Indigenous Students' Early Engagement with Numeracy: The Case of Widgy and Caddy

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This paper reports on a component of a research project, Young Australian Indigenous students Literacy and Numeracy (YAILN), a longitudinal study investigating learning and teaching activities that support Young Indigenous Australian students as they enter formal schooling. In Queensland students are allowed to attend a non compulsory year of schooling, Preparatory (Prep), if they reach the age of 5 years by June in the year that they enrol. In YAILN one of the participating Indigenous schools' preparatory intake included Indigenous students who had not reached the required age for Prep. Numeracy understandings for two of these students, Widgy and Caddy were tracked during their pre prep year of schooling. Both Widgy and Caddy are from low socio-economic families. Their pre and post test numeracy results and the interview conducted at the beginning of their 'official' preparatory year suggest that this extra year of schooling enhanced their knowledge of mathematics and has (a) put them on an even footing with students from more advantaged backgrounds as they enter Prep, and (b) given them a distinctive advantage over other Indigenous students who have not had equivalent experiences.

Introduction

Young Indigenous Australian students continue to experience difficulties at school, especially in the areas of literacy and numeracy. Results from the National Report on Schooling, National Benchmarks for reading, writing and numeracy in Years 3, 5 and 7 demonstrate a high percentage of Indigenous Australian children performing well below the benchmark (ACER, 2005; MCEETYA, 2008). The latest National Report on Schooling in Australia (MCEETYA, 2008) includes the following results for Indigenous Australian children in Year 7 obtained from testing in 2006. Sixty-three percent are achieving results at the benchmark for reading (p. 27), 73.8% are achieving at the benchmark for writing (p.28) and 47.5% are achieving at the benchmark for numeracy (p. 29). These results have been improving since 1999, but there is still much to be done. Unjustified blame has been laid upon Indigenous students in the past and absenteeism, disadvantaged social background and culture have all be seen as contributing factors (Bourke & Burden, 2000). This paradigm is seen as irresponsible (Cooper, Baturo, Warren, & Doig, 2004; Matthews, Howard, & Perry, 2003). Our longitudinal research project, Young Australian Indigenous students' Literacy and Numeracy (YAILN) aims to improve learning literacy and numeracy outcomes for Indigenous students.

Theoretical Underpinnings

Briefly the research base and design principles that underpinned the development of the Numeracy aspect of YAILN were:

- *Maths Ability*: All children are capable of learning mathematics. Children do not have to be made ready to learn. They freely engage with informal mathematics in everyday life (Greenes, 1999).
- *Role of the teachers:* Play is not enough to assist learning in the early years. Children learn through play but they only discover a certain amount when left to their own devices. Adult guidance is needed to assist them to reach their potential for learning (e.g., Balfanz, Ginsburg, & Greenes, 2003; Vygotsky, 1962). Indigenous students gain less from attending play based programs (Tayler, Thorpe, & Bridgstock 2006).
- *Types of activities:* Hands on activity based learning best supports young Indigenous students engage with mathematics (Cooper, Baturo, Warren, & Grant, 2006).
- *Role of oral language:* A focus on the language of mathematics fosters important language acquisition and assists students acquire meta-cognitive abilities. This focus is even more relevant for students whose first language is not English (Pappas, Ginsburg, & Jiang, 2003).
- *Maths curriculum:* Young students are capable of dealing with a comprehensive mathematics curriculum.

- *Indigenous students' language:* Discourses of Indigenous families often do not match that of the school (Cairney, 2003). Teachers need to create a bridge for young Indigenous students between Aboriginal English (AE) and Standard Australian English (SAE) as these students grapple with new language, new concepts and vocabulary presented for literacy and numeracy.

YAILN is now in its second year. The students who participated in our first year were all from the preparatory classrooms, a non compulsory year of schooling prior to Year 1. Prep classes are conducted 5 days a week and children stay all day. Participants must be 5 by 30 June in the year they start Prep. At the completion of the first year of YAILN our results indicated that although Indigenous Australian students scored significantly lower on the numeracy pre test, intervention focussing on (a) the language of mathematics, and (b) representations that support mathematical thinking in both directed teaching and play based contexts assisted these students to bridge the gaps in their learning (Warren, Young, & deVries, in review). The particular focus of this paper is to investigate the impact that engagement with YAILN had on two Indigenous pre preparatory students aged 4 years 4 months and 4 years 5 months.

One of YAILN schools, a totally Indigenous school (School D), enrolled 2 students in their Prep class that had not reached the age of 5 by 30 June, hence the term pre preparatory students. The class consisted of up to 18 students, many of whom did not attend school on a regular basis. Of the 18 students we managed to consistently track 9 students over the school year, 5 that were the correct age for Prep, 2 Year 1aged students and the 2 pre prep students. The focus of this paper is the 2 pre prep students (Widgy and Caddy). The particular aims are:

1. To ascertain the effect, if any, participating in YAILN had on their understanding of mathematics, in particular their understanding of number, patterning and oral language; and
2. To gauge how these understandings compared to Indigenous students who had not engaged in any numeracy activities before commencing the preparatory year.

The literature suggests that students from low socio-economic backgrounds begin school with many disadvantages. It seems that children who bring to school early mathematical knowledge are advantaged in terms of their mathematical progress through primary school (e.g., Aubrey, Dahl, & Godfrey, 2006), a consequence of this being that students with little mathematical knowledge at the beginning of formal schooling remain low achievers throughout their primary years and probably beyond. Denton and West (2002) showed that low income students usually come to preschool with the same basic readiness to learn as the more advantaged students. The difference lies in how they engaged with advanced concepts and skills. Results from this study indicated 63% of students from high income families and 37% of students from low income families had a strong understanding of the number sequence and could read two digit numbers, identify the ordinal position of an object and solve simple word problems by the end of kindergarten. These differences were seen to reflect the mathematical knowledge each group brought to school. In this instance, by the end of their first year of schooling the gap still remained.

International studies suggest that allowing disadvantaged students and students with lower educated parents to attend school at an early age has a positive effect on their literacy and numeracy scores. Leuvan, Lindahl, Oosterbeek, and Webbink (2004) in a Dutch study involving data from over 16000 students reported that early learning makes subsequent learning easier. They found that increasing enrolment by one month increases the language and maths scores of students from a low socio-economic background or ethnic minorities by 0.06 standard deviation, while for those non-disadvantaged students early enrolment did not make a difference. Both Widgy and Caddy's families were from low socio-economic backgrounds.

Method

In its first year YAILN was a collaboration between researchers and 5 schools in North Queensland. The design of YAILN was a multi-tiered teaching experiment with the 7 preparatory teachers participating in professional dialogue/learning with the researchers on 4 occasions throughout the school year. On each occasion all the teachers were released from their classrooms to participate in a day of professional learning. Subsequent to these days the researchers visited all participating classrooms to continue professional dialogue and assist teachers to trial resources and activities. Discussions during these visits focussed on both mathematics and literacy learning in the early years. From a mathematical perspective the focus of the dialogue was three fold (a) the role of mathematics language in assisting young students engage in mathematical thinking, (b)

representations and activities that support mathematical learning in the early years with an emphasis on the language associated with these activities, and (c) how this learning underpins higher levels of mathematical understanding.

In the classroom all activities were situated within the early childhood philosophy of activity based learning with students being encouraged to engage with these activities in a play-based and focussed learning and teaching context. During discussions with their students, teachers promoted the explicit mathematical language embedded within learning activities. They also encouraged students to orally communicate about aspects of each activity and assisted Indigenous students distinguish between AE and SAE in their communications. Initially the focus was not explicitly on number but how various representations worked in a numberless world and the associated mathematical language. For example, each classroom was given a large 5 by 5 grid and the activities involved students playing games while using their whole body. These activities gave students opportunities to talk about 'What is beside you? What is behind you? What comes next? How do you move to that position on the grid? Which row is it in? Which column is it in?' Students were also encouraged to 'act out' positional worlds in their home and school environment, recording these actions digitally, and with their parents writing sentences about their actions. In the later part of the year students then 'mapped' this language onto contexts involving numbers, for example, "What number is beside 9? comes after 9? What number is next? What numbers are between 3 and 8? How do you move from 9 to 11?"

Data Gathering Techniques and Procedures

All schools were a two hour plane flight from the researchers' home town making the sites difficult to visit. Queensland is one of the largest states in Australia. Thus the data tended to be gathered in one week blocks, with the researchers visiting the sites five times during the year. Data gathering comprised four components, namely, pre and post tests, student portfolios, classroom observations, and teacher interviews. In total 120 preparatory students participated in YAILN. All pre and post tests were conducted in a one on one assessment interview. Due to the intensity of the data collection with each assessment interview taking up to one hour, 30 minutes of numeracy and 30 minutes for literacy, only 48 students participated in both the pre and post numeracy tests. This purposely selected sample consisted of all Indigenous students, and a selection of Australian students and students from other cultures representative of a range of abilities. The pre assessment interview (pre test) occurred two months after the school year had commenced. The pre and post tests and teacher interviews occurred in March and November. Insights into the first research question are provided by the results of the tests administered in the pre and post assessment interview.

In order to answer our second research question, at the beginning of the second year when Widgy and Caddy had officially enrolled in preparatory year, a short interview was conducted with Jo, Widgy, Sussi, and Fran. Sussi and Fran were young Indigenous girls who had not attended a pre preparatory year of school. Jo had attended pre preparatory at School D but enrolled midyear and hence did not complete the pre test for numeracy. Unfortunately Caddy was absent the week that the interview occurred. The aim of this interview was to gauge how Widgy's and Jo's understanding of mathematics compared with two students who had not attended a pre preparatory year of school. This interview focussed on their understanding of the number 5.

Pre and Post Tests Results

The pre and post assessment interview consisted of a number test, a patterning test and an oral language test. The number test (School Entry Number Assessment (SENA) consisted of an interview comprising three main sections; number recognition, counting, and early addition and subtraction. This instrument was developed by the researchers and was based on the Mathematics component of School Entry Assessment (SEA), a tool designed by the New Zealand Government. The Patterning test consisted of 11 questions. Students were asked to copy, continue and complete repeating and to identify the repeating part in each. This instrument was also developed by the researchers. BOEHM, the third test, is a commercially produced standardised oral language test. Figure 1 presents samples of typical question from SENA and the Patterning test.

Figure 1. Sample questions from SENA and the Patterning test.

The results of a pre and post test, an interview conducted with 48 students selected from 5 prep school settings (average age 4 years and 11 months) indicated that although the Indigenous Australian students (n = 14) scored significantly lower on the pre test, after one year of school there was no significant difference in their scores as compared with the whole cohort (Warren, Young and DeVries, in press). For both the Patterning test and Oral Language tests, while there was no significant difference for the pre test results and the post test results for Indigenous Australian students and non Indigenous students, both groups exhibited significant improvement in both areas by the completion of the first year of the project.

The Effect Participating in Pre Prep for Widgy and Caddy

The total possible scores for the three tests were: SENA (28), Patterning (11), and Oral language (50). Table 1 presents the pre and post means and standard deviations for the whole sample, 48 students. Fourteen students were Indigenous and 34 students were from non Indigenous backgrounds.

Table 1

Mean Scores and Standard Deviations for All Students (n =48)

Test	Pre test scores		Post test scores	
	Mean	**SD**	**Mean**	**SD**
SENA (28)	14.40	5.34	21.25	3.68
Patterning (11)	3.71	3.06	8.42	1.86
Boehm (50)	27.80	7.74	37.88	7.59

A Wilcoxon Signed Rank Test was performed to ascertain if there were any significant differences between the students' pre and post test scores for the three tests. The Wilcoxon Signed Rank Test revealed a significant difference between the students' pre and post test scores for SENA ($Z = 5.82$, $p < 0.001$), Patterning ($Z = 5.92$, $p < 0.001$), and Boehm ($Z = 5.91$, $p < 0.001$). School D, the school that both Widgy and Caddy attend, is one of the participating schools in YAILN. Pre and post test scores for the three tests were obtained for nine of students from the "preparatory" class at School D. Table 2 presents the mean scores and standard deviations for each test.

Table 2

Mean Scores and Standard Deviations for School D (n =9)

Test	Pre test scores		Post test scores	
	Mean	**SD**	**Mean**	**SD**
SENA (28)	8.67	5.75	19.89	4.37
Patterning (11)	1.67	2.65	7.78	2.05
Boehm (50)	22.0	4.85	32.78	9.32

The Wilcoxon Signed Rank Test revealed a significant difference between the students' pre and post test scores for SENA ($Z = 2.67$, $p < 0.001$), Patterning ($Z = 2.68$, $p < 0.001$), and Boehm ($Z = 2.55$, $p < 0.001$). Table 3 presents the mean scores and standard deviations for Widgy and Caddy for the three tests.

Table 3

Pre and Post Test scores for Widgy and Caddy

Test	Widgy		Caddy	
	Pre test	Post test	Pre test	Post test
SENA (28)	2	15	10	17
Patterning (11)	0	5	5	9
Boehm (50)	21	23	21	34

Widgy and Caddy's pre and post scores indicated a marked improvement in their understanding of number, patterning and oral language after their participation in a pre prep program.

Widgy and Caddy's scores as compared with their cohort and the whole sample indicated that this improvement was similar to the trends exhibited in their cohort and the whole sample. While Widgy and Caddy's post scores for SENA were below the average scores of their cohort and the whole sample, both post scores were within 1 standard deviation from the mean post scores. Widgy was also below the mean score for the cohort and the whole sample for patterning and Boehm, but she still exhibited significant improvement in both scores. Caddy's post patterning score was above the mean patterning score for his cohort and the mean score for the whole Group. His post Boehm score was above the mean score for his cohort and just below the mean score for the whole group. These results would suggest that attending pre preparatory year of schooling did make a significant impact on both of these students' understanding of number concepts, patterning and oral language.

It should also be noted that Widgy and Caddy's post test scores were also above the mean scores for the whole sample pre test scores. This suggests that they now have a very strong foundation on which to build their mathematical understanding as they formally participate in the prep year of schooling. The next section presents the data relating to the second research question, how do these understandings compare to Indigenous students who did not attend pre prep?

Comparing Students Who Attended Pre Prep With Students Who Did Not Attend

The interview consisted of five main components: One-to-one counting to 5: Conversation of 5, Subitising to 5, Counting on to and counting back from 5, and Creating stories about 5 (e.g., 2 and 3 make 5). The preparatory guidelines for Queensland schools (QSA, 2006) indicate that by the end of Prep students should know all about 5, hence the choice of the number five. The interviews were extremely short of approximately 3 minutes' duration. The interview was conducted with four students; Jo and Widgy (both had attended pre prep) and Sussi and Fran (both had not attended pre prep). All four students are presently are in the prep year at School D. All interviews were video-taped. Table 4 presents a summary of the results for the four students. Due to space restrictions these results are presented as dot points.

Table 4

Results Comparing Pre Prep Indigenous Students with Indigenous Students Who Have Not Attended Pre Prep

Students	Understanding of 5
Attended Pre Preparatory year of schooling	
Jo	Recognises all numbers to 5 without counting
	When 2, 3, 4 balls are hidden, recognises how many are left and how many have been taken away without counting
	Can create all the stories about 5 (e.g., 0 and 5, 1 and 4, 2 and 3).
Widgy	Conserve all numbers to 5
	Correctly count different arrangements of numbers to 5
	Subitise to 5
	Can create some of the stories about 5
Did not attend a Pre Preparatory year of schooling	
Sussi	Cannot correctly count different arrangement of numbers to 5
	Can subitise 1 and 2
	Can create 2 and 3 makes 5
Fran	Cannot consistently count to 5.

There was a clear distinction between the understandings that the two groups held about the number 5. Jo was successful on all aspects of the interview. She could answer all questions about 5 and throughout the interview did not use counting to assist her in her responses. Widgy initially had to count the number of objects that the interviewer presented but as the interview progressed switched into discussions about 5 which did not require her to count the objects. Sussi could not consistently count to 5. She had the numbers to 3 under control but experienced difficulties once the interview went beyond 3. Fran could not consistently count to 5. Both Jo and Widgy clearly understood the questions asked in the interview, especially the language of mathematics associated with the questions being asked. The interview was conducted by the students' preparatory teacher, who was also Widgy and Jo's pre prep teacher.

Discussion and Conclusions

Given that this paper shares the results of two Indigenous students who attended a pre preparatory year it is difficult to draw conclusions for the whole Indigenous community. For these two students the results clearly demonstrate that their attendance at school prior to the preparatory year assisted them in obtaining a better understanding of important mathematical concepts. The results also suggest that the understandings that they held at the beginning of their preparatory years is equivalent to the understandings that many students from non Indigenous students hold as they begin school.

The results begin to confirm the theoretical underpinnings of the YAILN project. The role of oral language in developing mathematical understanding especially for students whose first language is not Australian Standard English cannot be underestimated. As indicated by the results of the interview conducted at the beginning of the second year of the project, the students who had participated in pre prep not only possessed a better understanding of numbers to 5 but also the associated mathematical language used to access this understanding. Pappas, Ginsburg, and Jiang (2003) believe a focus on the language of mathematics fosters important language acquisition and assists students acquire meta-cognitive abilities. This research begins to confirm this finding.

For these Indigenous students it appeared that direct teaching together with play based opportunities were also important in learning mathematics at an early age. The results of the SENA component of the pre test for the number and the interview results for the two Indigenous students who had not attended pre prep,

indicated that Indigenous students begin school with little knowledge about number. Most did not know the names of the numbers nor could they meaningfully count to 5. We are suggesting that this is not the type of knowledge that emerges solely from play based situations. Adult guidance is needed (Greenes, 1999) and this is especially important for Indigenous students (Tayler et al., 2006).

Both Indigenous students reported in this paper are from a low socio-economic background. Allowing these students to attend school early certainly had a positive effect on their numeracy scores (Leuvan et al., 2004). Their pre test results suggest that they brought to school a paucity of mathematical knowledge, especially knowledge related to understanding white mathematics. Aubrey et al. (2006) claim that, students with little mathematical knowledge at the beginning of formal schooling remain low achievers throughout their primary experience. The results of this research suggest that attendance in a pre prep year of school may be an effective way to address this gap. Widgy and Caddy are now on an equal footing with other students as they begin their prep year. Both students remain part of our longitudinal study. Denton and West (2002) hypothesise that early learning makes subsequent learning easier, is yet to be tested. Our initial conversations with their prep teacher and the distinctions between these students' understanding of 5 as compared to students who had not attended a pre prep year suggests that this is indeed the case.

The question remains, what mix of pre prep students to prep students is most beneficial for learning? In alignment with our theoretical underpinnings we are suggesting that the ratio of pre prep to prep students should be low. Children can only discover so much through play. As the prep students' learning occurs they are in a position to assist pre prep students to higher levels of understanding, assisting pre prep students reach their learning potential (Balfanz, Ginsburg, & Greenes, 2003). We propose that learning from older peers with explicit teacher-directed learning are most effective for pre prep Indigenous students in developing early numeracy understandings.

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