

Maths in the Kimberley Project: Evaluating the Pedagogical Model

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The Mathematics in the Kimberley Project is a three-year research and development project that focuses on mathematical pedagogy in remote Aboriginal community schools. The research team has regularly reported on the project at MERGA conferences, and in this symposium we evaluate the pedagogical model that underpins the project. After two years of the project, the data indicate that some aspects of the pedagogical model have been successful, but other aspects have not been particularly fruitful and still require greater thought, research and development.

Paper 1: Richard Niesche, Peter Grootenboer, Robyn Jorgensen (Griffith University) and Peter Sullivan (Monash University). *The Maths in the Kimberley Project: An Overview*.

Paper 2: Peter Grootenboer (Griffith University). *Effective Features of the Maths in the Kimberley Inclusive Pedagogy Model*.

Paper 3: Robyn Jorgensen (Nyangatjatjara Aboriginal Corporation and Griffith University). *Group work, Language and Interaction: Challenges of Implementation in Aboriginal contexts*.

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The Maths in the Kimberley Project: An Overview

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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.

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, 2008; Hayes, Mills, Christie & Lingard, 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).

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 much of the 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 inclusive pedagogy 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 shows the mean scores from the classroom lesson observations.

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

These comprised of videotapes sent in by teachers and some tapes made by members of the research team while visiting schools. Lessons are scored from 1-5 based on the inclusive pedagogy model. To illustrate the scoring, a score of 1 means the pedagogical aspect was

not evident in the lesson and a 5 mean the pedagogy was a central and significant part of the lesson (for more detail see Zevenbergen, Niesche, Grootenboer, & Boaler, 2008).

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:

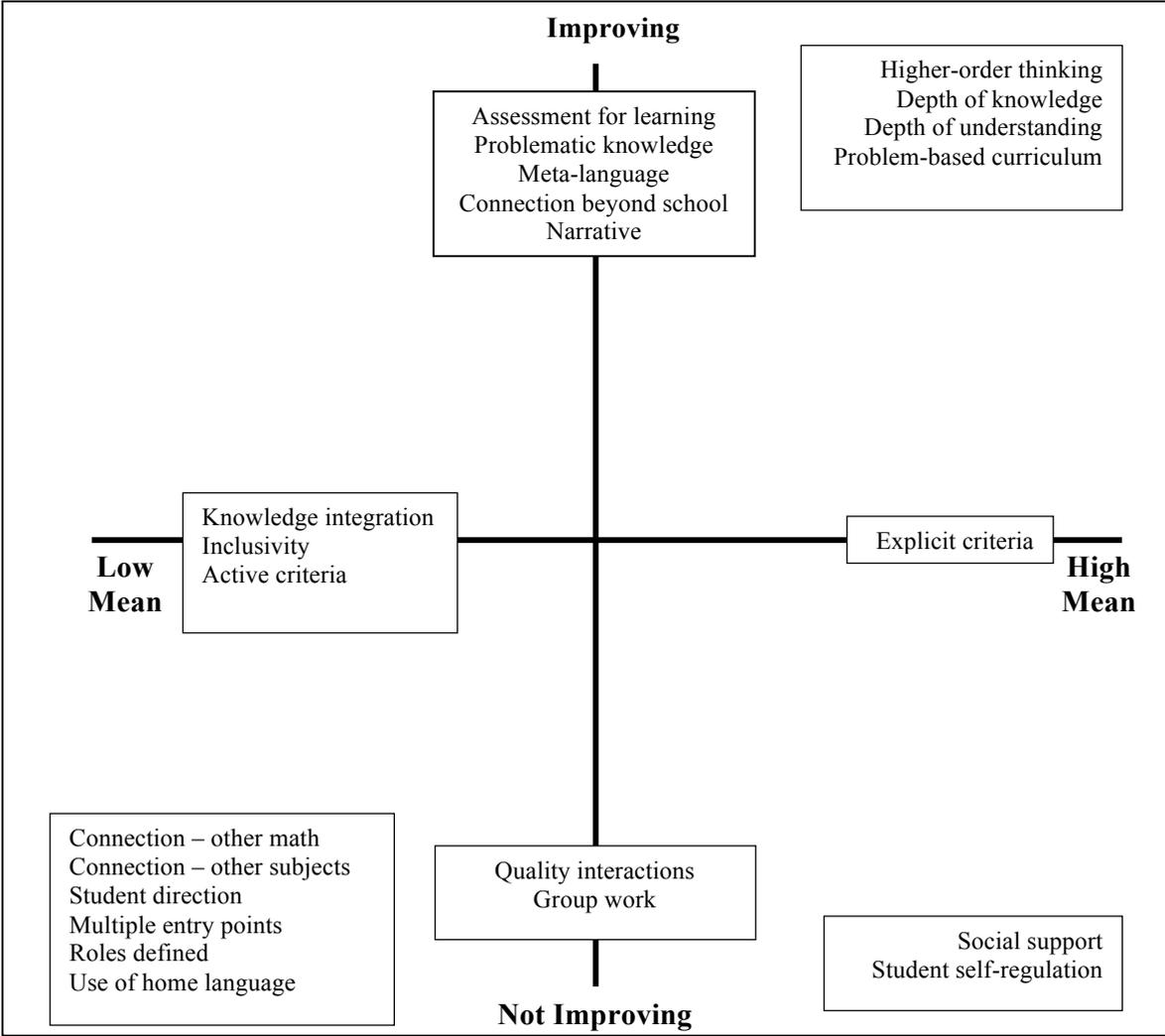


Figure 1: Analysis of Pedagogical Dimensions

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. However, of significant concern 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.

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 the 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 (Niesche, Grootenboer, Jorgensen & Sullivan, 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. This indicated 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 lesson 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 required 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 Niesche, et al., 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 hypothesising, 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 Niesche, et al., this symposium). This indicated 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 do not know and cannot 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 indicated 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 (see Table 1 in Niesche, Grootenboer, Jorgensen & Sullivan, 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 aspect 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 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 model need to be considered carefully in terms of 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 research 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, the 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 also the communities. This requires further work in Indigenous education research.

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