Bridging the Numeracy Gap for Students in Low SES Communities: The Power of a Whole School Approach

Ann Gervasoni
Australian Catholic University
Ann.Gervasoni@acu.edu.au

Linda Parish
Australian Catholic University
Linda.Parish@acu.edu.au

Cait Upton, Teresa Hadden, Kathie Turkenburg, Kate Bevan, Carole Livesey, Deirdre Thompson, Melissa Croswell and Julie Southwell
Ballarat, Sandhurst, Sale and Western Australia Catholic Education Offices

This paper explores the impact of the *Bridging the Numeracy Gap Project* on the whole-number learning of Prep and Grade 1 students living in a low SES community. The findings suggest that an approach that includes a specialist mathematics teacher who provides specialised programs for mathematically vulnerable students, and who works in partnership with classroom teachers to design individual learning plans, and classroom mathematics programs that cater for the diverse range of students' learning needs, has a positive effect on mathematics learning and instruction.

Education is well established as a significant factor in breaking the cycle of poverty for marginalised people in Australia and throughout the world (Zappalà, 2003). Education provides knowledge that ultimately empowers people to access further education, employment and active citizenship. Sadly, educational outcomes for those students living in low Socio-Economic Status (SES) communities and Aboriginal and Torres Strait Islander communities are lower than for students not living in these communities (Commonwealth of Australia, 2008; Zevenbergen & Nieske, 2008). Thus, the current Australian Federal Government has both a continued and renewed emphasis on closing the education gap between these groups of Australians. One initiative launched by the Federal Government is a series of Pilot Projects that seek insight about how to close the literacy and numeracy gap for Australian students. This paper reports on one Pilot that is a collaborative project between 42 school communities, Catholic Education Offices in the regions of Ballarat, Sandhurst, Sale, and Western Australia, and Australian Catholic University.

Background

Key approaches used to improve mathematics in this Pilot are: classroom teachers administering a one-on-one interview-based mathematics assessment using the *Early Numeracy Interview* and associated framework of Growth Points (Clarke, Cheeseman, Gervasoni, Gronn, Horne, McDonough, Montgomery, Roche, Sullivan, Clarke, & Rowley, 2002; Gervasoni, Hadden, & Turkenburg, 2007), having a specialist teacher to assist teachers to use this data to guide instruction and curriculum development at individual, class and whole school levels (Gervasoni & Sullivan, 2007), and using the *Extending Mathematical Understanding* Program (Gervasoni, 2004) in the second year of formal schooling to provide intensive specialised instruction for students who are mathematically vulnerable. For the purpose of exploring the effect of these approaches on students' early school learning, this paper compares the Prep and Grade 1 children's growth in whole number learning at one regionally-based Victorian school to a representative population of

L. Sparrow, B. Kissane, & C. Hurst (Eds.), *Shaping the future of mathematics education: Proceedings of the 33rd annual conference of the Mathematics Education Research Group of Australasia.* Fremantle: MERGA.

Victorian students. This school is situated in one of the lowest socio-economic-status (SES) communities in the State.

The Early Numeracy Interview and Framework of Growth Points

The *Early Numeracy Interview* (Department of Education Employment and Training, 2001), developed as part of the *Early Numeracy Research Project* (Clarke et al., 2002), is a clinical interview with an associated research-based framework of Growth Points that describe key stages in the learning of nine mathematics domains. This interview and the Growth Points were used in this research to gather the data examined in this paper.

The principles underlying the construction of the Growth Points for the *Early Numeracy Research Project* (ENRP) were to: describe the development of mathematical knowledge and understanding in the first three years of school in a form and language that was useful for teachers; reflect the findings of relevant international and local research in mathematics (e.g., Steffe, von Glasersfeld, Richards, & Cobb, 1983; Fuson, 1992; Mulligan, 1998; Wright, Martland, & Stafford, 2000; Gould, 2000), allow the mathematical knowledge of individuals and groups to be described, reflect, where possible, the structure of mathematics, and enable a consideration of students who may be mathematically vulnerable.

The Growth Points form a framework for describing development in nine domains, including four whole number domains that are the focus of this research: Counting, Place Value, Addition and Subtraction, and Multiplication and Division. The processes for validating the Growth Points, the interview items and the comparative achievement of students in project and reference schools are described in full in Clarke et al. (2002).

To illustrate the nature of the Growth Points, the following are the Growth Points for Addition and Subtraction. These emphasise the strategies children use to solve problems.

1. Counts all to find the total of two collections.
2. Counts on from one number to find the total of two collections.
3. Given subtraction situations, chooses appropriately from strategies including count back, count down to & count up from.
4. Uses basic strategies for solving addition and subtraction problems (doubles, commutativity, adding 10, tens facts, other known facts).
5. Uses derived strategies for solving addition and subtraction problems (near doubles, adding 9, build to next ten, fact families, intuitive strategies).
6. Extending and applying. Given a range of tasks (including multi-digit numbers), can use basic, derived and intuitive strategies as appropriate.

Each Growth Point represents substantial expansion in knowledge along paths to mathematical understanding (Clarke, 2001). They enable teachers to: identify any children who may be vulnerable in a given domain, identify the zone of proximal development for each child in each domain so instruction may be customised and precise, and identify the diversity of mathematical knowledge in a class. The whole number tasks in the interview take between 15-25 minutes for each student and are administered by the classroom teacher. There are about 40 tasks in total, and given success with a task, the teacher continues with the next tasks in a domain (e.g., Place Value) for as long as the child is successful. Teachers report that the *Early Numeracy Interview* (ENI) provided them with insights about students' mathematical knowledge that might otherwise remain hidden (Clarke, 2001). This was an important reason for using the ENI as part of the *Bridging the Numeracy Gap* project.

The Extending Mathematical Understanding (EMU) program

Another key aspect of the approach used in the *Bridging the Numeracy Gap Project* was providing the opportunity for students who were mathematically vulnerable to participate in an EMU program. This is a series of lessons specifically designed by a specialist teacher for the purpose of accelerating students' learning. Groups of three students participate in these lessons for 30-minutes per day, 5 days per week for a total of 25-50-hours depending on student progress. Each lesson centres on whole number learning with specific focuses on quantity (counting and place value), investigations involving addition, subtraction, multiplication, and division problems with an emphasis on the development of reasoning strategies, reflection on learning, and a home task. The EMU program, also used by most schools involved in the ENRP, is taught by specially qualified teachers who have completed a course (at Masters level) that includes 36 hours of course work, a minimum of 25 hours of field-based learning, and a program of professional reading.

An Approach for Improving Mathematics Learning at School A

This paper examines the mathematics learning outcomes for students belonging to a school known as School A and compares progress in learning to students participating in the ENRP. This school is part of a regional Victorian town that is listed by the State Government as one of the five-most disadvantaged communities in the state, and has an enrolment of 200 students who are educated across nine classrooms. Of the Prep-Grade 2 students participating in this project, 28% of their families receive the Education Maintenance allowance, no students have language backgrounds other than English, and no students have severe language difficulties. Only one Prep student has a disability. At the beginning of 2009, 48% of Grade 1 students and 50% of Grade 2s were identified as being vulnerable in at least one number domain. Three of the four Prep-Grade 2 classroom teachers and the Mathematics Co-ordinator were qualified as EMU teachers, and the Mathematics Co-ordinator implemented an EMU program in 2009.

For the past eight years, the school has been implementing a whole school approach to improving mathematics learning guided by the design elements of the Hill and Crévola model (1997). Important features of this approach have been the appointment of a school mathematics co-ordinator to provide curriculum leadership, assessment by the classroom teachers of all students at the beginning of each year using the *Early Numeracy Interview* and the associated Growth Point framework, identification of mathematically vulnerable students, professional learning team meetings during which issues associated with learning and teaching mathematics are discussed, and implementation of the *Extending Mathematical Understanding* (EMU) Program for some Year 1 mathematically vulnerable students.

In 2009, the school agreed to participate in the *Bridging the Numeracy Gap in Low SES and Indigenous communities Pilot Project*. This enabled the school to increase the number of students who participated in an EMU Program, and highlighted the importance of the EMU specialist teacher also working in partnership with classroom teachers for the purpose of designing, implementing and monitoring the impact of individual learning plans for vulnerable students, and participating in professional learning team meetings to provide leadership, advice and professional learning opportunities for classroom teachers.

The purpose of this paper is to determine whether these activities had an effect on the students' mathematics outcomes, as measured by the ENRP Growth Point framework.

Another purpose was to compare the Growth Point distributions of students in School A to that of the ENRP distributions that were representative of Victorian students. This would enable the research team to determine whether or not the Growth Point distributions for students in this very low SES community were similar to Growth Point distributions that were representative of Victorian students.

Children's Whole Number Knowledge

When Beginning School

One key issue for this research was to determine whether the whole number knowledge of students beginning school in this low SES community is similar to the knowledge of students overall. For this purpose the Growth Point distribution of Prep students in School A (*n*=18) was compared to that of the representative ENRP distribution (*n*=1711). Figure 1 shows the distributions for counting knowledge at the beginning and end of the year.

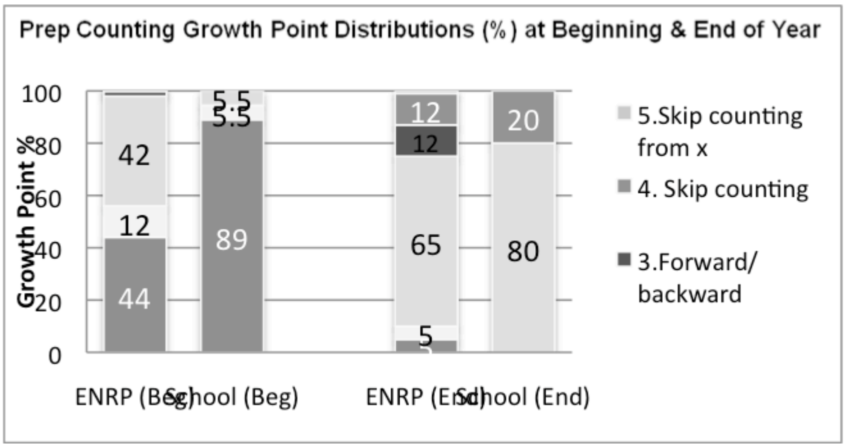

Figure 1. Counting Growth Point Distributions (%) for ENRP (1999) and School A (2009) Prep Students at the beginning and end of the year

The Growth Point distributions for students when they first begin school indicate a large difference between the two groups, with double the proportion of School A students (89%) not yet able to rote count to 20. Further, more than 40% of the ENRP Preps could count a collection of 20 items, compared with hardly any School A students. This data suggests that Prep students at School A have had less experience with school-like counting activities prior to commencing formal schooling, and that becoming familiar with number names and counting sequences will be an important focus of their initial curriculum.

Similar comparisons were made for the domains of Place Value, Multiplication and Division Strategies, and Addition and Subtraction Strategies. However, the Growth Point distributions for School A and ENRP students in these domains were all similar. These comparisons lead to the question as to why such large differences exist between the groups in counting and not in the other domains. One explanation may be that children in this low SES community encounter numbers greater than ten less often than students in other communities. Thus a recommendation for School A is to provide Prep students with many rich opportunities to encounter and explore numbers beyond ten.

Learning Outcomes after One Year at School

The *Bridging the Numeracy Gap Project* enabled School A to allocate more time for the Mathematics Co-ordinator to work with classroom teachers to assist with analysing their ENI data to identify mathematically vulnerable students, to refine their classroom programs to meet the needs of each individual, and to develop their professional knowledge during professional learning team meetings. Examination of the students' Growth Points at the end of Prep demonstrated that they had made significant progress. Figure 1 also shows School A's Prep (*n*=15) Counting Growth Point distributions at the end of the year compared to the ENRP Prep cohort (*n*=1675). The data show that the School A students made good progress in Counting over the year, despite the fact that few students at the beginning could rote count to 20 (Figure 1). By the end of the year the Growth Point distributions were very similar, and this suggests that the school program was successful in bridging the knowledge gap. Figure 2 compares the Growth Point distributions for Addition and Subtraction Strategies of the Prep students at the beginning and end of the year.

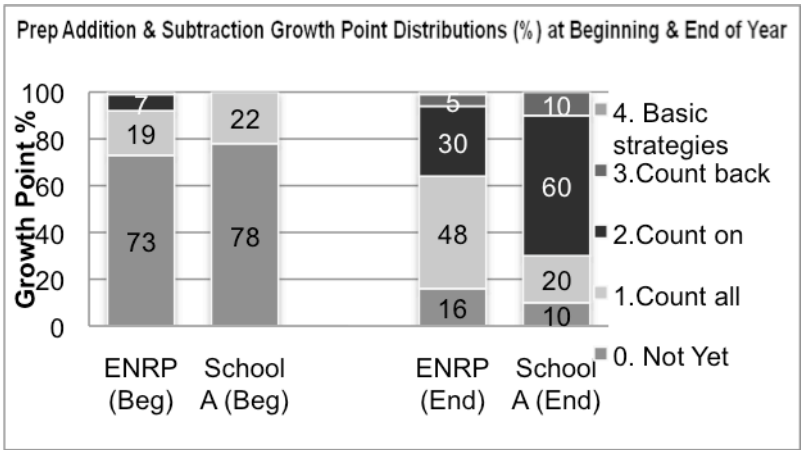

Figure 2. Prep Addition & Subtraction Strategies Growth Point Distributions for ENRP and School A students at the beginning and end of the year

These data suggest that the students in School A (*n*=18) progressed considerably further over the year than did the ENRP cohort (*n*=1702). Seventy percent of School A Preps could at least use the count-on strategy in an addition problem (9+4), compared with only 35% of ENRP Preps. This suggests that the Prep program in School A was highly effective in assisting students to develop addition strategies. However, it must be noted that for each domain, there were one or two children at School A, who made little progress in relation to the Growth Point framework across the year.

Progress for Grade 1 Students

An important feature of the Grade 1 mathematics program at School A was the opportunity for mathematically vulnerable students to participate in the *Extending Mathematical Understanding* (EMU) Program, a series of lessons specifically designed and implemented by a specialist teacher. Participation in the Pilot Project meant that School A could offer this opportunity to more students than in previous years.

Figure 3 shows the Counting Growth Point distributions at the beginning and end of Grade 1 for three groups of students: the ENRP cohort in 1999 (*n*=1662), School A students (*n*=23), and School A students who participated in an EMU program (*n*=9).

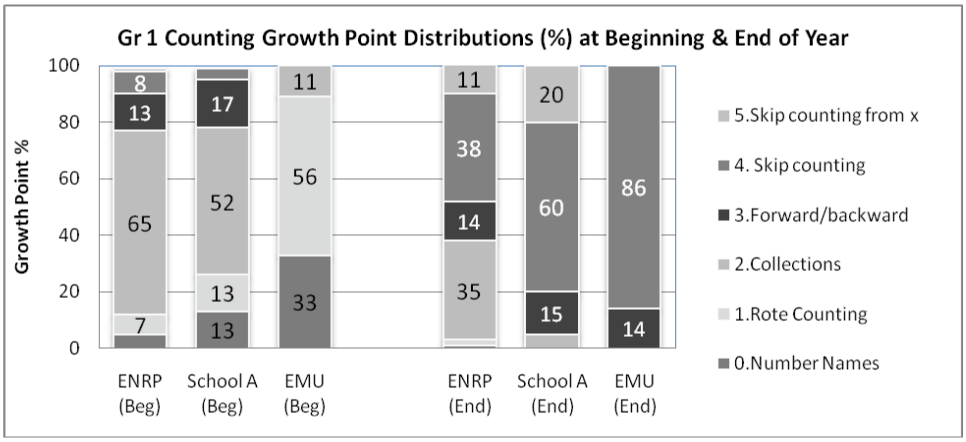

Figure 3. Grade 1 Counting Growth Point Distributions for ENRP (1999), School A (2009) and EMU (2009) students at the beginning and end of the year.

The data show that although a greater proportion of School A students began the academic year on Growth Points 0 or 1, compared with the ENRP students, the students in School A made greater progress overall. Indeed, 80% of School A students compared with 49% of ENRP students reached Growth Points 4 and 5 by the end of the year. Similarly, the students participating in the EMU program all progressed well in counting, with the majority of students reaching Growth Point 4. This suggests that the approach in School A was highly effective for the most mathematically vulnerable students also.

Grade 1 students in School A also made good progress in the other whole number domains. Figure 4 shows the Growth Point distributions for Addition and Subtraction Strategies as an illustrative example.

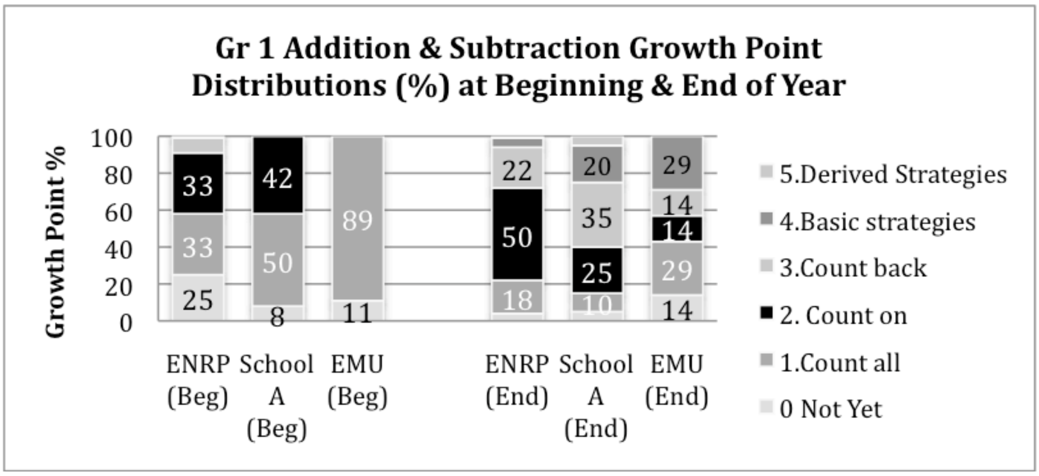

Figure 4. Addition & Subtraction Strategies Growth Point Distributions for Grade 1 ENRP (1999), School A (2009) and EMU (2009) students at the beginning and end of the year.

Figure 4 shows that at the start of the year most students in School A (*n*=23) could at least use the count-all strategy to solve an addition problem, compared with only 75% of ENRP students (*n*=1658), but that none of the EMU students (*n*=9) used the count-on strategy. By the end of the year, about 60% of School A students (*n*=-20) and 40% of the

EMU students (*n*=7) were using the count-back strategy or basic reasoning strategies, compared to only 30% of ENRP students (*n*=1603). This indicates a considerable advance for School A students, with only three students not yet using the count-on strategy.

In evaluating the impact of the *Bridging the Numeracy Gap* project on the school community in 2009, the views of the Principal and Numeracy Leader were sought. The Principal made the following statement.

> "In light of our school's context (Low SES community) we were fortunate to fit within the criteria of the Bridging the Numeracy Gap Project and we have been able to strengthen the positive work that we had already begun. In particular the project has enabled:
>
> All teachers (P-6) to use the [Early Numeracy] Interview to target children's needs;
> All teachers to be more proficient in analysing data (ENI/NAPLAN/Pupil reports) to identify issues and areas of growth;
> All teachers to increase their understanding of numeracy pedagogy, via PLT (Professional Learning Team) meetings each fortnight and coaching support from the Numeracy leader;
> Up-skilling of all teachers in numeracy practices, i.e.: 3 out of 4 junior school teachers are EMU trained. Thus, improving classroom teaching and reducing the number of children needing additional support;
> Sufficient leadership support in mathematics;
> Our school to raise the profile of numeracy;
> Our school to increase the number of students who can access the EMU program;
> Significant improvements in [maths] outcomes (Assessment tool/NAPLAN/My School/ reports);

The EMU teacher explained that the impact of the Pilot extended to families also.

> "The EMU Program has earned a positive reputation in our school with many families keen to know what we are actually doing and how they can support their children at home. Last year (2009) we ran a very successful evening for families and students focusing on the development of mental computation strategies. As part of this evening we also invited the students to 'teach' their families some of the rich activities they use in the classroom with their teacher. All families went home with a gift bag containing simple items/activity boards that they could use at home with their children. The response was very positive, with families feeding back that they feel more able to support their child."

These comments suggest that the Project has both enhanced the learning environment for students, and increased the capacity of the entire school community to enable children to learn mathematics successfully.

Conclusion

The Counting Growth Point data for School A Prep students confirms previous research findings that the mathematical knowledge of children in low SES communities when students begin school is lower than for their peers overall (Griffin & Case, 1997). This does not mean that these students are less able, but suggests that some students' home environments may not provide them with the type of experiences that prepare them for learning school mathematics. Further, students' informal mathematical knowledge may be culturally specific, and not be obvious to the teacher during the assessment process (Zevenbergen & Niesche, 2008).

The school community described in this paper has an expert Mathematics leader who provides specialised mathematics programs for mathematically vulnerable students, and works in partnership with classroom teachers to design individual learning plans, and classroom mathematics programs that cater for the diverse range of students' learning needs. This collaborative and rigorous approach for designing highly effective learning environments is having a positive impact on mathematics learning and instruction.

The findings from this research demonstrate that school communities in low SES areas can "bridge the numeracy gap" in the early years of schooling through providing rich learning environments and specialised instruction for students. Australians rely on schools and teachers in these communities to provide students with an education that enables them to shake off the shackles of poverty and marginalisation.

References

Clarke, D. (2001). Understanding, assessing and developing young children's mathematical thinking: Research as powerful tool for professional growth. In J. Bobis, B. Perry & M. Mitchelmore (Eds.), *Numeracy and beyond: Proceedings of the 24th Annual Conference of the Mathematics Education Research Group of Australasia* (Vol. 1, pp. 9-26). Sydney: MERGA.

Clarke, D., Cheeseman, J., Gervasoni, A., Gronn, D., Horne, M., McDonough, A., Montgomery, P., Roche, A., Sullivan, P., Clarke, B., & Rowley, G. (2002). *ENRP Final Report*. Melbourne: Australian Catholic University.

Commonwealth of Australia (2008). *National numeracy review report*. Retrieved 18 March 2010, from COAG Web site: http://www.coag.gov.au/reports/docs/national_numeracy_review.pdf.

Department of Education Employment and Training. (2001). *Early numeracy interview booklet*. Melbourne: Department of Education, Employment and Training.

Fuson, K. (1992). Research on whole number addition and subtraction. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 243-275). New York: Macmillan.

Gervasoni, A. (2004). *Exploring an intervention strategy for six and seven year old children who are vulnerable in learning school mathematics*. Unpublished PhD thesis, La Trobe University, Bundoora.

Gervasoni, A., Hadden, T., & Turkenburg, K. (2007). Exploring the number knowledge of children to inform the development of a professional learning plan for teachers in the Ballarat diocese as a means of building community capacity. In J. Watson & K. Beswick (Eds), *Mathematics: Essential Research, Essential Practice Hobart: MERGA* (Proceedings of the 30th annual conference of the Mathematics Education Research Group of Australasia, 305-314). Hobart: MERGA.

Gervasoni, A., & Sullivan, P. (2007). Assessing and teaching children who have difficulty learning arithmetic. *Educational & Child Psychology, 24*(2), 40-53.

Gould, P. (2000). Count Me In Too: Creating a choir in the swamp. In *Improving numeracy learning: What does the research tell us?* (Proceedings of the ACER Research Conference 2000, pp. 23–26). Melbourne: Australian Council for Educational Research.

Griffin, S., & Case, R. (1997). Re-thinking the primary school math curriculum: An approach based on cognitive science. *Issues in Education, 3*(1), 1-49.

Hill, P. W., & Crévola, C. A. (1999). The role of standards in educational reform for the 21st century. In D. D. Marsh (Ed.), *Preparing our schools for the 21st century* (Association of Supervision and Curriculum Development Yearbook, pp. 117-142). Alexandria, VA: ASCD.

Mulligan, J. (1998). A research-based framework for assessing early multiplication and division. In C. Kanes, M. Goos & E. Warren (Eds.), *Teaching mathematics in new times* (Proceedings of the 21st annual conference of the Mathematics Education Research Group of Australasia, Vol. 2, pp. 404-411). Brisbane: MERGA.

Steffe, L., von Glasersfeld, E., Richards, J., & Cobb, P. (1983). *Children's counting types: Philosophy, theory, and application.* New York: Praeger.

Wright, R., Martland, J., & Stafford, A. (2000). *Early numeracy: Assessment for teaching and intervention*. London: Paul Chapman Publishing.

Zappalà, G. (2003). *Barriers to participation: Financial, educational and technological. A report into the barriers to societal participation among low-income Australians*. Camperdown, NSW: The Smith Family. Retrieved March 18, 2010, from http://www.thesmithfamily.com.au/webdata/resources/files/TSF_barrieries_2003.pdf

Zevenbergen, R., & Nieske, R. (2008). *Reforming mathematics classrooms: a case of remote Indigenous education*. Working Paper No. 2, Brisbane, Qld: Griffith Institute for Educational Research, Griffith University