Chapter 4
Children's Mathematical Knowledge Prior to Starting School and Implications for Transition

Ann Gervasoni and Bob Perry

Abstract Research over the past 10 years has established that many children starting school are more mathematically capable than teachers, mathematics curricula and text book writers assume. This issue and implications arising for children's transition to school are explored in this chapter through examining data for 125 children who participated in the Australian *Let's Count Longitudinal Evaluation Study* in 2012, 1438 children who participated in the Australian *Early Numeracy Research Project* (ENRP) in 2001, and the new *Australian Curriculum—Mathematics*. The children's mathematics knowledge was assessed using the *Mathematics Assessment Interview.* The findings suggest that large numbers of children in both the *Let's Count* preschool group and the ENRP Beginning School group met the new *Australian Curriculum—Mathematics Foundation Standard* prior to beginning school. This suggests that many children may be inadequately challenged by the mathematics tasks and instruction they experience in their first year of school.

4.1 Introduction

Children making the transition to school have a diverse range of backgrounds and experiences. As a result, teachers expect that children will differ with respect to their confidence, knowledge, skills, and disposition to learning mathematics. It is commonly assumed also that children living in economically and socially disadvantaged communities are over-represented in the group of children with the least formal mathematics knowledge when they begin school, and that it is important that prior-to-school experiences help to overcome this disadvantage. An ongoing challenge for education authorities is providing suitable guidelines for mathematics instruction and curricula that, on the one hand, respond well to children's differences to

A. Gervasoni (✉)
Monash University, Melbourne, Australia
e-mail: ann.gervasoni@monash.edu

B. Perry
Charles Sturt University, Albury-Wodonga, Australia
e-mail: bperry@csu.edu.au

B. Perry et al. (eds.), *Mathematics and Transition to School,* Early Mathematics Learning and Development, DOI 10.1007/978-981-287-215-9_4

ensure that all will thrive mathematically, whilst on the other hand, reflect and build upon the mathematics that children typically know when transitioning to school. Research over the past 10 years has established that many children starting school are more mathematically capable than teachers, mathematics curricula and text book writers assume. This finding suggests that many children may be inadequately challenged by the mathematics tasks and instruction they experience in their first year of school, and that this may have a negative impact on their mindsets and opportunity to thrive mathematically. This chapter provides insight about this issue by examining data about children's mathematical knowledge around the time that they transition school. The data are drawn from two Australian studies. The first is the *Let's Count Longitudinal Evaluation Study* that assessed children just prior to their beginning school (Gervasoni and Perry 2013). The second is the *Early Numeracy Research Project* (ENRP) (Clarke et al. 2002) that assessed children's mathematics just after they began school.

The 125 children participating in the *Let's Count* study in 2012 were from economically disadvantaged communities and were assessed in December 2012 in order to provide baseline data about the range of children's mathematical knowledge in these communities prior to an intervention planned for 2013–2014, and prior to their beginning school in 2013. The 1438 children participating in the *Early Numeracy Research Project* in 2001 were assessed in March 2001 just after they started school and were from 34 Victorian schools that were selected to provide a representative sample of the Victorian population. We decided to compare the mathematical knowledge of the *Let's Count* group with that of the more representative ENRP cohort to gain insight about any apparent differences in the mathematical knowledge of the two groups, as measured by the Mathematics Assessment interview. The mathematics knowledge of both groups was also compared to that assumed by the new *Australian Curriculum—Mathematics* (Australian Curriculum, Assessment and Reporting Authority, ACARA 2013) in order to determine how adequately the new mathematics curriculum responds to children's mathematics knowledge when they begin school, and whether any issues for children living in 'disadvantaged' communities were apparent.

In order to appreciate the context and data examined in this chapter, some details about early childhood education in Australia are provided. Australian children most commonly begin primary school in February each year when they are between 4 years and 6 months and 5 years and 9 months of age, although some differences exist between the States and Territories. The first year of primary school is referred to in the *Australian Curriculum* as the Foundation Year. Primary school teachers teach all curriculum areas and have completed a 4-year degree in Primary Education that includes several units focused on mathematics education. In the year prior to beginning school, most Australian children attend preschool for at least 15 h per week. Their preschool teachers mostly have completed a 3- of 4-year degree in early childhood education. Within the past 5 years, new national curricula documents for both preschools and primary schools have been introduced. These documents will be discussed later in this Chapter.

4.2 Expectations of Mathematics Performance and 'Disadvantaged' Communities

In communities nominated by governments as 'disadvantaged', there can be expectations that, on average, children will not perform as well academically as same age children from more 'advantaged' communities (Caro 2009). For children in the early years of school, similar results concerning the relationship between a child's mathematical performance and their family or community's socio-economic status have been reported (Carmichael et al. 2013; Rimm-Kaufman et al. 2003). As a result of their work, Carmichael et al. (2013, p. 16) felt confident to make the statement "the socio-economic status of the community in which the family resides was the strongest home microsystem predictor of numeracy performance, explaining 10.5 % of the variance in the home-community microsystem model".

However, there is also evidence from Australian and international research that many young children begin school as capable mathematicians who already exceed many of the first year mathematical expectations of mandated curricula or textbooks (Bobis 2002; Clarke et al. 2006; Ginsburg and Seo 2000, Gould 2012; Hunting et al. 2012). For example, Gould (2012, p. 109) concludes from his study of the results of the mandated *Best Start* assessment in New South Wales (NSW Department of Education and Communities 2013) that the expectation in the *Australian Curriculum—Mathematics* that students can make connections between the number names, numerals and quantities up to 10 by the end of the first year at school "would be a low expectation for at least half of the students in NSW public schools". Even in 'disadvantaged' communities (Ginsburg and Seo 2000) and rural and regional communities (Hunting et al. 2012), many children demonstrate that they are powerful mathematicians before they start school. The examination of children's knowledge presented in this Chapter will consider whether this is also true for children in the *Let's Count* and ENRP groups.

4.3 The Early Years Learning Framework and the Australian Curriculum—Mathematics

The current introduction of an Australian curriculum for the first time signifies a time of great change in the Australian education scene. Previously, the federal structure of the Australian constitution has ensured that states and territories have held responsibility for school education while they have shared responsibility for prior-to-school education and care with the Australian government. From 2006, through a cooperative agreement between the eight State and Territory governments and the Australian government, more national approaches have been developed. One result has been the implementation of national mathematics curriculum approaches in both prior-to-school and school sectors. The *Early Years Learning Framework* (Department of Education, Employment and Workplace Relations, DEEWR

2009) was developed for the prior-to-school sector, and the *Australian Curriculum—Mathematics* (ACARA 2013) for the school sector. These curricular documents provide an unprecedented opportunity in Australia to consider and explore just what mathematics children starting school know and bring with them and how their mathematics knowledge developed prior-to-school.

The *Early Years Learning Framework* (DEEWR 2009) promotes preschool children's achievement of five broad learning outcomes. The most relevant to mathematics learning (with the most relevant key components) are:

> Outcome 4: Children are confident and involved learners
> (Children develop a range of skills and processes such as problem solving, enquiry, experimentation, hypothesising, researching and investigating)
> Outcome 5: Children are effective communicators
> (Children begin to understand how symbols and pattern systems work).

The *Early Years Learning Framework* does not specify particular content achievement levels in mathematics but makes the following general statement.

> Children bring new mathematical understandings through engaging with problem solving. It is essential that the mathematical ideas with which young children interact are relevant and meaningful in the context of their current lives. Educators require a rich mathematical vocabulary to accurately describe and explain children's mathematical ideas and to support numeracy development. Spatial sense, structure and pattern, number, measurement, data argumentation, connections and exploring the world mathematically are the powerful mathematical ideas children need (DEEWR 2009, p. 38).

In contrast, the *Australian Curriculum—Mathematics* (ACARA 2013) provides a content-based achievement standard for children at the end of their first year at school:

> Students make connections between number names, numerals and quantities up to 10. They compare objects using mass, length and capacity. Students connect events and the days of the week. They explain the order and duration of events. They use appropriate language to describe location.
> Students count to and from 20 and order small collections. They group objects based on common characteristics and sort shapes and objects. Students answer simple questions to collect information.

This achievement is supported by the Foundation Year proficiencies that focus on understanding, fluency, problem solving and reasoning:

> Understanding includes connecting names, numerals and quantities.
> Fluency includes readily counting numbers in sequences, continuing patterns, and comparing the lengths of objects.
> Problem Solving includes using materials to model authentic problems, sorting objects, using familiar counting sequences to solve unfamiliar problems, and discussing the reasonableness of the answer.
> Reasoning includes explaining comparisons of quantities, creating patterns, and explaining processes for indirect comparison of length.

These Foundation standards and proficiencies indicate what Australian children are expected to know and do in mathematics at the end of their first year of school.

4.4 *Let's Count*

Let's Count (Perry and Gervasoni 2012) is an Australian early mathematics program designed by The Smith Family and the authors to assist parents and family members to help their children aged 3–5 years play, investigate and learn powerful mathematical ideas in ways that develop positive dispositions to learning, and learning mathematics. A key focus of the program is to notice, explore and discuss mathematics as part of everyday activities. The Smith Family is a children's charity "helping disadvantaged Australian children to get the most out of their education, so they can create better futures for themselves" (The Smith Family 2013). *Let's Count* is supported by the Origin Foundation and developed in partnership with Blackrock Investment Management. It was piloted in 2011 in five communities designated as experiencing social and economic disadvantage across Australia. In 2012/2013, The Smith Family introduced a refined *Let's Count* program in six additional sites and further sites were included in 2013/2014. All sites are designated as 'disadvantaged' with high proportions of children classified as starting school 'at risk' developmentally, as measured by the Australian Early Development Index (AEDI) (Centre for Community Child Health 2013). For further details about *Let's Count*, see MacDonald (Chap. 6 of this volume).

4.5 The *Let's Count* Longitudinal Evaluation

The authors of this chapter are responsible for the longitudinal evaluation of *Let's Count*. One aim of this evaluation is to determine whether the *Let's Count* approach has an impact on the formal mathematical knowledge children construct prior to beginning school. Over 2012/2014, data will be gathered at multiple points from early childhood educators (surveys and interviews), parents and other adult members of families (interviews) and children in the year before they start school (one-on-one assessment interview). In this chapter, we consider only the assessment interview data for 125 children in 2012 who formed the study's comparison group.

4.5.1 Assessing Children's Knowledge of School Mathematics

The tool selected to assess children's mathematical knowledge for the *Let's Count Longitudinal Evaluation* was the *Mathematics Assessment Interview* (Gervasoni et al. 2010; Gervasoni et al. 2011). This assessment was designed for young children, is task-based and interactive, derived from extensive research, and enables mathematical learning to be measured in nine domains. One section of the assessment focuses on early mathematics concepts for children beginning school. This assessment was originally developed as part of the *Early Numeracy Research Project* (ENRP) (Clarke et al. 2002; Department of Education, Employment and Training

2001) and following refinement during the *Bridging the Numeracy Gap* project was renamed the *Mathematics Assessment Interview* (MAI) (Gervasoni et al. 2010; Gervasoni et al. 2011).

The principles underlying the construction of the tasks and the associated mathematics growth point framework were to:

- describe the development of mathematical knowledge and understanding in the first 3 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., Fuson 1992; Gould 2000; Mulligan 1998; Steffe et al. 1983; Wright et al. 2000);
- reflect, where possible, the structure of mathematics;
- allow the mathematical knowledge of individuals and groups to be described; and
- enable a consideration of children who may be mathematically vulnerable (Gervasoni and Lindenskov 2011).

The interview includes four whole number domains (Counting, Place Value, Addition and Subtraction, and Multiplication and Division); three measurement domains (Time, Length and Mass); and two geometry domains (Properties of Shape and Visualisation). The assessment tasks in the interview take between 30–45 min for each child and were administered in this evaluation by independent, trained assessors who followed a detailed script. Each child completed about 30 tasks in total, and given success with one task, the assessor continued with the next tasks in a domain for as long as a child was successful, according to the script. The processes for validating the growth points, the interview items and the comparative achievement of students are described in full in Clarke et al. (2002).

A critical role for the assessor throughout the interviews was to listen and observe the children, noting their responses, strategies and explanations while completing each task. These responses were noted on a detailed record sheet and then independently coded to

- determine whether or not a response was correct;
- identify the strategy used to complete a task, and
- identify the growth point reached by a child overall in each domain.

This information was entered into an SPSS database for analysis. Of particular interest for this study were the children's responses to tasks in the early mathematics concepts section and the initial tasks in the other domains. Links between the tasks and the *Australian Curriculum—Mathematics* (ACARA 2013) will be made.

4.5.2 The 2012 Let's Count Comparison Group

The 125 children in the *Let's Count* comparison group were assessed in December, 2012. They did not participate in the *Let's Count* program but provided a measure of the level of mathematics known by children in *Let's Count* communities prior to

Table 4.1 Percentage of *Let's Count* children assessed as developmentally 'at risk' in one or more AEDI domains (2012 data)

State	*Let's Count* Centres	State average	Australian average
1	10.8–21.0	19.9	22.0
2	20.5–36.8	19.5	22.0

Table 4.2 Percentage of *Let's Count* children assessed as developmentally 'at risk' in two or more AEDI domains (2012 data)

State	*Let's Count* Centres	State average	Australian average
1	2.7–11.0	9.2	10.8
2	11.3–24.3	9.5	10.8

the program commencing. All were eligible to begin school in January, 2013 and aged between 4.5 and 5.5 years. They attended preschool programs in ten centres in two large regional Australian cities. By chance, more boys (56 %) were assessed than girls (44 %).

All of the preschool centres were situated in, and drew children from, communities identified as 'disadvantaged' through community measures such as the Australian Early Development Index (AEDI). The AEDI assesses 'disadvantage' through calculating the percentage of children starting school in a particular district who are deemed to be developmentally 'at risk' in one or more, or two or more, of the following domains:

- physical health and wellbeing;
- social competence;
- emotional maturity;
- language and cognitive skills; and
- communication skills and general knowledge (Centre for Community Child Health 2013).

Tables 4.1 and 4.2 provide an overview of AEDI data concerning the 'at risk' levels from the *Let's Count* communities in the two states. They show that State 1 communities are tracking near the State and National averages while State 2 communities are tracking more 'at risk' compared to the State and National averages.

Data from both levels of developmentally 'at risk' measures show that although the two state sites have been deemed to be 'disadvantaged', their results on the AEDI measures are quite different. We shall return to this later in the paper.

4.6 Children's Mathematical Knowledge

The *Mathematics Assessment Interview* results for the 125 children in the *Let's Count* comparison group are presented in tables in the following section of this chapter. The results have been grouped to match the associated components of the

Table 4.3 Percentage success on tasks with small sets (usually small plastic teddies)

Tasks	*Let's Count* ($n=125$)	ENRP ($n=1438$)	Australian Curriculum Foundation standard
Tasks with small sets			
Count a collection of 4 teddies	95	93	*Students make connections between number names, numerals and quantities up to ten*
Identify one of two groups as "more"	90	84	
Make a set of five teddies when asked	77	85	
Conserve five when rearranged by child	79	58	
Combine 5+3 blue teddies and total	75	na	
Make collection of seven (when shown number 7)	63	na	
Knows one less than seven when one teddy removed	61	na	
Knows one less than seven without recounting	25	na	
Part part whole tasks			
Show six fingers (usually five and one)	79	78	
Six fingers second way	27	20	
Six fingers third way	10	8	
One to one correspondence task			
Know five straws needed when asked to put one straw in each of five cups	88	92	

Australian Curriculum—Mathematics Foundation Year standard. This enables an assessment to be made about the appropriateness of the curriculum standard for children at the end of their first year at school. Each table shows the percentage of children who were successful with each task for the *Let's Count* prior-to-school group in December 2012 and the 1438 children in the ENRP beginning school group in February/March 2001 (Clarke et al. 2006). Due to the refinement of some assessment tasks in 2009, results for some tasks were not available for the ENRP group. These have been indicated with 'na' in the tables. It should be noted that the ENRP cohort are representative of first year of school children across State 2. The average age of these children is approximately 3–4 months greater than the average age of the *Let's Count* cohort.

Table 4.3 focuses on children's success with tasks involving small sets of objects.

For this set of tasks, the *Let's Count* and ENRP cohorts have performed similarly, with both showing that about 75 % of the children were able to demonstrate the curriculum standard before they begin school (*Let's Count)* or shortly thereafter (ENRP).

Table 4.4 shows the percentage of children able to recognise the number of dots on a card (either in a standard pattern or a random collection) without counting them, and also their ability to match a numeral to the number of dots. High percentages of children from both the *Let's Count* and the ENRP cohorts were able to subitise small numbers of dots in both random and standard configurations. Not

Table 4.4 Percentage success in subitising tasks and matching numerals to dots

Tasks	*Let's Count* (*n* = 125)	ENRP (*n* = 1438)	Australian Curriculum Foundation standard
Subitising tasks			
Recognise zero without counting	81	82	*Students make connections between number names, numerals and quantities up to ten*
Recognise two without counting	94	95	
Recognise three without counting	83	84	
Recognise random three without counting	86	na	
Recognise four without counting	70	71	
Recognise random four without counting	50	na	
Recognise five without counting	44	43	
Recognise nine without counting	16	9	
Matching numerals to dots tasks			
Match numeral to zero dots	73	63	
Match numeral to two dots	90	86	
Match numeral to three dots	73	79	
Match numeral to three random dots	82	na	
Match numeral to four dots	73	77	
Match numeral to four random dots	69	na	
Match numeral to five dots	65	67	
Match numeral to nine dots	38	41	

surprisingly, standard configurations led to higher success rates than random arrangements of the dots as subitising is known to be a pattern recognition activity (Wolters et al. 1987).

Perhaps more surprising is that about one-sixth of the *Let's Count* cohort could subitise nine dots while less than one-tenth of the ENRP cohort could do so. It should be noted that the nine dots were presented as in Fig. 4.1 which is the logo for a popular television network in Australia. Perhaps young children are watching more television in 2012 than they were in 2001?

The majority of students could also match numerals to the number of dots, although nine was much harder to match than the other numbers. The ability to recognise quantities without counting and match numerals to numbers of objects is important for future number work and it would seem that the majority of children from both the *Let's Count* and ENRP cohorts are well on their way to achieving the Foundation standard.

Subitising is an example of the importance of pattern and structure in young children's mathematical learning. The Foundation proficiencies of fluency and reasoning focus on continuing and creating patterns. The data presented in Table 4.5 suggest that about three-quarters of children from both the *Let's Count* preschool cohort and the ENRP school cohort can match patterns at the time of their transition to school, and about one-third of children from both cohorts can continue and explain a pattern.

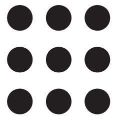

Fig. 4.1 Nine dots

Table 4.5 Percentage success in pattern tasks

Tasks	*Let's Count* (*n* = 125)	ENRP (*n* = 1438)	Australian Curriculum Foundation standard
Pattern tasks			
Name colours in pattern	98	94	*Fluency proficiency includes: continuing patterns. Reasoning proficiency includes: creating patterns.*
Match pattern	72	76	
Continue pattern	34	31	
Explain pattern	34	31	

The results concerning patterning suggest that many children will need more than an 'ABAB' pattern to either match or continue in order for there to be sufficient challenge in this important aspect of mathematics development.

The Foundation standard of the *Australian Curriculum—Mathematics* also focuses on students counting to and from 20 and ordering small collections. Several tasks in the MAI focused on sequence counting, counting a larger collection of at least 20 items and ordering numerals. The percentage of students able to complete these tasks is presented in Table 4.6.

The data suggest that the majority of the *Let's Count* cohort can rote count to 10 and at least one-quarter can complete the rote forward count to 20, indicating that they have already met this component of the Foundation standard. This result is reinforced by Gould (2012) who found that 16% of students in New South Wales could rote forward count to at least 30, the standard in that state for the end of the

Table 4.6 Percentage success with counting and ordering numerals

Tasks	*Let's Count* (*n* = 125)	ENRP (*n* = 1438)	Australian Curriculum Foundation standard
Counting tasks			
Rote count to ten	87	na	*Students count to and from 20 and order small collections*
Rote count to 20	29	na	
Count a collection of at least 20 and, when one item is removed, knows total without recounting	8	na	
Ordering numbers tasks			
Order numeral cards 1–9	48	46	
Order numeral cards 0–9	32	38	
Orders three one digit numbers	47	na	
Orders three two digit numbers	28	na	

Table 4.7 Percentage success with length and time measurement tasks

Tasks	*Let's Count* (*n* = 125)	ENRP (*n* = 1438)	Australian Curriculum Foundation standard
Length Measurement Tasks			
Ordering three candles smallest to largest	73	61	*Students compare objects using mass, length and capacity*
Ordering four candles smallest to largest	54	50	
Accurately compares two lengths—string and stick	65	na	
Measures length using informal units	8	na	
Time measurement tasks			*Students connect events and the days of the week*
Aware of the purpose of a clock	83	na	
Knows some days/months	17	na	

first year of school under the previous state syllabus (NSW Department of Education and Training, DET 2002). Few of the *Let's Count* children could both count 20 teddies successfully and identify how many teddies remained when one teddy was removed. It appears that a focus on the cardinal value of numbers to 20 would be a profitable area for instruction in the first year at school, though this is only connected vaguely with the Foundation standard "connecting names, numerals and quantities".

The absence of ENRP cohort comparisons for most of these counting and ordering tasks is unfortunate and results from the ENRP data entry being less differentiated for these tasks. On the two ordering questions that are comparable, both cohorts perform similarly.

Several tasks in the interview focused on measuring length and time. Table 4.7 highlights that many children beginning school are able to compare and order lengths, in line with the Foundation standard, and are also aware of the purpose of a clock. Seventeen percent of children knew the names of some days of the week and months. In the cases where comparisons are available with the ENRP cohort, the *Let's Count* cohort is on or above par.

Spatial reasoning is a key aspect of learning mathematics (Clements and Sarama 2004; Perry and Dockett 2008). The data presented in Table 4.8 show the success rates of both the *Let's Count* and ENRP cohorts with tasks involving describing and interpreting locations, recognising the properties of shapes and using mental imagery to manipulate shapes.

The data suggest that the *Let's Count* cohort was proficient in these spatial tasks and almost all children met the Foundation standard prior to beginning school. In the three tasks for which there is comparable ENRP data, the *Let's Count* cohort succeeded to at least at an equivalent level. These data provide impetus for teachers in the first year of school to consider how they can engage children in more probing tasks than the shape recognition and naming experiences that occur frequently in preschools and the first year of school.

Table 4.8 Percentage success on spatial tasks

Tasks	*Let's Count* ($n=125$)	ENRP ($n=1438$)	Australian Curriculum Foundation standard
Language of location tasks			
Beside	94	88	*Students use appropriate language to describe location*
Behind	87	87	
In front of	91	83	
Properties of shapes tasks			*Students group objects based on common characterist-ics and sort shapes and objects*
Knows square	85	na	
Knows circle	92	na	
Knows rectangle	74	na	
Knows some triangles	83	na	
Knows all triangles	63	na	
Visualisation Tasks			
Identifies a reoriented rectangle in room	89	na	
Identifies and traces possible shapes when a shape is partially hidden	16	na	

Peeking Over Task

Close your eyes for a moment while I get the next task organised. ... Now open your eyes. [Hold the green piece of paper with the partially hidden yellow shape in front of the child].

I have a yellow shape that is peeking over thispiece of paper. We can only see part of the yellow shape. [Place the paper down on the table]. What do you think the shape might be?

Show me with your finger how that yellow shape "goes" underneath. [If necessary for understanding, ask can you draw aroundthe outside of the shape with your finger?]

Fig. 4.2 Example of the peeking over task from the visualisation section of the interview

The most difficult geometry task involved the recognition of hidden shapes and required children to use spatial imagery. The task is reproduced in Fig. 4.2 to illustrate the level at which the *Let's Count* cohort were successful.

Such performance is well beyond that expected by the Foundation standard and alerts first year of school teachers to the possibility that, for a sizeable portion of their class, more advanced experiences are required than is typically suggested in curriculum guidelines.

The MAI also includes a range of tasks involving calculations, although few of the *Let's Count* cohort progressed far in these domains. The results from four calculation tasks (Table 4.9) show that many of the children were capable of completing the initial addition, multiplication and division tasks, thus providing a school starting level which might be viewed as surprising. All tasks were presented orally and involved the use of materials. There are no ENRP comparison data available for these tasks.

Table 4.9 Percentage success on calculation tasks involving materials

Tasks	*Let's Count* ($n=125$)	Australian Curriculum Foundation Standard
Calculation tasks		
Adds 5+3 when screen over five removed	49	*Problem solving proficiency: using materials to model authentic problems, sorting objects, using familiar counting sequences to solve unfamiliar problems, and discussing the reasonableness of the answer*
Adds 9+4 when screen over nine removed	25	
Calculates total for two teddies in four cars	48	
Divides 12 teddies between four mats	31	

Most children who were successful with the first three tasks worked out the answers by counting all the items one by one. A small number of students used the counting on strategy. Most children solved the division task through grouping rather than sharing by ones. The results and the children's strategies indicate that a large group of children are well on their way to meeting the Foundation problem solving standard before beginning school.

4.6.1 Performance Differences Between Girls and Boys

One question of interest for the study was whether there was any difference in performance between girls and boys. For the most part, data from the MAI is categorical (mainly Yes/No). So, for all such items, χ^2 tests were run to ascertain differences across gender. In only one case was a statistically significant result returned (at the 5% level). This was for the question "What colour is the 3rd teddy (in a line of teddies)?" and a higher percentage of boys answered correctly than girls. However, with $p=0.046$, this single result is only marginally statistically significant and probably not educationally significant, given that boys and girls performed equally on identification of the fifth teddy.

4.6.2 Performance Differences Between the Two States

A similar χ^2 analysis for all suitable MAI items was used to ascertain if there were any statistically significant differences across the geographical origin of the data from State 1 or State 2. Sixty-four children (51.2% of the cohort) attended preschool in State 1 while 61 (48.8%) were from State 2. On 14 of the individual MAI questions, statistically significant differences (at the 5% level) were found across the two states. Table 4.10 provides details of these.

The findings in terms of state differences cluster in interesting ways. On the items that have delivered statistically significant differences between the states, State 2 children in the *Let's Count* cohort have performed more ably on the counting, subitising

Table 4.10 Statistically Significant Differences across Geographical Location

MAI Item	χ^2 value	*p*	Better performing state
Please get five blue teddies	4.770	0.024	State 2
(After changing arrangement of five teddies) tell me how many teddies now	6.309	0.011	State 2
Five teddies and three teddies. How many teddies altogether: 5+3	4.515	0.027	State 2
Put a green teddy behind the blue teddy	5.041	0.023	State 1
Please make the same pattern	5.566	0.015	State 1
I'm going to show you some cards quite quickly. Tell me how many dots you see. (4)	3.928	0.037	State 2
Add in question for subitise 3–2 as I do not seem to be able to find it	4.134	0.035	State 2
Find the number to match the dots. (2)	8.261	0.004	State 2
Find the number to match the dots. (3)	5.056	0.020	State 2
Please show me six fingers	4.272	0.032	State 2
Add in question for enumerates #2	10.664	0.005	State 1
Add in question for enumerates #1	21.711	0.000	State 1
Add in question for enumerates #0	15.233	0.000	State 1
Here are some numbers (*two, five, nine on separate cards)*. Order these from smallest to largest. Please point to the largest. Please point to the smallest	5.927	0.012	State 1

and matching numerals to sets of dots while State 1 children have performed more ably on the location, enumeration and ordering tasks. In particular, the enumeration tasks are enlightening in terms of the methods used by the children. In all three of the enumeration tasks listed in Table 4.10, State 2 children are more likely to obtain the correct answers but State 2 children who do get correct answers are much more likely than State 1 children with correct answers to subitise rather than count.

It is tempting to suggest that there may be curriculum or pedagogical differences between the preschool programs in each state but we do not have any evidence for this as the specific programs undertaken by the children in the *Let's Count* comparison group were not studied.

4.7 Implications for Transition

It is well established that the play, exploration and engagement of young children in everyday activities in the preschool and other venues involves much informal mathematical activity (Ginsburg and Seo 2000; Hunting et al. 2012; Perry and Dockett 2008; Wager 2013). Nevertheless, the data presented in this chapter highlight the broad range of formal mathematics knowledge that many children construct prior to beginning school, perhaps through their own play, perhaps through more intentional teaching instigated by their early childhood educators. This finding supports the findings of earlier research (Bobis 2002; Clarke et al. 2006; Gervasoni and Perry 2013; Ginsburg and Seo 2000, Gould 2012; Hunting et al. 2012).

The *Early Years Learning Framework for Australia* (DEEWR 2009) extols the virtues of play as an important pedagogy in early childhood education. While it is not the only pedagogy used in preschools, it is well accepted and widely adopted.

> Play provides opportunities for children to learn as they discover, create, improvise and imagine. When children play with other children they create social groups, test out ideas, challenge each other's thinking and build new understandings. Play provides a supportive environment where children can ask questions, solve problems and engage in critical thinking. Play can expand children's thinking and enhance their desire to know and to learn. In these ways play can promote positive dispositions towards learning. (DEEWR 2009, p. 15)

While the results presented in this chapter highlight the diversity of children's mathematical knowledge, it is also apparent that children's everyday home and preschool experiences prepare a large proportion of them well for the transition to learning mathematics at school. It also appears that there is little relationship between the extent of young children's mathematical knowledge before they start school and the rating of 'at risk' status given to their communities by first year of school teachers. While both geographical sites were deemed to be 'disadvantaged', they had quite different AEDI profiles. The State 2 sites measured as 'more disadvantaged' on the AEDI than the State 1 sites but the mathematical performance of the children in the *Let's Count* comparison group were mostly consistent across the sites. Even when there were statistically significant differences across the sites, the message was mixed with the children from State 1 performing better on some tasks and less well on others. There is a body of research that suggests a strong link between levels of community disadvantage and the academic performance of the children from communities (Carmichael et al. 2013; Caro 2009) as they move through school. Data from the study reported here suggest that either this might not play out in the same way for preschool children or that the AEDI is not a very reliable predictor of preschool children's mathematical performance. This is an important finding for education authorities and teachers to consider.

Comparison of children's mathematics knowledge with the *Australian Curriculum—Mathematics* Foundation standard and proficiencies suggest that large numbers of children in both the *Let's Count* preschool group and the ENRP Beginning School group met the end of year Foundation Standard in Number, Measurement and Geometry prior to or just after beginning school. An implication of this finding is the critical need for teachers to find out what mathematics children know when they begin school and extend the Foundation mathematics curriculum right from the first day of school to challenge and engage many children in mathematics learning. While teachers are skilled in differentiating instruction for children, these findings highlight the importance of this role.

Overall, it appears that the new *Australian Curriculum—Mathematics* Foundation standard is neither sufficiently challenging for children nor adequate for signaling to teachers the type of experiences and instruction that are important. Whilst acknowledging that the *Australian Curriculum—Mathematics* encourages teachers to adjust curriculum and instruction to match children's knowledge, it must also adequately reflect the mathematical capabilities of children when they begin school. The data presented in this chapter suggest that Australian education authorities need to undertake more fine-tuning to set the Foundation standard at a level that sufficiently engages and challenges children at the time of transition.

4.8 Conclusion

The findings reported in this chapter indicate that, prior to beginning school, many Australian children have constructed powerful mathematical ideas that involve number, measurement and geometry. It is essential that both preschool and primary school teachers notice the extent of the mathematics that children know and use so that they can build upon and extend this knowledge during children's play and explorations. The findings also suggest that it is essential for first year of school teachers to examine curriculum documents critically and in light of their own assessment of children's mathematics knowledge and capabilities, with the intention of refining and extending these frameworks. Only then can our community ensure that all children have the opportunity to thrive mathematically during the transition to school and beyond.

References

Australian Curriculum, Assessment and Reporting Authority (ACARA). (2013). The Australian curriculum: Mathematics v2.4. http://www.australiancurriculum.edu.au/Mathematics/Curriculum/F-10. Accessed 15 Sept 2013.

Bobis, J. (2002). Is school ready for my child? *Australian Primary Mathematics Classroom, 7*(4), 4–8.

Carmichael, C., MacDonald, A., & McFarland-Piazza, L. (2013). Predictors of numeracy performance in national testing programs: Insights from the longitudinal study of Australian children. *British Educational Research Journal*. doi:10.1002/berj.3104.

Caro, D. H. (2009). Socio-economic status and academic achievement trajectories from childhood to adolescence. *Canadian Journal of Education, 32*(3), 558–590.

Centre for Community Child Health. (2013). *Australian early development index*. http://www.rch.org.au/aedi/. Accessed 14 Nov 2013.

Clarke, D., Cheeseman, J., Gervasoni, A., Gronn, D., Horne, M., McDonough, A., Montgomery, P., Roche, A., Sullivan, P., Clarke, B., & Rowley, G. (2002). *Early Numeracy Research Project final report*. Melbourne: Mathematics Teaching and Learning Centre, Australian Catholic University.

Clarke, B., Clarke, D. M., & Cheeseman, J. (2006). The mathematical knowledge and understanding young children bring to school. *Mathematics Education Research Journal, 18*(1), 78–102.

Clements, D. H., & Sarama, J. (2004). Young children's composition of geometric figures: A learning trajectory. *Mathematical Thinking and Learning, 6,* 163–184. doi:10.1207/s1532783mtl0602_1

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

Department of Education, Employment and Workplace Relations (DEEWR). (2009). *Belonging, being and becoming: The early years learning framework for Australia*. Canberra: Commonwealth of Australia. http://www.deewr.gov.au/earlychildhood/policyagenda/quality/pages/earlyyearslearningframework.aspx. Accessed 16 May 2012.

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., & Lindenskov, L. (2011). Students with 'special rights' for mathematics education. In B. Atweh, M. Graven, W. Secada, P. Valero (Eds.), *Mapping equity and quality in mathematics education* (pp. 307–323). Dordrecht: Springer.

Gervasoni, A., & Perry, B. (2013). Children's mathematical knowledge prior to starting school. In V. Steile (Ed.), *Mathematics education: Yesterday, today and tomorrow* (Proceedings of the 36th annual conference of the Mathematics Education Research Group of Australasia., pp. 338–345). Melbourne: MERGA

Gervasoni, A., Parish, L., Upton, C., Hadden, T., Turkenburg, K., Bevan, K., Livesey, C., Thompson, D., Croswell, M., & Southwell, J. (2010). Bridging the numeracy gap for students in low SES communities: the power of a whole school approach. In 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, pp. 202–209). Fremantle: MERGA.

Gervasoni, A., Parish, L., Hadden, T., Turkenburg, K., Bevan, K., Livesey, C., & Croswell, M. (2011). Insights about children's understanding of 2-digit and 3-digit numbers. In J. Clark, B. Kissane, J. Mousley, T. Spencer, & S. Thornton (Eds.), *Mathematics: Traditions and [new] practices* (Proceedings of the 23rd biennial conference of The AAMT and the 34th annual conference of the Mathematics Education Research Group of Australasia, Vol. 1, pp. 315–323). Alice Springs: MERGA/AAMT.

Ginsburg, H. P., & Seo, K.-H. (2000). Preschoolers' mathematical reading. *Teaching Children Mathematics, 7*(4), 226–229.

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

Gould, P. (2012). What number knowledge do children have when starting kindergarten in NSW? *Australasian Journal of Early Childhood, 37*(3), 105–110.

Hunting, R., Bobis, J., Doig, B., English, L., Mousley, J., Mulligan, J., Papic, M., Pearn, C., Perry, B., Robbins, J., Wright, R., & Young-Loveridge, J. (2012). *Mathematical thinking of preschool children in rural and regional Australia: Research and practice*. Melbourne: Australian Council for Educational Research.

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.

NSW Department of Education and Training (DET). (2002). *Count me in too professional development package*. Sydney: Author.

NSW Department of Education and Communities (2013). Best Start Kindergarten assessment. http://www.curriculumsupport.education.nsw.gov.au/beststart/assess.htm. Accessed 3 Oct 2013.

Perry, B., & Dockett, S. (2008). Young children's access to powerful mathematical ideas. In L. D. English (Ed.). *Handbook of international research in mathematics education* (2nd ed., pp. 75–108). New York: Routledge.

Perry, B., & Gervasoni, A., (2012). *Let's Count educators' handbook*. Sydney: The Smith Family.

Rimm-Kaufman, S. E., Pianta, R. C., Cox, M. J., & Bradley, R. H. (2003). Teacher-rated family involvement and children's social and academic outcomes in Kindergarten. *Early Education & Development, 14*(2), 179–198.

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

The Smith Family (2013). Who we are. http://www.thesmithfamily.com.au/. Accessed 27 Aug 2013.

Wager, A. A. (2013). Practices that support mathematics learning in a play-based classroom. In L. D. English & J. T. Mulligan (Eds.), *Reconceptualizing early mathematics learning* (pp. 163–181). Dordrecht: Springer. doi:10.1007/978-94-007-6440-8_4

Wolters, G., van Kempen, H. & Wijlhuizen, G.-J. (1987). Quantification of small numbers of dots: Subitizing or pattern recognition? *The American Journal of Psychology, 100*(2), 225–237.

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

Ann Gervasoni is Associate Professor - Numeracy at Monash University. Ann has worked in teacher education, professional learning and primary teaching for 32 years. Ann was a member of the research team for the Early Numeracy Research Project (1999–2001) in Victoria, and research director for the Bridging the Numeracy Gap project in Western Australia and Victoria (2009–2010). Ann's research interests include mathematics education in early childhood and primary education, mathematics intervention programs and community approaches for supporting the learning of those most vulnerable in our community.

Bob Perry is Professor in the Research Institute for Professional Practice, Learning and Education and School of Education at Charles Sturt University, Albury-Wodonga, Australia. Bob's current research interests include powerful mathematics ideas in preschool and the first years of school; ethical tensions in researching with children; transition to school, with particular emphasis on starting school within families with complex support needs, preschool education in remote Indigenous communities, and transition to school for Indigenous families. Bob shares his life with his partner, Sue Dockett, and their son, Will, both of whom ensure that he keeps his feet firmly on the ground.