This lesson was entirely teacher-centred and it predominately involved a sequence of low-order questions that involved very little mathematics. However, towards the end of the second year of the project, the same teacher submitted another video-taped lesson that involved a relatively open-ended task that required the students to think mathematically about a practical local situation.

This change in the teachers' mathematical pedagogy has been significant and often difficult. It appears that they are developing a perspective that sees the students as capable of learning complex mathematics with appropriate scaffolding. In the project there has been an emphasis on scaffolding the teachers and providing rich mathematical tasks that have high intellectual quality in the professional development part of the project. This has led to a shift in the teachers' views of their learners from deficit, low level thinking to a perspective that sees their students as capable and confident. Early in the project a number of the participating teachers commented on the "students' deficiencies" that "stop them from learning maths", whereas, in later conversations and interviews they made more comments like:

... there is no reason why they [their students] couldn't do things like that. Every other school can do it and other kids can do it. Sometimes I have thought that there is too much of a feeling or reliance on the fact that there's these great cultural differences that make things difficult. I am sort of a strong believer that these things that whilst there are these differences, there's no reason why they can't do these things.

It has been an important and positive outcome for the MitK project that the teachers seem to view the students in their classrooms as competent and capable learners of mathematics. Hayes, Mills, Christie and Lingard (2006) confirmed the critical importance of high academic expectations for all learners so educational outcomes are good and equitable can be achieved. To this end, the improvement in the intellectual quality of the video-taped lessons has been an endorsement of the 'inclusive pedagogy' model. This has been particularly pleasing because mathematics is the subject where the content can often be reduced to the memorisation of basic facts and algorithmic efficiency.

Significant Mathematical Content

A major issue facing the project team is the relatively weak mathematical identities (personal knowledge, skills and attitudes) of many of the participating teachers. Most of the participants involved with the project are primary teachers, and in the schools where there is a secondary class, the teachers (who teach all subjects) are not mathematics specialists.

For me I've always just struggled with mathematics. So I always find it a tough gig myself. I guess there have been some PDs that we've done ... and it was only this time that I am starting to understand it.

Therefore, it is fair to say that the teachers as a group have fairly limited mathematical knowledge and understanding, and generally it would not be their favourite subject. Of course, this is not peculiar to remote Aboriginal schools. An important aim of this project has been to enhance the quality and depth of the mathematical content in the teachers' mathematics lessons. The data from the video-taped lessons, and the other sources, show that there have been distinct improvements in the mathematical integrity of the lessons being presented in the classrooms of these remote Aboriginal community schools. To illustrate, the video-taped lesson data (see Sullivan & Niesche, this symposium) revealed an increase in the quantity and quality of pedagogy that had *connections beyond the school* (mean score of 1.4 in 2008, mean score of 2.8 in 2009), *depth of knowledge* (2.4 to 3.5), and *depth of understanding* (2.3 to 3.4).

In the project the teachers have been encouraged to use rich mathematical tasks that have strong academic quality and that facilitate deep mathematical learning (Grootenboer, 2009). For this to occur, the lessons needed to have opportunities for students to engage in the activities and practices of mathematicians such as hypothesizing, making conjectures, rationalising, and justifying ideas and findings (Burton, 2004).

To illustrate, late in the second year of the project a lesson with a Year 2/3 class was observed where the focus was on number patterns – in particular multiples of 5. After an introduction using a 1-100 number board and open questions about "any patterns they could see", the teacher went on and posed the question, "how many fingers are in our school today?". The students were placed in groups and together they developed at least one strategy to solve the problem. After briefly sharing and discussing their strategies, they then visited the other classes to gather their data. On their return, they worked in their groups using "any equipment they needed" to work out their solution and then prepare a presentation for the class. Throughout the lesson the teacher rarely gave direct answers, but she often asked questions that encouraged the students to think mathematically and more deeply about their work.

In the example above the teacher facilitated forms of mathematical thinking that involved more than memorisation and recall. By employing such an approach, Boaler and Staples (2008) found in their *Railside* study, that students "regarded mathematical success much more broadly" (p. 629), and they performed well in the standard assessments. At this stage there is

evidence (somewhat anecdotal) that the students are showing similar gains, and despite many confounding factors, there is an expectation that the results of their external testing (e.g., NAPLAN) will reveal markedly better results.

As the teachers developed the substantive mathematical content of their pedagogy, there was also a more focussed consideration of the broader mathematical identities of the students. In their lessons the participating teachers more regularly tried to consider and address the students' mathematical attitudes and beliefs, and their emotional responses to the subject. This was evident in many overt and subtle ways in the lessons video-taped and observed. One teacher tried to provide a pertinent and connected context for the students by employing the idea of a 'story shell':

The story shell, that's my...yeah relating the mathematics to life through the story shell so that we can provide a context, I really put a lot of effort, that's one of my main focuses, and it's really worked cause I enjoy telling stories. And that's something that I've put a greater focus on. I used to do it every now and then, whereas now I try and do it each and every maths lesson, each thing they're attempting has got some sort of context that the students can relate to.

Assessment for Learning

Another pedagogical aspect that appeared to improve throughout the project was the teachers' use of *assessment for learning*. Again, this is evident in the data from the analysis of the video lessons where the mean score rose from 1.9 in the first year to 2.8 in the second year (see Sullivan & Niesche, this symposium). This indicates that the teachers have moved from relying primarily on low level assessment techniques to introducing some assessing of higher order mathematical thinking. A number of the teachers have commented that thoughtful questions judiciously used throughout their mathematics lessons have been powerful in accessing their students' knowledge, ideas and understandings. This enabled them to then pose further questions to facilitate the students' mathematical learning and growth.

Recently, one-on-one diagnostic interviews have been undertaken with many of the students, so the teachers can prepare and teach their mathematics lessons more cognisant of their students' capabilities. One of the new teachers (commenced in 2009) commented;

... doing the student interviews has been really useful. Useful for me to find out where the kids are actually at, because I felt like I've spent a term kind of going, 'oh my God, what is going on here, where is everyone at, how do I cater for that?' But with the individual interviews, you can systematically really find out, and then build on that.

Overall, there has been a notable increase in the use of assessment to understand what students do know and can do, rather than what they don't know and can't do, and this has led to improved pedagogy.

The Learning Environment

It is worth noting that throughout the project the data have indicated that the teachers are generally providing a learning environment that is supportive and regularly characterised by quality interactions between the teacher and the students. However, this cannot be necessarily attributed to the interventions of the project because there have been no notable increases in the data related to these pedagogical features over the initial two years (e.g., the *social support* mean score went from 3.0 in 2008 to 3.2 in late 2009). Nevertheless, this also indicates that while the teachers have been able to improve intellectual quality of their lessons and increase the significant mathematical content, they have also been able to maintain a supportive learning environment.

Concluding Comments

The implementation of the Inclusive Pedagogy model in the remote Aboriginal schools of the Kimberley region was in many respects a major intervention. It required the teachers to reconceptualise their mathematical pedagogy while dealing with many professional and personal issues that arise for the generally young and inexperienced teachers in these schools. Furthermore, the model was developed from the findings of studies conducted in quite different contexts, and while it was based on sound practice and substantial research, there were no guarantees that it would be appropriate or effective in the context of very remote Aboriginal schools. The evaluation of the model after two years indicates that a number of the dimensions of the model are working well and are effective for these particular teachers and learners. Indeed, as the model is now being revised, these features relating to intellectual and academic quality will be reiterated and reinforced in order to facilitate increasingly improved educational outcomes for these disadvantaged learners.

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Group Work, Language and Interaction: Challenges of implementation in Aboriginal contexts*

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While research suggests that the use of group work can enhance student learning, there are considerable challenges to implementing this practice in remote Aboriginal communities. When employed properly, group work requires students participate in deep dialogue and/or shared tasks that build collaborative interactions that help facilitate deeper mathematical understandings. However, we have found in the Maths in the Kimberley (MitK) project, that developing and implementing group work in this context is highly problematic. Practically, linguistically and culturally, teachers were confronted with considerable obstacles to implementation, and these issues are discussed in this paper.

The underperformance of Aboriginal Australians is a recognised problem in education. This concern arises from NAPLAN tests for all year levels that show alarmingly poor performances for remote Aboriginal students (MCEECDYA, 2009). This cohort of students is the most at risk group of students in the educational landscape. In the Maths in the Kimberley (MitK) project, the overarching aim was to implement reform pedagogies that would support the development of rich learning environments in mathematics teaching and learning. The express goal of the project was to enhance numeracy learning for the students in the communities. While, as has been discussed earlier in this symposium, there have been some successes with the project, there have been other aspects of the pedagogy where there have been no observable or significant changes in practice

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(see Table 1 in Sullivan & Niesche, this symposium). In this paper these pedagogical aspects are outlined, and I discuss some of the significant barriers to pedagogical reform in remote Aboriginal communities and raise ethical questions as to whether mainstream pedagogy can/should be implemented in Aboriginal communities where the cultural differences are great and may be very different from those of mainstream Australia.

Background

In the MitK project we have drawn on a particular corpus of pedagogical reform that has been proven to be very effective in other disadvantaged contexts. For example, the work of Boaler (2008) has shown how particular pedagogical practices – in her case, Complex Instruction (Cohen & Latan, 1997) – had enhanced the learning of some of the most challenging communities in California. We have drawn on this work, along with the work of Productive Pedagogies (Lingard, 2006) recognising that this is also being challenged and moved forward (Mills et al., 2009) to exemplify and create quality learning environments.

The research team developed a pedagogical model that included critical variables for enhancing educational outcomes, but not all of these have been simple or immediately successful in this context. The problematic embedding of these aspects of pedagogy have created a deep challenges for the research team – in terms of trying to embed the practices in the communities as well as ethical dilemmas for the research team. In this paper, I draw attention to the group learning of the approach in the project. This draws on the work of Boaler's complex instruction (Boaler, 2006) where group work was a strong feature and the work of Cobb and colleagues (Yackel, Cobb, & Wood, 1991) where interactions in quality group work yielded strong mathematical learning. The assumption in these projects is that group work, when properly conducted, and where students engage in rich learning tasks, produces opportunities for rich and deep learning in mathematics. It would appear from Boaler's (2008) work that this approach also has significant other language and social learnings that are valuable for students from linguistically and culturally diverse backgrounds as they transition from their home culture into school/mainstream culture. As this research has produced significant learning for students, it has been adopted in the MitK Project.

In our project, we have sought to have teachers work with students in small groups where they can negotiate meaning in their home language (Kriol) on the premise that this will reduce cognitive load, enable deeper engagement from students both socially and cognitively and will help them in the development of deep mathematical understandings. We also adopted Cohen and Latan's (1997) principle of reporting back on the guise that students could negotiate meaning in their home language but being proficient in English required fluency in that language but also in the social practices (in this case, reporting to peers in a full classroom context). For students whose lives are centred in remote communities but their long term career and social good requires that they are proficient in Standard Australian English, adopting practices such as reporting back helps to

transition into mainstream English with its linguistic nuances of social interactions.

Dilemmas of Pedagogical Reform in Remote Aboriginal Contexts.

The research team have found that the most challenging aspects of the inclusive pedagogies relate to those areas where language is central – group work, high interactivity and reporting back. These elements have been problematic for teachers and stem mainly from differences in the culture of the students and the culture of school mathematics. The scores on these elements have remained constant in the project, suggesting no gain. We have sought the input from teachers to help us understand the difficulties around these pedagogies. Teachers have reported that the culture of the Kimberley communities is still strong and as such there are many cultural norms that are violated with the use of these pedagogies.

Group Work

Kimberley Aboriginal kinship relationships require that some students may not be able to speak or work with other students due to particular 'skin' groupings. These cultural norms are very strong. In classrooms, this means that grouping these students is not possible. Further, in those smaller communities, there are some classrooms where the numbers are so small that arranging groups where the students could be put into non-skin groups is not possible. In these small classrooms, it was also the case that the whole class may be from the one family and hence reluctant to work with older/younger siblings. The dilemma for us is that group work has been shown to be a powerful tool to enhance learning yet in this context, the violation of cultural norms is so strong, that it may not be a useful tool for learning.

The reporting back process was also problematic due to the cultural norms around 'showing off'. In the Kimberley culture, teachers reported that showing off how much someone knew (or did not know) was a 'shame job'. The notion is 'shame' is very strong in this region so asking students to publicly show their knowledge was not appropriate. For example, in some cases, a younger person may know may know something that an older student did not know. Teachers reported that this process was a 'shame job' for the older student so that younger students were reluctant to publicly put down the older student. The dilemma for the research team is that the concept of 'shame' is a very powerful one in Aboriginal cultures so there would need to be considerable renegotiation of classroom protocols if this pedagogy were to be developed more.

Related to both of these pedagogies, is that of high interactivity. The teachers would pose questions to create high interactivity but the social norms of the Aboriginal students in a mainstream classroom limited this

potential. The students were all very keen to answer the questions posed by the teachers but part of the role of young people in these communities is to please others. The game that was enacted during questions is that the students must guess what the teachers wanted. What appears to happen is that once a question is posed, if the teacher does not respond with a 'correct' then the students engage in a guessing game where all sorts of responses are offered. For example, in one lesson the teacher asked a question – "what happens when I add 5 and 3?" The students offered a wide range of responses – including 8 but when this (along with the other responses) were not indicated as being correct, they kept calling out numbers. This pattern of interaction was observed across all schools and all classrooms. Interviews with teachers confirmed that this was common practice in all schools. While teachers reported their frustration with the game, they were unable to change this dynamic despite concerted attempts to do so. Further interviews with Aboriginal adults indicated that this was a part of the culture where young people learn that it is always good to please elders by being compliant, and that, in this case, compliance would be engaging in the question/answer interaction. They suggested that for the students, they would see the questions are requiring a response and hence this would be the 'game' rather than replying with the mathematically correct answer.

These challenges to the inclusive pedagogy need to be considered carefully in both pedagogy and ethics. While there is a substantial literature that suggests that such practices may enhance learning, this study has been conducted in schools that are Western/modern in their approach. The contexts for remote Aboriginal communities are substantially different in terms of cultural norms.

Use of Home Language

In observing the groups working, or students seated as a whole group on the mats in front of teachers, it was clear that there was considerable use of Kriol, including instructions from the Aboriginal Education Workers (AEW). However, the interactions were either social or disciplinary (from the AEW) and were not related to the development of mathematical concepts. In discussing this with teachers (individually, in professional development forums and in focus groups), teachers raised concerns about not knowing what the students were talking about and whether they would remain on task. We have observed that there is a sense of loss of control among teachers if they wanted to encourage the use of home language. While originally, the team felt that 'loss of control' was not a good reason for absolving the use of home language, as we have progressed further into the project, we have come to understand the complexities of working in remote communities and the quickness with which the tenor of a classroom can change. There is a volatility that is not common in mainstream settings. Hence, teachers feel a stronger need to remain in control of lessons so that if there are community issues that flow over into the classroom, the teachers are able to remain

in control. For example, in communities there is often friction between family groups. If an incident occurs in community, then this can flow over into the classroom. Often taunting and teasing is evidence of this flow over. Where the possibility arises for students to engage in home language and this taunting may continue unbeknown to the teachers, there was a concern that the issue can escalate quickly into quite a large fight. As such, teachers felt a strong need to keep a tighter rein on interactions than they would if the communications could be understood by the teachers.

Summary

The research team now need to confront some of the original assumptions that were made at the commencement of the project around good mathematical pedagogy. We face the dilemma where research indicates that some practices have significant learning benefits but when such practices are placed in remote Aboriginal contexts, there are different challenges, circumstances, beliefs and social practices. For us, questions arise as to whether practices, such as group work, may be the domain of Western/modern education and are not culturally appropriate for these contexts. We have to consider whether the adoption of group work and other elements of the reform pedagogy are in violation of cultural norms and hence unacceptable in these contexts, or whether depriving the students of these experiences places them at further educational risk. Similarly, we must contend with issues around teacher professional learning because the turnover of teachers is very high (very few stay beyond 2 years). How then, is it possible to develop sustainable practices that require significant support when there is a continual change of teachers?

What we can conclude is that the changes needed to Indigenous education are profound and urgent. However, such changes must be considered in light of the needs and cultures of the people with whom we, as researchers and educators, work. These people are not only the teachers but the communities. This requires further work in Indigenous education research.

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Dispersing Mathematics Curriculum Leadership in Remote Aboriginal Communities*

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In remote Aboriginal communities, there are many challenges that confront educators, the least of which is leadership that challenges the status quo and moves Aboriginal communities forward in their access to, and engagement with, the mathematics school curriculum. This paper draws on data from the *Maths in the Kimberley (MITK)* project where the complexities around reforming mathematics were investigated through leadership models. It was considered that the complexities faced by principals in their day-to-day management of schools closed down their capacity for curriculum leadership. A new model of curriculum leadership, based on the Accelerated Literacy model was adopted for numeracy reform. This model, its genesis and its implementation is discussed along with the mitigating context that shapes the need for models of leadership that focus on curriculum reform for remote Indigenous contexts. The implications of this model are discussed in conjunction with the field of mathematics educational research.

The underperformance of Aboriginal Australians⁵ is a recognised concern in education. Educators, policy makers, governments and Aboriginal

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⁵ In this paper and the overall project we only use the term Aboriginal rather than Indigenous or Aboriginal and Torres Strait Islander people. This is due to the fact that the project is only working with Aboriginal people in a remote location of

communities are vocal in the need for reforms that will enable greater access of Aboriginal students to school knowledge. This is particularly the case for remote Aboriginal communities as they are consistently recognised as being most at risk of poor performance in national tests such as NAPLAN (NAPLAN, 2008). Remote Aboriginal students have been shown to be considerably lower in their scores in literacy and numeracy than students (Indigenous and non-Indigenous) in urban settings. This trend is even more concerning the longer they stay at school since the gap in performance increases with the time in school (MCEECDYA, 2009).

The Maths in the Kimberley project is a research project⁶ designed to trial an innovative pedagogical approach in the teaching of mathematics in six remote Aboriginal schools in the Kimberley region of Western Australia. Drawing on the work of Boaler (2008), Boaler and Staples (2008), and the Productive Pedagogies model developed in Queensland (Hayes et al., 2006; Lingard et al., 2001), this project seeks to improve the achievements of Aboriginal students in learning mathematics. While other papers have been written outlining these aspects of the project (for example, see Jorgensen, Grootenboer, Niesche, & Lerman, 2010; Jorgensen, Sullivan, Grootenboer & Niesche, 2009; Zevenbergen & Niesche, 2008), here we wish to acknowledge the importance of school leadership in initiating and sustaining these reforms. In this paper, we demonstrate some of the unique challenges faced by the principals of these schools and argue that new ways of dispersing curriculum leadership is required to effectively implement both curricular and pedagogical reforms in mathematics education in these schools. The term 'distributed leadership' has become problematic in recent years as not only is it used to describe a range of understandings and processes (Woods, Bennett, Harvey & Wise, 2004) but also result in significant discrepancies in its usage (Mayrowetz, 2008). We prefer the term 'leadership dispersal' (Lingard et al., 2003, p. 14) to designate the ways that leadership is exercised by a range of staff in schools not just something that is directed by the principal and distributed or devolved to others.

The data in this paper are drawn from extracts of interviews conducted across the project. Some the data were collected in the initial phases where we sought to gain a sense of the issues and the context of the study. We have since conducted focus interviews with various staff (teachers, principals, consultants) about particular aspects of the project, including the need for professional development around mathematics teaching, and learning and assessment. Now in its third year, the databank of interview data is very comprehensive.

Australia. We acknowledge the standard protocols of naming the first people of Australia but suggest that it is more appropriate in this paper to remain with the convention of using only Aboriginal to refer to the focus communities.

⁶ This project is funded by the Australian Research Council through its Linkage Grants Scheme. The Industry Partner is the Association of Independent Schools of Western Australia.

Remote Aboriginal Education: Complexities for School Principals

The principals of remote Aboriginal schools face a very different prospect than their peers in the city and even many rural areas. Particular difficulties come in the form of remoteness and access to resources, the large numbers of early career teachers, a high turnover of staff, complex relationships with the local communities and significant cultural issues to deal with on a day to day basis. All these factors impact upon the capacity of leaders in remote areas to deliver quality curriculum, and in this case mathematics curriculum. With increasing calls from certain sectors of government and the leadership field that principals need to be 'curriculum leaders', the models of leadership that are premised on urban or mainstream education are grossly inadequate for the significant reformation needed in these communities. In this section of the paper we outline some of the difficulties faced by school principals.

First, most of the teaching staff in remote contexts are often in their first or second year of teaching (Heslop, 2003). This is not to suggest that these teachers are necessarily 'inferior' to more experienced teachers, but rather, that these teachers have different needs to those of experienced teachers. Teacher turnover is high with some not coping with the challenging contexts and often not even completing their contracts. Examples have included some teachers only lasting a few weeks while others have survived a term and not returned after the break. A few teachers may stay on but the usual contract in these schools is two years. Thus retention of staff is low and with that comes the on-going demand of professional learning, inductions and sustainability of reforms. Many of these early career teachers have also expressed particular anxieties about their limited mathematical understandings and difficulties in teaching school mathematics.

Second, remoteness and access to professional learning opportunities creates challenges for teachers to be able to learn and/or develop new and more appropriate ways of teaching mathematics. In the MiTK project, the distance between the two furthest schools is over 1000kms. This distance is a feature of remote education and is not unique to this project. This distance creates unique challenges for many aspects of school leadership. Principals have to close the schools in order for the teachers to attend professional learning sessions. This is due to the fact that many of the schools are small and only have one or two teachers. Therefore, access to replacement teachers is not possible and closure of the school impacts on student learning and attendance data. As the schools are funded on attendance and enrolments, closure of the school has a considerable risk for financial management. In our context, teachers have negotiated closing school for one day and the second day of professional learning is undertaken on the weekend. For example, the first day of the workshop is on a Friday for which the school is closed, and day two is on Saturday. Teachers then usually return to their communities on Sunday.

Third, the demands on the principal as community leader are enormous. Independent Aboriginal schools and Colleges work on a model where the

principal is the head and must report to, and work with, the local community council. This Council works in a similar fashion to a Board of Directors and the principal reports to that Council and enacts the wishes of the Council. The principal is regulated by the statutory authorities – such as Federal and State governments. These agencies provide funding for the schools for which the principal is accountable. The level of governance is phenomenal for independent Aboriginal schools and for which the principal is solely responsible. There are considerable demands on the role in terms of funding, enrolments, buildings, grounds, safety, compliance, governance and so forth. In the modern age, these responsibilities make up a full time role without the support of a government system behind the school. For instance, as one principal remarked:

An unfair proportion of my time is spent dealing with the financial aspect, I suppose the business side of things, the sourcing of funding, acquitting funding. So yeah I would say that if you look at the way that government schools are funded, there is a lot more expectation for the independent principal to source and acquit things (Interview with Principal 1).

Similarly when asked about the amount of time spent on funding, budget applications and other compliance procedures, another principal responded:

Oh, yeah that takes up most of my time. That's a good point. Things that take up my time as principal percentage wise is an issue because I would rather dedicate it towards curriculum and in classroom kind of stuff where. Being in these kinds of communities it's still probably 40% community work, 60% school, and 50% of the school is probably actual day to day school stuff whereas the rest is just all stuff that would probably be done externally at other schools. (Interview with Principal 2)

Furthermore, in these remote communities, the school is often the first port of call for the community members in terms of providing advice or reading/translation of letters, reports, requests etc. The principal also assumes responsibility for the maintenance of water pumps, power supply and so on. The principal may also take on roles to create enterprise activities within a community. For example, in one community the principal has opened an art gallery at the school and is trying to create a bakery in the local store. These enterprises create employment opportunities in the small communities and help to secure some funding and employment for the communities.

I knew that the role here would be quite removed from the standard metropolitan principal. The roles and duties and expectations are more of a community leader as well as principal and in this particular setting I also run the community art gallery which is owned and operated by the school. (Interview with Principal 1)

Within this context, principals have little opportunity for curriculum leadership despite a recognised need and well-intended efforts in this area. The over-governance of remote Aboriginal schools dramatically inhibits

principals a role in curriculum leadership. As such, models of curriculum leadership are needed that create spaces for curriculum innovation in mathematics that allows teachers to develop appropriate forms of curriculum, pedagogy and assessment within the confines identified above. In such a context, clearly the need to improve mathematics learning must be shifted from the role of the principal to another level.

I guess there's no real leadership in it, you know we could be totally off the planet, you know deciphering these WA curriculums in possibly the most bizarre ways, you know, no one from WA is working here at the moment [laughs]. Yeah, I guess having being able to get that leadership in that regard as well, you know it disappoints me that I can't get to that as well. (Interview with Principal 2)

A Model for Dispersing Curriculum Leadership

The schools in which the MiTK project is operating all use the Accelerated Literacy (unknown, 2009) approach to teaching literacy. This approach has considerable hands on support for teachers with a literacy consultant who works across the schools to effectively provide two schools with a full time consultant. Teachers working in remote areas have argued for the importance of face-to-face interactions rather than electronic forms (Niesche & Jorgensen, 2010). This consultant provides teachers with curriculum documents, model lessons, modelling teaching practice, and providing feedback to teachers on their teaching. It is a very intensive program and has acquired significant funding from the Federal government for its implementation.

In response to the ongoing challenges facing the schools' principals to commit significant time to curriculum issues and the success of the Accelerated Literacy program, the MiTK schools have combined their professional learning funds to secure support in 2009 for one numeracy consultant to work across the 6 communities. As a result the numeracy consultant spent at least one full week per term in each school. The other time was spent in larger schools or in a regional area developing resources to support teaching. In 2009, further funds were sought to extend the project in 2010 with a further consultant being added to the Kimberley region in which the project is located as well as being extended into the Pilbara region. The principals saw the value in such a model and were keen to support it. Both numeracy consultants have taught in the region before, one also having been principal so their familiarity with the particularities of the schools and contexts are crucial.

Unlike schools in urban settings where new teachers are usually provided with mentor teachers in their first years of teaching, such a partnership is highly improbable in remote areas due to the fact that the staff are almost all neophyte teachers, so there is little capacity for senior staff to mentor. The model of dispersing curriculum leadership is one of high interaction with the teachers and students whereby the consultant teacher works closely with the teacher. Teachers and the consultants see this type of role as critical to changing the practices of teachers. They see the role as

important in terms of supporting new teachers. For instance, one of the numeracy consultants commented:

It is important that teachers have support. Many of them are new to teaching and don't know what to do other than what they learnt at uni. Unless we work with them, they don't get any new ideas. So this role is important to scaffold the new teachers. (Interview with Consultant)

And this:

What I have to do is after being with the teachers, I find that they don't know where to go next and they don't have the time or the resources to do that. My role is really to support them in moving forward. So when I go back to Broome, I prepare resources for them. These are usually the planning documents, and in some cases, even lesson plans along with the resources they need. We have built up a good bank of teacher resource books so then I can look at these to get ideas of how to build some better lessons and unit plans. (Interview with consultant)

Also, the staff numbers at schools are often very small so limited in the capacity to provide time out for mentoring:

There are not many chances for teachers to be able to get out to their class to go into another one to support another teacher. The schools are small and teachers have to take responsibility for their students. It is not possible for time release for teachers to move into other classes. Principals are too busy to even get into classes so that is not really possible either. (Interview with Consultant)

In addition to the lack of release time for teachers is the limitations due to technology and therefore resources. In many of the schools, access to internet is limited – both in terms of the physical capacity of satellites to download materials and in terms of costs for downloading. Small schools have only limited curriculum resources from which to draw. This meant that access to information to support teachers in the development of materials and learning opportunities was limited. Some of the teachers' comments included:

We are pretty limited here with resources. I would like to be able to do more planning but there is just not the stuff we need. (Interview with Teacher 1)

We've got some pretty good resource books here but I find I don't have the time or energy or often the inclination to do planning after school. I just want to get home and away from the place. I would do downloading from home but it is just so slow and always falls out. It is a pain. There are some great things available but it is just too hard to get them off the internet. (Interview with Teacher 2)

We can't download much from the internet. The bandwidth is pretty low so it might take forever to get something downloaded. We only have a small plan with the school so it does not take much to get

through that. It is very expensive to download because of the expense of the phone lines. (Interview with Teacher 3)

The principals are also aware of the issue of technology:

A difficulty has definitely been technology which has been a major issue in most of these schools, especially here. Especially now that pretty much all curriculum is headed towards using these new technologies. I feel we're still behind the eight-ball and slowly catching up but yeah, that's a bit of an issue. (Interview with Principal 2)

Scaffolding teachers to develop planned learning that goes beyond the 'activity' approach to teaching mathematics was evident in the approach being taken. The consultants saw the role as one which strong learning trajectories were to be developed so that teachers could plan better for long term learning. However, it was also recognised that part of this role was also to get over the problems of teacher's fear of mathematics:

Teachers are often scared of teaching maths so they don't do a good job of it. If anything, this role is one to help get new teachers of this and become confident in how to teach maths, but also what to teach in maths. They often don't have a good knowledge of curriculum so don't know where to go next or what to do so this role is to help them with that. (Interview with consultant)

Innovation in Mathematics Education

Related to the previous points – time, experience, confidence – is the capacity to innovate. In this project, we have found that the inexperienced teachers are reluctant to innovate as they are more likely to be in a 'survival' mode of teaching. Neophyte teachers need to move beyond survival mode and into new levels of teaching if they are able to innovate. However, the high turnover rates in remote schools may hinder the capacity of teachers to enter this phase of their teaching. We would contend that the issues around remote location coupled with culture shock of living in remote, isolated communities where the culture and social mores are very different from what has been experienced in the past, may delay the progression into higher levels of curriculum planning and implementation for many early career teachers. It may also be the case for experienced teachers for whom such experiences are unsettling, at least at the start.

The need for changed practices in the teaching of mathematics is never more urgent. The practices of the past have not been successful so the need for change is noted. What that change may be is beyond the scope of this paper. However, what is recognised is that practice needs to change in order to create pathways for Aboriginal learners in mathematics, and curriculum leadership is essential in this process. Where early career teachers may feel insecure with the teaching of mathematics and this is further compounded by the challenges posed through cultural and linguistic differences, the imperative of reform may be undermined by personal beliefs and self evaluation:

Many of the teachers don't have the confidence to move away from how they were taught in maths. They may have got some good ideas from their teacher training but they tend to fall back on old methods. If I provide them with the whole scheme of things they need, they are more likely to have a go at it. So I see it as important to get some really innovative things happening but where they are developed for them. I see what they have been teaching and then build from that but take them away from the old stuff they may have been using. (Interview with Consultant)

They have to experience different ways of teaching. The only way they are going to get that is through this role and the support we can offer them. It is not much good coming in and saying 'try this' and then not backing it up. There are too many other demands on them to allow them the time to develop something from scratch so it is best to do it this way. (Interview with Consultant)

Conclusion

From the preceding sections, we have sought to show that the typical association between the principal as being the leader is challenged in remote contexts and that other models may be more suitable, and necessary, when considering curriculum leadership. The complexities of remote education provision, leadership, compliance and reform may well be beyond the scope of the traditional role of a principal. We have illustrated how, in one remote context, that curriculum leadership in mathematics education can be undertaken in a dispersed model of leadership.

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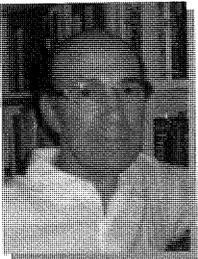
Research team biographies



Professor Robyn Jorgensen is a professor of education at Griffith University. Her work has centred on issues of equity and access for the most disadvantaged groups of students. These include students from working-class families, students living in rural and remote areas and Indigenous students. The work has focused on teaching practice and how this is implicated in facilitating or hindering access to mathematical understandings. She recently spent 12 months in remote Australia as CEO/Principal of an Aboriginal college. She has been the Chief Investigator on 8 Australian Research Council grants, is widely published and has been invited to speak at many forums. She has been involved in advising state education departments on reforms, including in South Australia, Northern Territory and Queensland. She has served on the Ministerial Advisory Committee for Science, Technology, Engineering and Mathematics (STEM), was Chair of the Queensland Studies Authority's Mathematics Syllabus Advisory Board, and is currently the eminent mathematics professor for the Australian Association of Mathematics Teachers' "Turn the Page" project which aims to improve mathematics learning for Indigenous students.



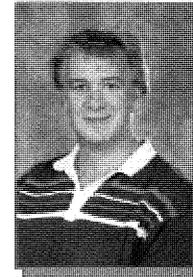
Professor Peter Sullivan is a professor of science, mathematics and technology education at Monash University. Previously at Australian Catholic University and La Trobe University, he has extensive experience in research and teaching in teacher education. Prior to this, Peter was a teacher for 10 years and worked in schools and universities in Papua New Guinea for 6 years. Peter is a member of the Social, Behavioural and Economic Sciences panel of the Australian Research Council College of Experts, and Associate Editor, Journal of Mathematics Teacher Education.



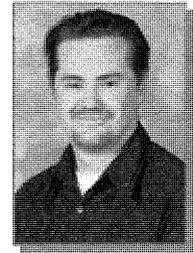
Professor Stephen Lerman was formerly a secondary school teacher of mathematics in various schools in London and in Israel, including 5 years as a Head of Mathematics in North London. He has been in mathematics teacher education and research since then and is now Professor of Mathematics Education at London South Bank University. He has for many years been interested in sociocultural theory and how it informs and interrogates teaching and research and has published a number of papers and edited books on this theme. He has also been lead researcher on a several funded projects. His recent work has drawn on sociological theory to inform studies of disadvantage in school classrooms. For more information see his website <http://myweb.lsbu.ac.uk/~lermans>



Professor Jo Boaler is a Professor of Mathematics Education at Stanford University. She is an elected fellow of the Royal Society of Arts (Great Britain), and a former president of the International Organization for Women and Mathematics Education (IOWME). Prior to her time at Stanford she was the Marie Curie Professor at The University of Sussex, England. At Stanford University she was awarded an "Early Career Award" from the National Science Foundation in the United States. She is the author of several books and a regular contributor to national television and radio in the United States and the UK. Her latest book *What's Math Got To Do With It?* is published by Penguin (2008) and aims to increase public understanding of the importance of mathematics, and the nature of effective teaching approaches. She has worked with members of the British Government to bring effective research-based approaches into schools in England. Her work has appeared in newspapers across the world, including *The Wall Street Journal* and *The Times*.



Associate Professor Peter Grootenboer is a Mathematics Educator in the School of Education and Professional Studies at Griffith University. Peter's research interests are in mathematics education and educational leadership. In particular, he has focused on affective development in mathematics learning, praxis development in teacher education, identity and disciplinarity, and school appraisal systems and principles.



Dr Richard Niesche is a Postdoctoral Research Fellow in the School of Education at The University of Queensland, Brisbane, Australia. He has worked as a primary and high school teacher in both Queensland and New South Wales. He has taught at an Independent Indigenous School in Queensland for 3 years and has been researching Indigenous Education and leadership since 2003. His research interests include educational leadership, Indigenous education and social justice. He has a forthcoming book with Routledge titled *Foucault and Educational Leadership: Disciplining the Principal* to be published in March 2011.

Publication list

This book includes the published articles and papers from the first two years of the *Maths in the Kimberley Project*. The aim of the *Maths in the Kimberley project* is to address the issue of underperformance of remote Indigenous students in mathematics through using a framework of high demand mathematics along with an innovative pedagogical model.

Title of paper	Page	Original publication for citing
Reforming mathematics classrooms: A case study of remote Indigenous education	3	Zevenbergen, R. & Niesche, R. (2008). <i>Reforming mathematics classrooms: a case of remote Indigenous education</i> . Working Paper No. 2, Brisbane: Griffith Institute for Educational Research, Griffith University.
Creating equitable practice in diverse classrooms: Developing a tool to evaluate pedagogy	39	Zevenbergen, R., Niesche, R., Grootenboer, P. J., & Boaler, J. (2008). Creating equitable practice in diverse classrooms: Developing a tool to evaluate pedagogy. In M. Goos, R. Brown, & K. Makar (Eds.), <i>Navigating currents and charting directions</i> (Proceedings of the 31st annual conference of the Mathematics Education Research Group of Australasia, Brisbane, Vol. 2, pp. 637-644). Brisbane: MERGA.
Scholastic heritage and success in school mathematics: Implications for remote Aboriginal learners	49	Jorgensen, R., & Sullivan, P. (2010). Scholastic heritage and success in school mathematics: Implications for remote Aboriginal learners. In I. Snyder & J. Nieuwenhuysen (Eds.), <i>Closing the gap in education? Improving outcomes in southern world societies</i> (pp. 23–36). Clayton: Monash University Publishing.

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