

One on One Numeracy Intervention: A Pilot Project in Low SES Communities

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This paper reports on the structure and impact of a one on one numeracy intervention project conducted during 2009 with students in years 1, 4 and 8. The project was built on a Reading Recovery model, using research into how the brain learns mathematics and ideas of threshold concepts. Teachers were provided time to work individually with students at their point of need. The results suggested that the model was effective in both cognitive and affective terms, and that the learning gained through the project is beginning to result in whole school improvements in mathematics pedagogy.

This paper describes a numeracy intervention project conducted by the Catholic Archdiocese of Canberra/Goulburn as part of the Commonwealth Government Literacy and Numeracy Pilots in low SES schools. The pilot commenced in February 2009 and concludes in June 2010. It was conducted in ten schools in the region, from the South Coast and South Central NSW. It involved up to twelve students from each school in Years 1, 4 and/or 8. The paper describes the design of the project and provides some preliminary results of both teacher change and changes in affect and understanding among the students.

Literature review informing the project

The design of the project was influenced by several sources and previous studies. An initial decision was made to use a one on one intervention process, which has been shown to be effective in producing improved outcomes for struggling students (Phillips, Leonard, Horton, Wright, & Stafford, 2003). Several intervention models (Bryant, Bryant, Gersten, Scammacca, & Chavez, 2008; Dowker, 2001; Gervasoni, 2005; Wright, 2009) were examined. Most models structure intervention around a clearly developed and described framework. For example, Dowker (2001) identified eight components of early numeracy, while the *Math Recovery* project (Wright, 2009) used an instructional framework for early number organised into three strands, number words and numerals, counting and grouping, with thirty teaching topics.

However, for this project teachers were not provided with a set program, framework or developmental sequence that they were required to follow; rather they were asked to respond to students at their point of need. Since many of the teachers involved in the project had some experience of *Reading Recovery* (Clay, 1993) this was chosen as a way of structuring the intervention.

Other sources of research that informed the teachers' development of intervention strategies included research into how the brain learns mathematics (Sousa, 2008), discussions of mathematical concepts that could be termed threshold concepts (Meyer & Land, 2003) and existing frameworks for children's mathematical development such as the

Learning Framework in Number from *Count Me In Too* (NSW Department of Education and Training, 2000).

Brain based research stresses the need to build lessons around knowledge of how the brain best learns mathematics and brain activity during a period of time when new ideas are being learned. In particular the teachers in the project examined connections between oral, visual and symbolic representations of mathematics, using research about brain activity related to each representation. They also examined issues such as the structure of the mental number line and metalanguage. Based on their learning about mathematics and brain activity teachers chose to use activities such as a Think-Board (Gervasoni, 1999). This ensured that lessons included periods of active learning. They paid particular attention to the use of language by constructing a word wall.

Teachers also built on research into brain activity during a period of instruction (Sousa, 2008) to construct lessons that took advantage of periods of greatest and least activity. Each 30 minute lesson was planned to follow the structure:

- Short warm-up activity revising previously learnt ideas (5 minutes);
- Explicit teaching (10 minutes);
- Cognitive break (3 minutes);
- Related practice/ Consolidation of the key idea (10 minutes);
- Cognitive closure (3 minutes).

For each lesson teachers were asked to plan using a template based on a combination of ideas from Reading Recovery (Clay, 1993) and the concepts of brain based learning. The template asked teachers to plan each section of the lesson, document student responses during that phase of the lesson and summarise learning.

During professional development sessions considerable time was devoted to discussing the fundamental concepts of mathematics, such as place value, multiplicative thinking, and part-whole connections that have been shown to be both troublesome and essential for further understanding (Siemon, Izard, Breed, & Virgona, 2006). For the purposes of this project the idea of a threshold concept (Meyer & Land, 2003) was used to guide discussion and planning. While most of the research into threshold concepts has been based in tertiary education settings such as studying economics, physics or mathematics (Meyer & Land, 2005), it was felt that the characteristics of threshold concepts were particularly appropriate for deciding what might be essential for students struggling with mathematics in the early and middle years of schooling.

Threshold concepts are troublesome, integrative, irreversible and transformative (Meyer & Land, 2003). They are troublesome in that they are often difficult to grasp, sometimes counterintuitive and usually take considerable time to develop. They are integrative in that they make sense of previously disparate ideas. They are transformative in that once a threshold concept has been grasped the world “looks different”, and they are irreversible in that once one sees the world in that way one never reverts to more simplistic or primitive ways of seeing the world.

Place value provides an appropriate example of a threshold concept in early mathematics. To develop a robust understanding of place value students must see ten or one hundred as a group rather than a count, and must let go of a reliance on counting by ones. They need to be able to construct and deconstruct numbers as combinations of groups, a process that is troublesome for many students and even practising teachers (Ma, 1999). Indeed, the teachers in the project consistently reported that this was a concept that students did not understand well, even in Year 8. However, once one understands the place value structure of a number such as 137 it ceases to become a symbol on a page for a count

of objects and becomes instead a structure that can be visualised and decomposed flexibly, making sense of ideas and processes such as standard algorithms in arithmetic. This transforms the way students see number, and is irreversible in that given 137 objects students who have a strong understanding of place value will almost inevitably count them in groups of ten, which are then formed into groups of one hundred.

The threshold concepts identified and discussed by teachers were informed by and compared with existing frameworks describing children's development such as the *Learning Framework in Number* (LFIN) (Wright, 2002). The LFIN was particularly useful for interventions with Year 1 students, many of whom were identified as being at the perceptual stage of counting. Furthermore many of the Year 4 students had a poor grasp of strategies for single digit addition, and few had developed the capacity to count by equal groups necessary for multiplicative thinking.

The program

Initially schools identified as having a relatively high proportion of students from low SES backgrounds, including high numbers of indigenous students, and as having a high proportion of students achieving at/or below the benchmark shown in state numeracy testing, were approached to seek interest in being involved in the project. Ten schools were selected, being a mixture of primary schools having children in Years 1 and 4, central schools with children in Years 1, 4 and 8 and two high schools with Year 8 students. Each school was allocated resources based on enrolment, including a 0.4 salary component per identified Numeracy Intervention Project (NIP) teacher. While most schools were allocated one teacher, some with larger student enrolments were allocated two teachers. NIP teachers were selected by the school principal and were generally both experienced and capable. School principals were specifically asked to choose staff that might have influence over other staff at the school. In this way it was hoped that the project would have a flow-on effect by provoking pedagogic change across the school.

The teachers identified were provided with two days' initial professional development outlining the project, introducing some of the research discussed above and becoming familiar with an interview-based assessment instrument. In the case of children in Years 1 and 4 the *Schedule for Early Number Assessment* 1 or 2 (NSW Department of Education and Training, 2000) was used, while the *Nelson Numeracy Assessment Kit* (Giulieri, Davie, & Dale, 2004) was used for students in all years. Each teacher then identified students who might benefit from the intervention, using the results of interview assessments, school data and system-wide tests. Each teacher selected four students from Years 1, 4 or 8. In small primary schools this may have been two students in each of Years 1 and 4, while in larger primary schools with two NIP teachers one may have worked with four Year 1 students and the other with four Year 4 students. Similarly, in the high schools Year 8 students were selected, or in central schools a combination of students from different levels was selected. It is important to note that the students selected had not been identified as having special needs and were not receiving additional support from a paraprofessional. They were simply struggling with mathematics, although in many cases they also found other subject areas difficult. Years 1, 4 and 8 were chosen as these were not testing years for national testing, hence it was less likely that lessons would focus on answering typical test questions. It was also hoped that intervention in the year prior to national testing might lead to improvement in the following year's results. Of course, whether or not this was achieved remains to be seen.

At subsequent professional development days teachers were introduced to further research and developed a consistent lesson structure based on this research. Completing the planning and reflection template for each student each lesson proved time consuming and challenging, but forced teachers to pay close attention to the needs and learning of each student in the project.

One on one intervention was then conducted with each of the four students for which one teacher was responsible over a thirteen-week period from mid term 1 to the end of term 2. Each student was given a thirty-minute targeted intervention lesson in a dedicated space on four days during the week. Teachers generally had a fifteen-minute break between students during which time they documented learning and planned for the following day. At the end of the thirteen-week intervention each student was then provided with ongoing in-class support from a teacher assistant who had been specifically trained in the strategies developed during the Numeracy Intervention Program. A second phase was then commenced, however this is not reported on in this paper.

Results

All students in Years 4 and 8 were asked to complete the *Progressive Achievement Tests in Mathematics* (PATmaths) (Australian Council for Educational Research, 2005). This was administered to all students in each year level, including those not involved in the project, both prior to the commencement of the project and later during the year following the intervention. The results are shown in Table 1.

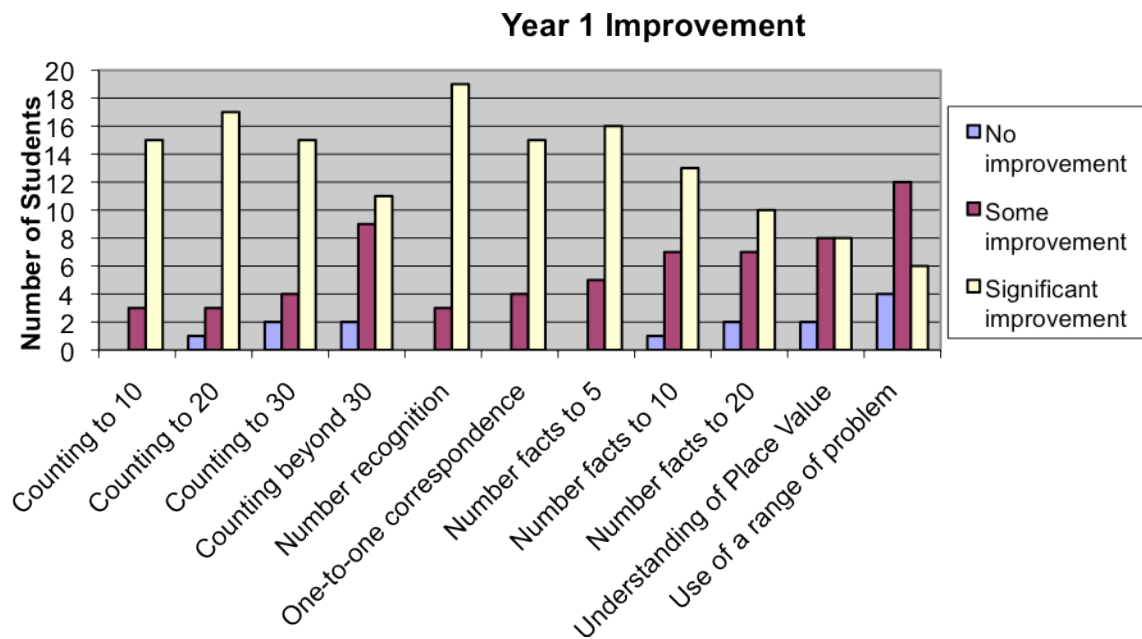
	NIP students	Non-NIP students
n	65	267
% increasing score	75%	66%
Mean increase in score	4.32	2.28

Table 1: Comparison of student results in years 4 and 8 on PATmaths

These results show modest but encouraging differences in the results of students involved in the NIP project compared to those that were not involved, with 75% of NIP students increasing their score compared to 66% of non-NIP students. However in at least one school every student involved in the project improved in the post-intervention test. A student t-test was conducted to compare the mean increase in score for the two groups (NIP and non-NIP), resulting in a p-value of 0.007. This suggests that being involved in NIP produced an increase in percentile ranking greater than that which would have been achieved outside the project. Of course, some caution should be exercised as the NIP students commenced, in general, at a relatively low level and thus it may have been relatively easy to increase the number of questions correct in PATmaths. Furthermore there was considerable variability between schools, however the number of students involved in NIP at any one school was not sufficient to conduct statistical analyses.

For Year 1 students it was not appropriate to use instruments such as PATmaths. Rather teacher judgment, particularly that of the regular classroom teacher informed by SENA, was used to evaluate the program. Each classroom teacher was asked to complete a survey requesting their judgment of students' understanding of fundamental concepts. They were then asked to complete the same survey following the NIP intervention. In almost every case teachers reported that students' understanding of fundamental concepts had improved dramatically, particularly in concepts associated with number, which was the focus of the project. Unsurprisingly the improvement was not as marked in problem

solving, as this was not an explicit focus of the intervention. The results for Year 1 are



shown in Figure 1.

Figure 1: Improvement of Year 1 students in mathematical understanding as assessed by classroom teachers

Classroom teachers in Years 4 and 8 were also asked to evaluate students' understanding of key concepts. While space prevents publication of these results in this paper, teachers also reported significant improvement. This was more pronounced in Year 4 than in Year 8, which is perhaps unsurprising as flawed understandings are often firmly embedded by the end of primary school and very hard to shift.

Classroom teachers were also asked to complete a pre- and post-survey on students' attitude to mathematics, confidence and problem solving. The results for Year 4 students are shown in Figures 2 and 3.

These results suggest that perhaps the most significant outcome of the project was an improvement in students' self-esteem and confidence. Teachers reported that some students were initially reluctant to be involved in the project for fear of being stigmatised as stupid. However, these feelings quickly disappeared, and students became excited and enthusiastic about attending NIP lessons. In one case a parent reported to the teacher that prior to the NIP project it had been hard to get her child to school, but that since NIP the child had become enthusiastic and could not wait to go to school. The increased confidence and enthusiasm developed through NIP appears to have had a flow-on effect to other areas of schooling.

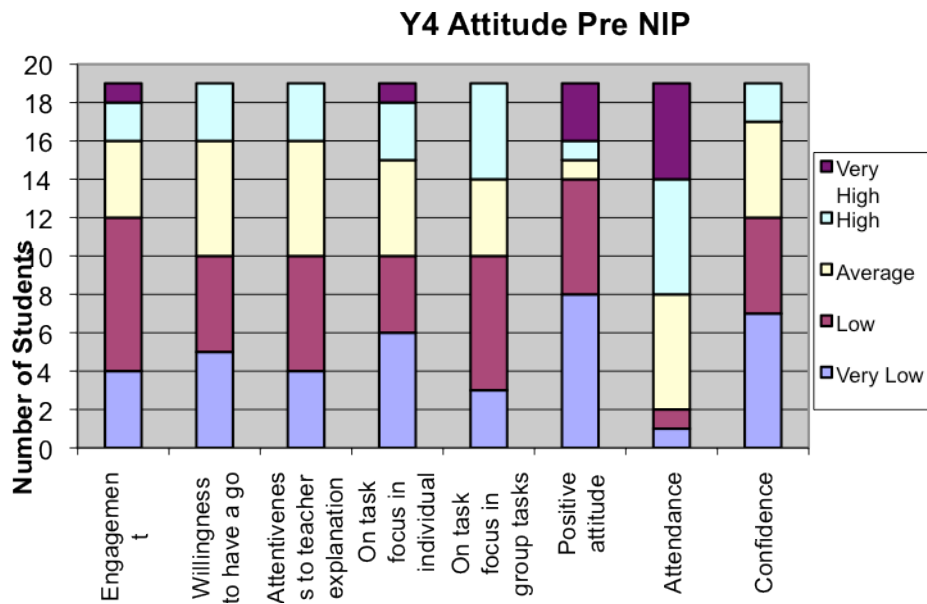


Figure 2: Year 4 students' attitudes to learning prior to NIP intervention as perceived by classroom teachers

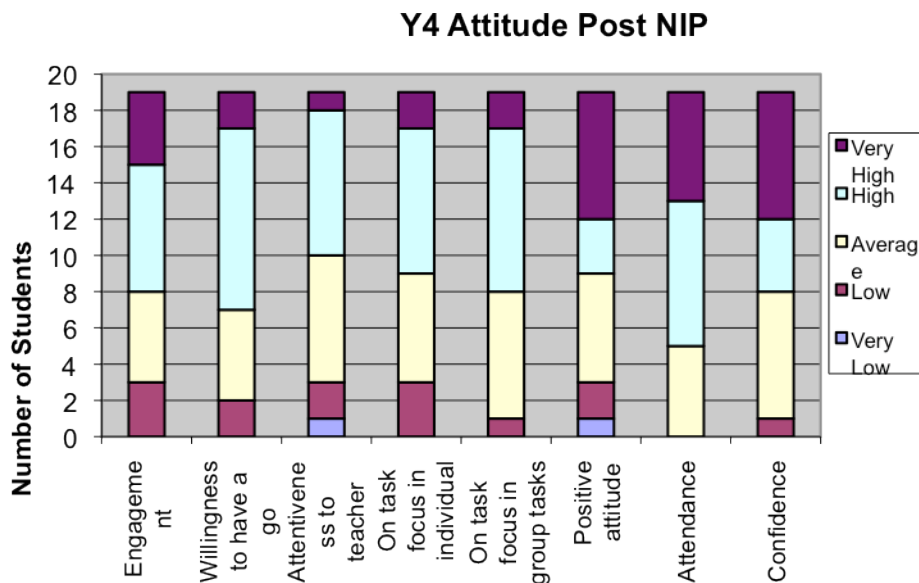


Figure 3: Year 4 students' attitudes to learning following NIP intervention as perceived by classroom teachers

What is particularly significant about these survey results is that they were the opinions of the classroom teacher, not the NIP teacher. In some cases classroom teachers were sceptical of a withdrawal program, as it could be seen to reflect on their own capacity to teach struggling students. A further implication of the withdrawal model was that students missed regular instruction for a total two hours per week. However, the results of the survey indicate that the classroom teachers, almost without exception, recognised the value of NIP both in affective and cognitive terms.

I feel special and privileged (Year 8 student).

I added up well because I am smart!! (Year 1 student)

I learnt to use my head instead of my fingers (Year 4 student)

I have a different child now. Since NIP she is happy to go to school and so much more confident
(Year 4 Parent)

School change

A key aspect of the design of the project was a whole school commitment, particularly from the school leadership team. In many cases timetables needed to be rearranged and special rooms found. It was hoped that the project might have a flow-on effect in improving mathematics pedagogy throughout the school. In most schools there has, to varying degrees, been some evidence of whole-school change. This has been particularly the case in schools where the NIP teacher was also a school leader such as the Deputy Principal. As in any such project the degree to which whole school change has eventuated relied on factors such as stability of staff, expertise of teachers and administrative support.

The most obvious change has been the way that lessons have been structured using ideas from brain activity during lessons. In some schools all teachers have been given a copy of *How The Brain Learns Mathematics* (Sousa, 2008) and have discussed the ideas in the book as a staff professional development activity. Parent information sessions have also been held. At these schools teachers have reported significantly enhanced student interest in mathematics and more productive use of lesson time.

This is the most effective numeracy development program I have ever seen (Secondary Principal)

NIP has been the best professional learning I have experienced (Primary Assistant Principal and Learning Support Teacher)

I think about ways to teach numeracy better all the time, even when I'm gardening (Year 1 NIP Teacher)

Conclusion

The NIP project has added to the weight of evidence supporting the efficacy of one on one intervention as a strategy for enhancing both affect and cognitive aspects of mathematics learning. The design of the project, building on ideas of threshold concepts and research into how the brain learns mathematics, enabled teachers to think deeply about their practice and plan interventions using a coherent framework. While it could be argued that any one on one intervention is likely to enhance outcomes for targeted students, the lesson structure used in NIP produced modest cognitive effects but strikingly positive affective results as reported by classroom teachers.

However, one on one intervention is an expensive model. The logistics of conducting the project would not have been possible without external funding accompanied by a significant investment of time from staff at the Catholic Education Office. Whether or not such a model is sustainable within the ten pilot schools or transferrable to other schools is therefore open to question. Nevertheless it is hoped that the flow-on effects of teacher learning will reduce the imperative for expensive intervention models in the pilot schools and that the teachers involved in the project may be able to share their knowledge in the wider community.

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