AUSTRALIAN INDIGENOUS STUDENTS' KNOWLEDGE OF TWO-DIGIT NUMERATION: ADDING ONE TEN

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With consistently low levels of academic performance and high rates of absenteeism (Bourke & Rigby, 2000), the students in this study are the most educationally disadvantaged group in Australia with respect to mathematics. This paper reports on a study undertaken with Years 5-7 students in a Queensland aboriginal community to determine their baseline knowledge of whole numbers. The results of a numeration test were analysed to identify major misconceptions, and selected students were interviewed to establish whether misconceptions were language-, context-, or mathematics-based, and then to "peel back" to culture- specific language and activities if language and concept proved to be the main sources of misconceptions. The interviews revealed that misconceptions were generally related to language and mathematics schema.

Research context. The students in this study live in a dispossessed multi-language indigenous community that was created through Government policy that had a penal objective. The history of this community has been one of exploitation, dependency and suppression of culture. Yet, although maintaining contacts with their language homelands, members strongly view their current community as their home. As a consequence, a culture has evolved that combines aspects of their original language group cultures and Western culture, a community language (called Aboriginal English) that is based on, but different from, standard English. The local political system is built on shifting divisions and language-group loyalties which impede developing consensus with respect to local pragmatic activities that may benefit the inhabitants' life chances, and this includes a community approach to education that would improve attendance and learning. The community has very low adult employment necessitating a reliance on welfare, leading to most of the problems described by Fitzgerald (2002), namely, alcohol and substance abuse, family violence, low health, transient population, discrimination and exclusion.

The community is an 8-9 hour drive from the University so that research visits (one week, four times a year) were set up in advance and consequently the actual research activities were highly contingent on the realities of the research context. For example, community, parent and student permission to undertake the research was obtained by the school's Community Liaison Officer in advance of the research activity but the students were often not available during the research visits.

This reported research project was undertaken at the local primary school. The teachers were generally in their first or second year of teaching and the school has a history of high turnover of staff. Within the year of this research project, there were five principals, four of whom were in Acting positions. Each teacher has an indigenous aide but, generally, the aides appear to be there for behaviour management rather than pedagogical purposes.

Mathematics context. Place value is one of the basic mathematics concepts with which indigenous students in this community have difficulty, with many students attending the secondary school unable to understand two- and three-digit numbers. In this they are not alone; research (Baturo, 1997, 2000, 2002; Jones et al., 1994) has produced a plethora of evidence that students have great difficulties in acquiring an understanding of place value. Baturo's numeration model (1997; 2000) gives some indication of the complexity of place value in that she indicates that there are three hierarchical levels which take account of Halford's (1995) complexity model. In particular, several researchers have pointed to the difficulty students have with: (a) *grouping/unitising* which involves quantifying sets of objects by grouping by 10 (in a base-10 system), treating the groups as units (Steffe, 1988), and using the structure of the notation to capture the information about the groupings (Hiebert & Wearne, 1992; Ross, 1990); and (b) *counting* principles (Baturo, 2002) such as *odometer* which require an understanding that a place is "full" when it has 9 units (which could be ones, tens, tenths, etc), that recording the next number requires a new position to the left of the place under consideration, and that numbers increase in value as they "move" to the left (and, conversely, decrease in value as they "move" to the right).

Modern teaching of mathematics to indigenous students is focusing on integrating mathematics into indigenous culture and experience so that the power of meaningful contexts can be harnessed in learning (Roberts, 1999). This recognition and valuing of the distinct cultural differences between indigenous and non-indigenous Australian cultures is a recent policy (Department of Education, Training and Youth Affairs, 2000); in the past, the dominant assumption in relation to the indigenous cultures of Australia was that both the peoples and their cultures would become assimilated into main stream Anglo Saxon culture (MacGregor, 1999). This concern for recognising and valuing indigenous culture reflects the emerging *ethnomathematics* position that "the accumulated experiences of the individual and one's ancestors are responsible for enlarging natural reality through the incorporation of mindfacts [ideas, particularly mathematics facts]" (D'Ambrosio, 1997, p. 16). It is particularly supported by Day (1996), who concluded that successful educational performance was closely linked to a healthy sense of indigenous identity.

In this study, primary indigenous students' understanding of place value for three-digit numbers was tested and difficulties associated with adding one and adding ten were probed with interviews. The interviews focused on whether mathematical tasks not understood in Standard English could be understood and completed if placed in an everyday out-of-school context familiar to the indigenous students.

METHOD

The methodology was predominantly qualitative using semistructured individual interviews.

Subjects. Eighteen Years 5-7 students who had undertaken the Diagnostic Mathematical Tasks (DMT) test (Australian Council of educational Research, 1994) participated in the semistructured individual interviews. The test was selected and administered by the school's Learning Support Teacher. The DMT comprise seven sets designed to be

administered from pre-school to Year 6 in Victoria and Years 1-7 in Queensland. However, at the project school, students were administered the test that was two years lower than their current year level. That is Year 5 students were administered DMT Level 3, Year 6 students DMT Level 4, and Year 7 students Level 5. However, poor performance by the Years 6 and 7 necessitated administering yet a lower level.

Instruments. There were two main instruments: (1) the DMT test results; and (2) a research-developed interview schedule comprising "first-level" tasks which focused on basic three-digit numeration (i.e., reading numbers when presented in pictorial and symbolic forms, place value to hundreds, and adding 1 and 10 to a given number). The schedule also included "peel-back" activities should the students be unable to answer the first-level tasks.

The task under discussion in this paper is shown in Figure 1. For the purposes of this paper it is categorised as *place value counting*.

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Write the number that is 1 more. __________
Write the number that is 10 more. __________
Contingent on performance with adding:
Write the number that is 1 less.
____
Write the number that is 10 less. ___________

Figure 1. Place value adding interview task.

For all first-level tasks, the first peel-back was to write a dollar sign in front of the number to determine whether this would trigger a real-world context for the symbolic representation. If the dollar sign did not elicit a response, then play money was used to represent $276. The second peel-back was to reduce the 3-digit number to 2 digits (i.e., 276 to 76). If this failed, the number 76 was proved in a money context as described for 276 and real money was used. To check the robustness of the student's response at this level of peeling back, an isomorphic number (e.g., 37) was embedded in either a card game or a sporting game context, depending on the student's out-of-school interests. (An earlier interview had elicited that many of the students had a passion for card games, football or netball.) For example, four playing cards comprising 3 tens and 1 seven was shown to the student who was asked to say what the score for this hand was and then say what it would be when another card with 10 was placed with the original 4 cards. If the student was more interested in sport, then the following scenario was given: *Your team scored 37 points in a football/netball match; the other team scored 10 more points. What was their score*?

Procedure. The test was administered and marked by the school's Learning Support Teacher in conjunction with the class teachers. We entered and analysed the results and provided these to the school along with a list of students (comprising a mixture of high, medium, and low-performing students) that we wanted to interview on an individual basis. However, the high absenteeism of the students resulted in our interviewing any available student from Years 5-7.

Analysis. The students' test results were recorded and then individual items were combined according to the numeration concepts of number identification, place value, counting, grouping and regrouping, comparing, ordering, and estimating. However, for the purposes of this paper only those related to adding 10 or 100 (for Year 7) are reported (see Figure 1 for the items and Table 1 for the results). The particular items on which the results were obtained are provided in

RESULTS

DMT results

Figure 2 tabulates the DMT items which led to the interview tasks whilst Table 1 provides the class means per item.

Place value adding

DMT3, Item 319. *Write the number 1 more than 299.* (Administered to Years 5 and 6.)

DMT3, Item 320. *Write the number 10 more than 163.* (Administered to Years 5 and 6.)

DMT5, Item 5024. *Add 100 to 20305.* (Administered to Year 7.)

Place value counting

Finish these counting patterns:

DMT3, Item 328. ___, ___, 73, 83, 93, ___.
(Administered to Years 5 and 6.)

DMT4, Item 4027. ___, ___, 1135, 1235, 1335, ___. (Administered to Year 7.)

DMT5, Item 5039. ___, 7974, 7984, 7994, ___, ___. (Administered to Year 7.)

Figure 2. DMT items on which the interview task was based.

	DMT means	
Year	Adding 1/10/100*	Counting sequence
Year 5 (*n* = 13)		
_ +1	Item 319: 07.7%	Nil example
_ +10	Item 320: 23.1%	Item 328: 00.0%
Year 6 (*n* = 8)		
_ +1	Item 319: 75.0%	Nil example
_ +10	Item 320: 50.0%	Item 328: 37.5%
Year 7 (*n* = 20)	Item 5024: 45.0%	Item 5039: 10.0%
		Item 4027: 50.0%

*Adding 100 was applicable to Year 7 only. For Year 7, there were DMT5 items related to adding 1 or 10.

Table 1 Indigenous Years 5-7 Students' DMT Means in Relation to Place Value Counting

Place value adding. Year 4 performed better on adding 10 than adding 1, a behaviour attributed to the artifact of the number provided (299) as the students needed to invoke the odometer principle twice. It is interesting to note, however, the improved performance on this item that was exhibited by Year 6. Furthermore, the Year 6 students performed much better on adding 1 than on adding 10, suggesting that the counting procedures may be more developed than place value.

Place value counting. The results show that the students performed better on the place value adding item than on the place value counting activity within each test level. This behaviour could be the result of having first to identify the adding 10 difference in the counting activity, having to count both forwards and backwards, and/or having to invoke the odometer principle. With respect to Year 7, the higher performance on the Level 4 counting (Item 4027) may have been the result of not having to invoke the odometer principle.

Interview results

Overall, 18 students were interviewed _ 5 from Year 5, 6 from Year 6, and 7 from Year 7. Their results are provided in Table 3. With respect to adding 1 to 276 (see Figure 1 for the interview task reported on in this paper), all the Year 7 students were able to do this successfully. Of the 6 Year 6 students, 4 were successful and the remaining two students were able to do it when the number was reduced to two digits, that is, 76. Of the 5 Year 5 students, two students only could add 1 to 276 but the remaining three students could add 1 to 56. Table 2 provides the results for the interview tasks and the various peel-back tasks.

	Interview task		
Task	Year 5 (n = 5)	Year 6 (n = 6)	Year 7 (n = 7)
Add 1 to 276	2	3	5
_ with $	0	0	0
_ with play money	1	0	0
_ 2-digit number	2	3	2
_ 2-digit with $	N/A	N/A	N/A
_ 2-digit number/play money	N/A	N/A	N/A
_ 2-digit number with cards	N/A	N/A	N/A
_ 2-digit number sport score	N/A	N/A	N/A
Add 10 to 276	0	2	2
_ with $	0	0	0
_ with play money	0	2	0
_ 2-digit number	2	1	2
_ 2-digit with $	0	1	0
_ 2-digit number/play money	2	N/A	2
_ 2-digit number with cards	1	N/A	1
_ 2-digit number sport score	N/A	N/A	N/A

*Adding 100 was applicable to Year 7 only. For Year 7, there were DMT5 items related to adding 1 or 10.

Table 2. Indigenous Years 5-7 Students' Interview Results in Relation to Place Value Counting

Because of the poor performance with respect to adding 1 and 10, the contingent tasks related to subtraction 1 and 10 (see Figure 1) were not included in the interview. The following protocols encapsulate the students' responses to the place value adding tasks.

Robert (Year 5)

Interviewer: What would 1 more than this number (pointing to 276) be?

Robert: 376.

Interviewer: What would be 10 more (pointing to 276)?

Robert: Ten more? Two thousand and seventy-six.

Peeling back to money and a 2-digit number didn't help Robert who was yawning throughout the interview and didn't appear interested in participating.

Interviewer: Do you play card games?

Robert: Yes. I earn a lot of money in card games. Do you play black and red?

Interviewer: Yes. You good at that?

Robert: Yep. Seven Down?

Interviewer: What's Seven Down?

Robert: You have to go, like, seven downwards. You know Two Card?

Interviewer: No. How do you play Two Card? [Robert explained the game.]. I'm going to do Coo'nCan _ If your score was already 45 points and you scored 10 more points in the next game, how many points would you have?

Robert: 60.

Interviewer: You've got 10, 20, 30 40 and 5 (showing with real cards) and I give you another 10 (showing card), what have you got?

Robert: 55.

Interviewer: How did you know that?

Robert: Because I added it up.

Interviewer: But when I said here "10 more than 45", you were having difficulty there. Is it easier with the cards?

Robert: Mmm.

Janice (Year 7) was considered a high performer within her class.

Interviewer: What's one more than 276?

Janice: 277.

Interviewer: Ten more?

Janice: 300?

Interviewer: What if I cross out the two, what number is there now? [76] What's one more than that? [77] What's ten more?

Janice: 80.

Interviewer: Let's put out $76 with this play money. What if I gave you one more $10 – how much would you have then?

Janice: 86

Interviewer If your team scored 35 points at netball (Janice liked netball) and the other team beat you by 10 points, what would they score?

Janice: 40…what they have?

Interviewer: They beat you by 10. You scored 35.

Janice: 45.

Interviewer: Well done.

DISCUSSION AND CONCLUSIONS

The results of all of these elementary place value/seriation tasks are of concern considering their importance in the development of the number system. Without adequate foundational knowledge, students cannot develop the facility for numbers (i.e., number sense) that is the focus of current mathematics syllabi (e.g., NCTM, 2000).

The seriation items evoked low performances suggesting that adding 1 or 10 to a 2- or 3-digit number may have been a nonprototypic task for these students. Baturo (2002) undertook a similar study with middle-high socioeconomic Western students being required to add 1 tenth or 1 hundredth to decimal numbers. That study produced similarly poor results suggesting that there is an inherent mathematical difficulty embedded in place value adding tasks.

There was some evidence that "peel-back" activities, namely using contexts such as money, cards, sports or reducing the number of places that need to be considered (e.g., 3- to 2-digit numbers). The results of both of these studies indicate the fragile nature of students' understanding of place value and seriation. Students cannot seriate without good place value knowledge. Whilst the contextual peel-back activities appeared to be effective, it is suspected that they were "of the moment". Therefore, the challenge for teachers is to find ways of abstracting the mathematics embedded in these activities.

With respect to teaching numeration processes, Ross (1990) claimed that children learn to represent numbers with concrete manipulatives (as practised in Queensland schools) through following the teacher's directions rather than from thinking about what they have constructed. The results of this study suggest that teachers need to be more creative in the types and levels of examples they provide to ensure that students have the robustness and flexibility of knowledge that is required for number sense.

Teaching indigenous students is fraught with difficulties associated with language, socialisation and cultural problems which are exacerbated by poor attendance. Teaching "good mathematics" in these circumstances would challenge experienced teachers but the teachers in this community have, historically, been very young teachers in their first or second ears of teaching. They should be applauded for the mathematics concepts they have been able to establish in such a difficult situation.

References

Baturo, A. R. (1997). The implication of multiplicative structure for students' understanding of decimal-number numeration. In F. Biddulph & K. Carr (Eds.), *People in mathematics education* (Proceedings of the 20th annual conference of the Mathematics Education Research Group of Australasia, pp., 88-95). Rotorua, NZ: MERGA.

Baturo, A. (2000). Construction of a numeration model: A theoretical analysis. In J. Bana & A. Chapman (Eds.), *Mathematics education beyond 2000* (Proceedings of the 23rd annual conference of the Mathematics Education Research Group of Australasia (pp. 95-103). Fremantle, WA: MERGA.

Baturo, A. R. (2002). Number sense, place value and "odometer" principle in decimal numeration: Adding 1 tenth and 1 hundredth. In A. Cockburn & E. Nardi (Eds.), *Proceedings*

of the 26th conference of the International Group for the Psychology of Mathematics Education, 65-72. Norwich, UK: PME.

Bourke, P. C. J., & Rigby, K. (2000). *Better practice in school attendance: Improving the school attendance of indigenous students*. Canberra, ACT: DETYA.

D'Ambrosio, U. (1997). Where does ethnomathematics stand nowdays? *For the Learning of Mathematics, 17*(2), 13-177.

Day, A. (1996). *Fusing the talents of indigenous Australians*. Darwin, NT: Department of Education.

Department of Education Training and Youth Affairs. (2000). *National Indigenous English and Numeracy Strategy (NIELANS)*. Canberra: ACT: DETYA.

Fitzgerald, A. (2002). *Cape York Justice Study Report*. Brisbane, QLD: Queensland Govt Dept of the Premier and Cabinet.

Hiebert, J., & Wearne, D. (1992). Links between teaching and learning place value with understanding in first grade. *Journal for Research in Mathematics Education, 23*(2), 98-122.

Jones, G. A., Thornton, C. A., Putt, I. J, Hill, K. M., Mogill, A. T., Rich, B. S., & Van Zoest, L. R. (1994). Multidigit number sense: A framework for instruction and assessment. *Journal for Research in Mathematics Education, 27*(3), 310-336.

MacGregor, M. A. (1993). Teaching mathematics in English to students of non-English speaking background. *Multicultural Teaching, 11*(3), 31-34.

National Council of Teacher of Teachers of Mathematics (2000). *Principles and Standards*. Reston, VA: NCTM.

Roberts, T. (1999). Mathematics registers in Aboriginal languages. *For the Learning of Mathematics, 18*(1), 10-16

Ross, S. H. (1990). Children's acquisition of place-value numeration concepts: The roles of cognitive development and instruction. *Focus on Learning Problems in Mathematics, 12*(1), 1-17.

Steffe, L. (1986). *Composite units and their constitutive operations*. Paper presented at the Research Presession to the Annual Meeting of the National Council of Teachers of Mathematics, Washington, DC.