Children's Number Knowledge in the Early Years of Schooling

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

This paper explores the number knowledge of 1015 children who began school in 2006 and of a further 3000 children in Grades 1-3. The data show that number knowledge varies considerably when children begin school, and that this variation extends as schooling proceeds. Teachers need to be aware of each child's current knowledge and ways to customise learning experiences if they are to meet each child's learning needs.

Introduction

Every child arrives at school on the first day with lots of number knowledge. Each child constructed this knowledge throughout their first 5 years of life as they interacted with their families, friends and environment. Because children's experiences and interests vary so much, then the number knowledge of children within a class is likely to vary, even when they first begin school. To examine this premise, this paper explores the number knowledge of children throughout the first 3 years of schooling.

Assessing Children's Number Knowledge

The data presented in this paper was collected in 2006 from over 4000 children attending 52 primary schools in the Ballarat Diocese of western Victoria, enabling a rich picture of children's number knowledge in this region to be formed. The practice in these schools is for teachers to assess each student in the first week of school using the *Early Years Interview* (Department of Education Employment and Training, 2001) for the purpose of gaining insight about each child's current mathematical knowledge.

Such assessment interviews are now widely used by teachers in Australia and New Zealand, due to the experience of three large-scale projects that informed policy formation (e.g., Gould, 2000; Clarke et al., 2002; Higgins, Parsons, & Hyland, 2003). A common feature of these projects was the use of a one-to-one interview and a research-based framework to describe progressions in mathematics learning (Bobis et al., 2005).

The development of the *Early Years Interview* and the associated framework of growth points are reported in detail elsewhere (e.g., Clarke, 2001; and Clarke, Sullivan, & McDonough, 2002), but it is important to note that the growth points describe major learning along a hypothesised learning trajectory (e.g., Cobb & McClain, 1999) and formed the basis for the development of assessment items. In the Ballarat Diocese, children's responses were analysed by the teacher to determine the growth points children reached in Counting, Place Value, Addition and Subtraction, and Multiplication and Division. To increase the validity and reliability of the data, teachers followed a detailed interview script, recorded answers and strategies on a detailed record sheet, and used clearly defined rules for assigning growth points. Children's growth points were entered into an excel spreadsheet and each school's data was aggregated to form the data set reported on here. The region's Numeracy Advisors and School Co-ordinators managed this process.

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Children's Number Knowledge

The Place Value growth points associated with the *Early Numeracy Interview* describe children's knowledge of reading, writing, ordering, and interpreting numbers for one-digit to four-digit numbers and beyond. The assessment tasks provide insight about concepts of quantity, number partitioning, use of a mental number line, and application of place value conventions for reading and writing numerals. Figure 1 describes the highest Place Value growth points reached by Prep to Grade 3 children in the Ballarat Diocese in 2006.

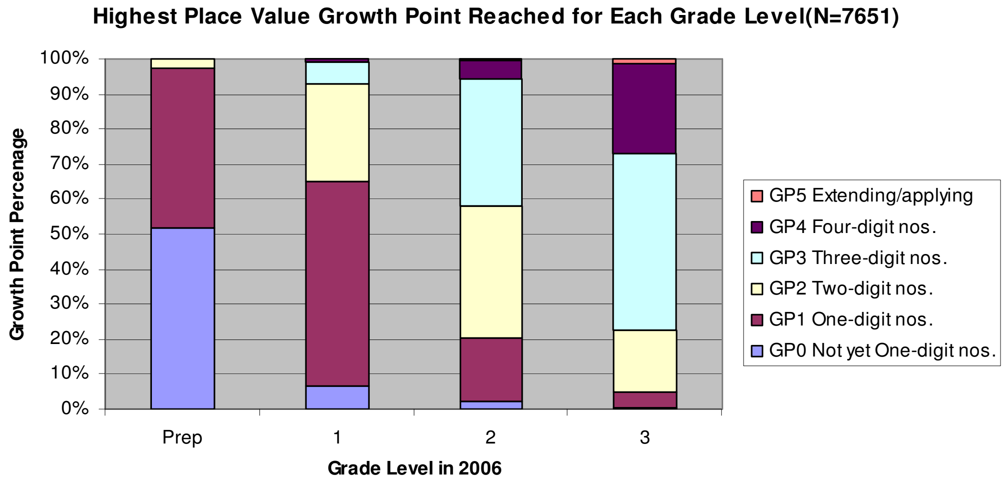

Figure 1. Percentage of Prep to Grade 3 children in 2006 reaching each of the place value growth points.

The data indicate that children's knowledge develops significantly during the first 3 years of school. Further, the complexity of the teaching process is highlighted by the spread of growth points within each grade. This spread of knowledge within one grade level has been noted in many previous students (e.g., Bobis et al., 2005).

Examination of the Prep data suggests that the children beginning school formed two distinct groups: those who knew how to read, write, and order all 1-digit numbers and who therefore required opportunities to explore 2-digit numbers, and those who did not. It is important to note that some children beginning school could already read, write, order, and interpret 2-digit numbers and thus required opportunities to explore at least 3-digit numbers. Similar to the findings of Wright (1992) this challenges a curriculum that typically focuses on numbers ranging from 1-20 when children begin school.

The data also suggest that for many children beginning Grade 1, a key issue was learning to interpret 2-digit and 3-digit numbers, although some needed opportunities to extend their number knowledge to at least 4-digit numbers. The issue for most children beginning Grade 2 was exploring 3-digit and 4-digit numbers. However, 20 percent of children beginning Grade 2 were not yet able to interpret 2-digit numbers, and it can be argued that these children would benefit from assistance to accelerate their learning. By the beginning of Grade 3, children's knowledge was spread from GP1-GP5. The extent of this range is highlighted by the fact that one-quarter of students were able to interpret 4-digit numbers, whereas another quarter were still learning to interpret 2-digit and 3-digit numbers.

The growth points reached by children in the Place Value domain provide an indication for teachers of the range of numbers that children may be expected to use for calculations and problem solving. The relevance of this becomes apparent when children are introduced to conventional written algorithms for calculations involving 2- and 3-digit numbers. Given that one quarter of Grade 3 children in this study were still learning to interpret 2- and 3-digit numbers, these children may be unlikely to understand the place value concepts underpinning formal algorithms, and this situation may impede their development of powerful mental reasoning strategies for calculating (Narode, Board, & Davenport, 1993). Indeed, data compiled for the Addition and Subtraction and Multiplication and Division Domains, but not shown here due to space constraints, show that 39% of Grade 3 children still used counting-based strategies for addition and subtraction calculations, and 47% needed to use models to solve multiplication and division problems. These children are unlikely to understand the abstract ideas associated with conventional algorithms and may focus only on the procedural knowledge associated with conventional algorithms.

Number Knowledge of Children Beginning School

When children first begin school, the data presented in Figure 1 show that that their ability to read, write, order, and interpret numbers varies considerably. It is useful to know if this finding extends to the other number domains also. For this purpose, Table 1 shows the percentage of Prep children who reached each Growth Point in the domains of Counting, Addition and Subtraction Strategies, and Multiplication and Division Strategies.

Table 1
Percentage of Prep Children in February 2006 Who Reached Each of the Counting, Addition and Subtraction and Multiplication and Division Growth Points

Counting Growth Points	Percent n=1015	Addition & Subtraction Strategies Growth Points	Percent n=925	Multiplication & Division Strategies Growth Points	Percent n=923
0. Knows some number names & sequences	46	0. Not Yet	59	0. Not Yet	67
1. Rote Counting (to at least 20)	19	1. Count all	34	1. Count all	28
2. Collections (at least 20 items)	32	2. Count on	6	2. Modelling when groups are perceived	5
3. Forward/backward (to at least 110)	2	3. Count down to	1	3. Modelling when groups not perceived	0
4. Skip counting (by 2s, 5s, 10s)	1	4. Basic strategies	0	4. Multiplication strategies	0
5. Skip counting from x (by 2s, 5s, 10s)	0	5. Derived Strategies	0	5. Division Strategies	0

The major issue to emerge from these data is the spread of growth points in every domain, right from the time children begin school, a finding noted in previous studies (e.g., Bobis et al., 2005). In Counting, just over half of the group knew the number word sequence to 20, and many of these children could count a collection of 20 items. The remaining children were still becoming familiar with number names and sequences to 20. However, some children counted beyond 110, and others skip counted by 10s, 5s, and 2s.

In Addition and Substraction, 7% of the children used the *count-on* strategy when asked to find the total of two collections (with nine items screened and another four items unscreened). In contrast, 34% used the *count-all* strategy, whereas the remaining children, on this occasion, were not able to solve the problem.

In the Multiplication and Division Domain, the data show that one-third of children beginning school solved the initial task that involved finding the total of 4 groups of two items. The others were not successful, and it is likely that the greatest factor in the task's difficulty was being able to interpret the demands of the task. In contrast, 5% of children on GP2 required learning opportunities focusing on developing mental images associated with groups and arrays in order to prompt the use of abstract multiplicative strategies.

In summary, the range of number knowledge in all domains for children beginning school is striking and highlights the importance of teachers identifying children's current knowledge and customising learning experiences to meet the individual learning needs.

Discussion and Conclusion

The data presented in this paper confirm the finding of previous studies that highlight the extent and diversity of children's number knowledge when they begin school and throughout the first three years of schooling. Teachers need to respond to this situation with ongoing monitoring and assessment to identify children's current number knowledge and customise learning experiences that cater for the range of learning needs.

Clearly, some children lag behind or stride ahead of their peers. These children may not always receive the opportunities needed to extend their knowledge further. For example, the Victorian Prep curriculum focuses on numbers ranging from 1-20, but many students have this knowledge when they first arrive at school. This highlights the fact that curriculum guidelines do not always match the learning needs of children and need to be refined by teachers if all children are to have the opportunity to thrive mathematically.

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