A Longitudinal Study of Growth in Literacy and Numeracy in the Primary School Years

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Acknowledgement

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Background

This paper reports on a seven-year longitudinal study. In 1998 an extensive investigation of the nature of growth in literacy and numeracy across the years of primary school was established at ACER as a national longitudinal study. It was intended that scales of developing literacy and numeracy achievement would be developed within this study, making it possible to show growth from the first year at school until the end of primary school.

This longitudinal study, known as the ACER Longitudinal Literacy and Numeracy Study (LLANS) commenced in 1999 in a context in which there was significant national interest in improving achievement in literacy and numeracy for all Australian children, and a particular interest in the development of foundational skills in the early years of schooling. The Commonwealth Government's Literacy policies for Australian schools had been described *Literacy for All: The Challenge for Australian Schools* (DEETYA, 1998). In 1997 Commonwealth, state and territory education Ministers had agreed to a national literacy and numeracy goal, *That every child leaving primary school should be numerate, and be able to read, write and spell at an appropriate level*, and a sub-goal, *That every child commencing school from 1998 will achieve a minimum acceptable literacy and numeracy standard within four years* (DEETYA, 1998). Central to the policy framework was the National Literacy and Numeracy Plan, which comprised several related elements, including *assessment of all students by their teachers as early as possible in the first years of schooling* (DEETYA, 1998, p. 10).

The national goal for literacy was reaffirmed in 1999 when State, Territory and Australian Government Ministers of Education endorsed new *National Goals for Schooling* and agreed that, in relation to literacy and numeracy, upon leaving school

> *students should have attained the skills of numeracy and English literacy; such that every student should be numerate, able to read, write, spell and communicate at an appropriate level.* (Ministerial Council for Education Employment Training and Youth Affairs, 1999)

The 1996 National School English Literacy Survey was the first (and only) national sample survey of the literacy achievements of students in Years 3 and 5 undertaken in Australia. The most significant finding of this survey was the wide range of literacy achievement among Australian school children at both years 3 and 5:

> *Data from the Main Sample in the Survey indicates that the top 10 per cent of students at both Year 3 and Year 5 are working at about five year levels ahead of the bottom 10 per cent of students* (Masters and Forster, 1997b, p. v))

In this context, a longitudinal study of literacy achievement across the years of primary schooling created an opportunity to further investigate this wide range of achievement. It was decided to broaden the study to include numeracy achievement as well as literacy achievement. A nation-wide sample of 100 schools was selected in proportion to the population of each state and territory, and ten students were randomly selected from each of these schools. This provided a cohort for the LLANS of 1000 children who commenced school in 1999.

Research Questions

The key research question in this seven-year longitudinal study was: 'What is the nature of literacy and numeracy development amongst Australian school children?' 'How does it vary for individuals and groups?'

Research methods

A longitudinal design was chosen as the most appropriate means of identifying patterns of growth in literacy and numeracy achievement. In cross-sectional studies, such as the 1996 National School English Literacy Survey, different students are assessed at a particular point in schooling, and this data is sometimes used to infer developmental patterns. A longitudinal design made it possible to investigate development and growth by following the same cohort of students across the years of primary schooling, in order to identify changes in literacy and numeracy achievement.

This longitudinal study involved children who commenced school in 1999. One thousand children from a random Australia-wide sample of 100 schools, selected in proportion to the population size of each state and territory, formed the original cohort for the study. Table 1 shows the number of schools in each State and Territory. With the approval of the education authorities the principals of these schools were invited to participate in the study. If a principal was unable to commit the school to participation in a seven year study, a replacement school from the sample drawn from the ACER national sampling frame was approached.

Table 1: Schools in states and territories

Australian Capital Territory	3
New South Wales	31
Northern Territory	2
Queensland	17
South Australia	10
Tasmania	3
Victoria	23
Western Australia	11
Total	100

The students were the focus of this study, not the schools. When students transferred to another school, they were retained in the study if their destination was known, and if the new school agreed to carry out the assessments. There was some attrition, but achievement data was collected from a significant proportion of the sampled students between 1999 and 2005. Each year, students completed assessments in literacy and numeracy. Two assessments were completed in the first two years of school, in order to take account of the rapid pace of learning in those years.

Theoretical framework

The LLANS is underpinned by the concept of developmental assessment. If we can measure students' performance in an area of learning using the same ruler over time, then we can construct a progress map (Masters and Forster, 1997) to describe typical progression of development in that area of learning. This progress map can provide a framework for reporting development of individual students based on repeated measures of achievement by these students. Locating students' achievements on the same scale over time can be useful in a variety of ways. An individual student's growth over time can be described. The progress of groups of students can be compared over time. The relative achievement levels of particular cohorts of students can be identified at different stages or year levels of schooling. The LLANS scales were constructed based on the Rasch model (Masters, 1982; Rasch, 1960) to provide progress maps for literacy and numeracy.

The assessment tasks

The literacy and numeracy assessments tasks were of critical importance to this study. Key criteria for developing the assessment tasks for the study were identified. The tasks were to:

- be research based, that is, they should assess aspects of literacy and numeracy that contemporary research indicated to be central to the development of strong literacy and numeracy skills;
- engage students and be built around contexts likely to be familiar to students in the early years of school;
- be administered one-to-one in an interview situation, if possible by the student's own teacher;
- involve, where possible, authentic texts and hands-on equipment;
- be easy to for teachers to administer, and supported with clear and explicit marking and recording guides;
- be designed to be administered in a reasonable time, taking account of the attention span of early years students, and teachers' workloads.
- link with the ACER Development Assessment Resource for Teachers (DART) tasks available for middle and upper primary school.

Literacy assessment tasks

Decisions about the critical aspects of literacy and numeracy to be assessed was established the scope of the study. For example, for literacy, the following aspects were assessed.

- Making Meaning from Text (comprehension)
- Reading Fluency
- Concepts about Print
- Phonemic Awareness and Phonics
- Writing

As Paris (2005) indicates, some of these skills, such as alphabetic knowledge, phonemic awareness, and oral reading fluency are constrained both theoretically and methodologically, while other skills, such as vocabulary and comprehension continue to develop throughout schooling and beyond. This study focused on all the above skills in the early years, and increasingly on skills of comprehension as students progressed to the later years of primary school.

Table 2 shows the tasks developed for the first survey, which was administered during the students' first term at school. *Precious Eggs* was a picture story book written especially for this LLANS project, which was read aloud to students by the teacher administering the assessment.

Table 2: Literacy assessment tasks, Survey 1

Making Meaning from Text	• listen to *Precious Eggs* and retell the story • explain the intentions of a character in the picture story book *Precious Eggs*
Reading Fluency	• read Lego, COCO-POPS, BP and Shell from photographs • read any text the student recognises in *Precious Eggs* • read any text the student recognises on a cereal box • read a single word (shade)
Concepts about Print	• recognise writing • identify front and title of *Precious Eggs* • show where to begin reading and reading direction • identify a full stop, question mark and quotation marks • explain the purpose of quotation marks • identify a word, a letter & the first & last letter of a word • match letters with the same and different fonts on cereal labels • identify a capital letter • match a lower case and capital letter
Phonemic Awareness	• identify two rhyming words from a list of three words (7 examples) • identify two words with the same first sound from a list of three words (7 examples) • name the letters s, h, a, d and e
Writing	• write own name • draw and write about a picture about *Precious Eggs*

A detailed marking guide was developed to help teachers' record students' responses. Tables 3 and 4 provide examples from the first survey.

Table 3: Marking Guide for retelling, Survey 1

Instructions and questions	**Marking guide**
Let's read the book again. **When we finish you can tell me the story.** *Do not discuss the pictures. Acknowledge the child's comments (if any) but do not engage in conversation.* *Read Precious Eggs to the child again.* *Close the book when you have finished reading it. Put the book aside.*	
	Gives a short summary of the story, includes a beginning, middle and end. (May be quite brief (e.g. 'They found some eggs, they moved them, the eggs hatched'.)
	Focuses on central point of story. (e.g. 'Long Neck and Beaky covered up the eggs so that no one could steal them'.)
	Incomplete story but includes some elements e.g. characters, an action, the ending (e.g. 'They had a nest, blossoms made them sneeze, then they went home. The eggs hatched into little baby birds'.)

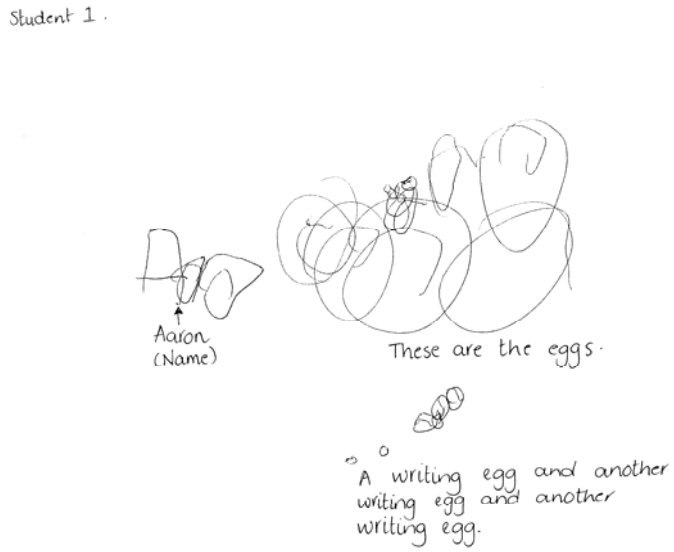
Now tell me the story that I read you. *If the child tells the story of the bush rat prompt them to tell you about the two birds.*	Tells a different story. no attempt

Table 4: Marking Guide: Illustrations

Instructions and questions	**Marking guide**
Put Precious Eggs in front of the child. *Point to the Bush Rat at the bottom of the front cover.* **Look at the Bush Rat and see what he's doing in the story**. *Allow child time to look through the book. When the child has finished close the book.* *Point to the Bush Rat on the front cover.* *What is this character doing in the story?*	 recognises sinister intentions (e.g. 'It's trying to steal the eggs'.) recognises he's interested in the birds. (e.g.' It's watching them'.) Unlikely interpretation of bush rat's actions (e.g. 'Crying because he's lost his little brother'. 'Swimming at the end'. 'Cutting the leaves off.') I don't know Other (please elaborate in space below.)

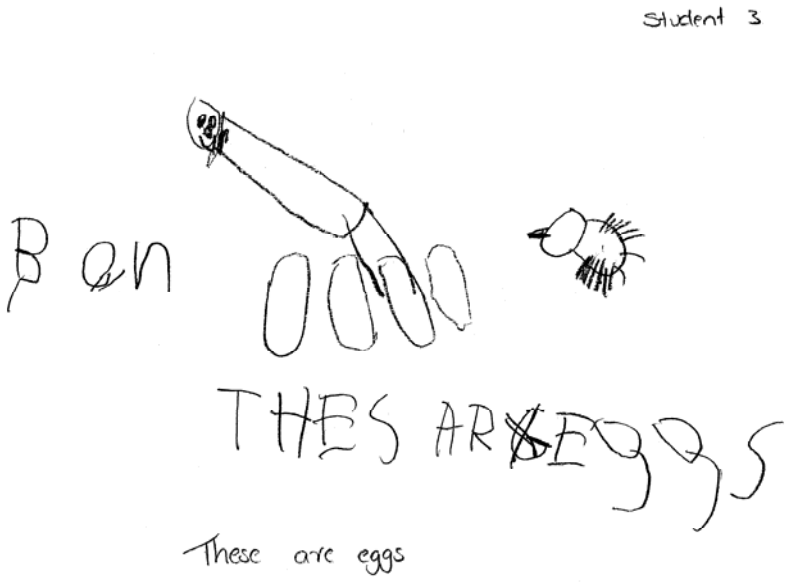
Writing

Students' writing reflected their understanding of the main events in *Precious Eggs*. Students wrote about the picture they had drawn after listening to *Precious Eggs*. The following samples provide a small selection of the broad range of emerging writing skills demonstrated by students early in their first year at school. Sixteen per cent of students included at least one recognisable word in their writing. Thirty-nine per cent of students included some recognisable letters in their writing; six per cent wrote scribble and thirty per cent of students made no attempt to write.



Sample 1

In sample 1 the student has illustrated his response to the text, focusing on the central role of the eggs in the story. He has written his name with a recognisable letter *A.* The teacher has transcribed the student's spoken descriptions of his drawing.



Sample 2

The writer of Sample 2 has written a recognisable sentence focusing on the eggs in the story, accurately spelling *eggs*, and writing *thes* for 'these' and *ar* for 'are'.

Sample 3

This writing sample (Sample 3), illustrates one of the main characters with an egg. The writer envisaged one of birds in the story as a duck. The writer's name is recognisable though two letters are incompletely formed.

Sample 4

Sample 4 shows a student's attempt to write names of the characters in the story. There are three recognisable words with plausible spelling. The use of vowels in the first two words demonstrates this student's emerging understanding of the conventions of spelling.

These five samples show the diversity of students' progress in learning to write.

Some aspects of literacy were demonstrated by a high proportion of students in the first survey. For example, most, but not all, students demonstrated understanding of book orientation and print directionality. They were also able to recognise writing. Table 5 shows the tasks assessing concepts about print that over three quarters of the students were able to complete correctly.

Table 5: Concepts about print

% correct	Task
88.9%	Can you point to the writing on this box? (cereal box)
80.3%	Can you tell me the name of any letters? (names at least one letter on a cereal box)
87.2%	Show me any letters that are the same. (identifies C, O and P as the same in COCO POPS)
87.5%	Point to the letters that are the same in these two pictures. (identifies O as the same in COCO POPS and LEGO)
89.9%	Show me the front of the book.
87.3%	The name of this book is *Precious Eggs*. Show me where it says *Precious Eggs*.
77.3%	I'm going to start reading the story on this page. Show me where to begin. (indicates top left hand of text on page)
87.4%	Show me which way to go. (indicates left to right)
77.6%	Where do I go after that? (indicates return sweep to left)
80.4%	Show me a word.
88.4%	Point to a letter.
80.5%	Show me the first letter in this word.

Figure 1 shows the Item variable map for Survey 1, constructed from Rasch estimates. On the right hand side of the map, item step thresholds are shown ranked on a logit scale according to the estimates of their difficulty, from the easiest (at the bottom of the map) to the most difficult (at the top of the map).

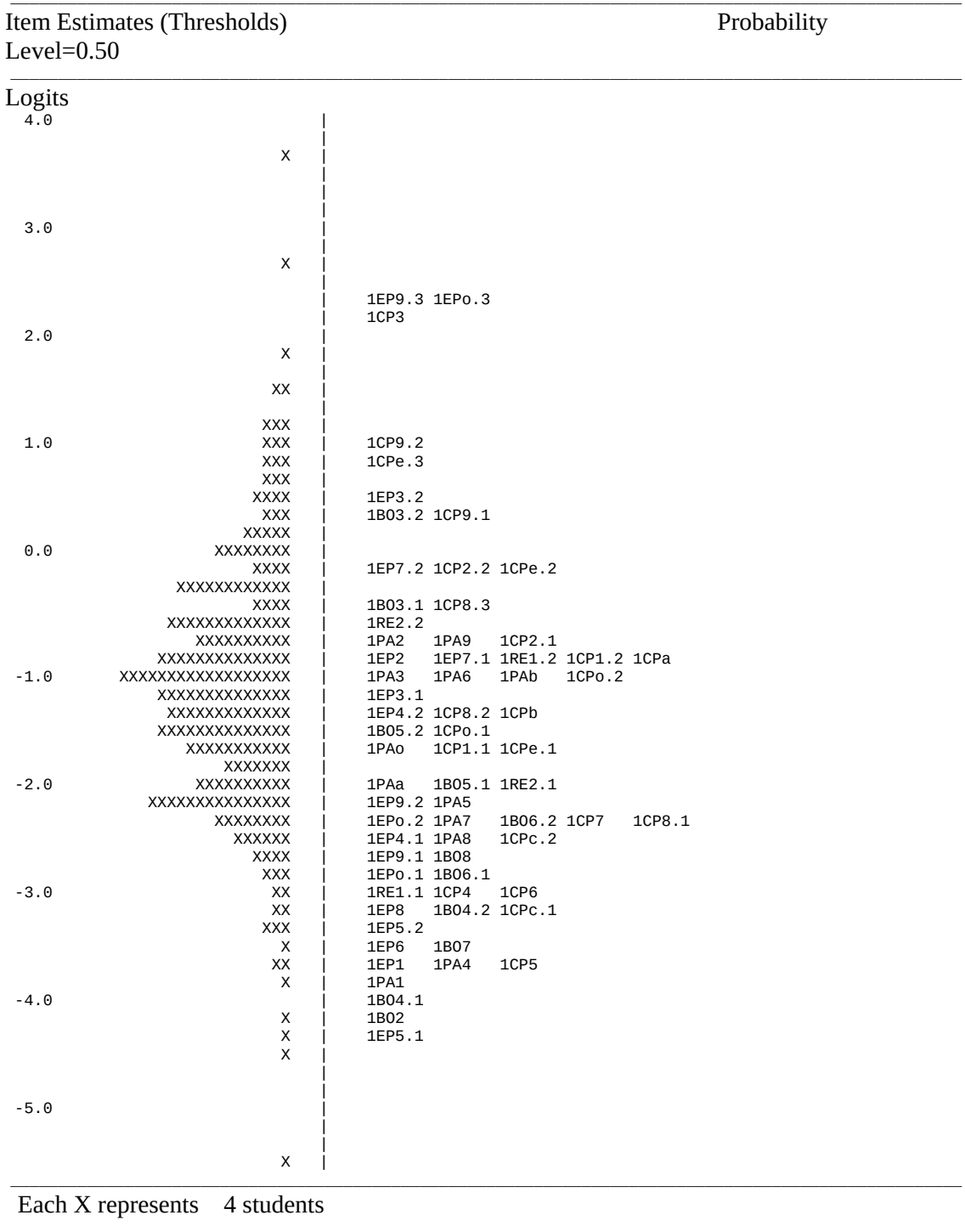


Figure 1: LLANS Literacy scale. Item Map for Survey 1

On Figure 1, the distribution of students' performances and the distribution of item difficulties are at about the same level. This indicates that this assessment survey was at an appropriate level of difficulty for this group of students. The map shows a good spread of the items and students' performances.

Numeracy assessment tasks

Table 6 shows the range of assessment tasks for the first numeracy survey.

Table 6: Numeracy assessment tasks, Survey 1

Number	• continue a repeating pattern ab, ab, ab …and make a repeating pattern • say age and identify numeral for age • use fingers to show age and use counters to represent age • identify 3, 7 • count picture of 8 objects and count out 8 counters • write 8 • count to 20 • give numbers after 6 and 13 and give numbers before 8 and 10 • count backwards from 5 and count backwards from 10 • count objects (7,14) • calculate 3 + 2 mentally and calculate 7 - 4 mentally • read $1.75 and 40c • identify numbers on a menu as representing prices
Space	• place objects *upside down*, *on top of*, *in front of*, *behind*, *under*, *close* and *a long way in front* • identify two shapes that are the same in some way and identify two shapes that are different in some way • identify two shapes with the same colour but the same in some other way • give the name for a square, circle and triangle
Chance & Data	• sort attribute blocks into 3 groups • describe criterion used for sorting

The responses to the numeracy assessment activities showed a wide range of achievement amongst students at the beginning of their first year at school. The following examples highlight some of the students' achievements in the number tasks assessed in Survey 1.

Students found it easy to continue a simple repeating pattern modelled by the teacher. Ninety-three per cent of students continued a pattern made by alternating a pop-stick with a counter for at least three repetitions. Seventy-four per cent of students were able to generate their own different repeating pattern using a combination of pop-sticks and counters.

Almost all students were familiar with the number for their own age. They gave their age (97%), used fingers to show their age (95%), used counters to represent their age (92%) and read the numeral for their age from the numbers sheet (92%).

Most students could identify some numerals and count some numbers under ten, as shown in Table 6. Sixty-four per cent also counted fourteen counters and seventy-two per cent wrote the number eight.

Table 6: Number assessment tasks, Survey 1

Skill	% correct	Task
numeral recognition	92%	identify the numeral three
	85%	identify the numeral seven
counting	91%	count 8 candles on a picture of a birthday cake
	85%	count out 8 counters
	88%	count 7 pop sticks
	64%	count 14 counters
writing	72%	write the number 8

Scales of developing achievement in literacy and numeracy

In order to measure progress over time in a developmental area, it was necessary for the students' performance in each survey to be measured on the same scale. It was therefore necessary to construct a LLANS Literacy Scale and a LLANS Numeracy Scale with each scale covering the full range of proficiency as assessed using easier tasks in the first year of school and more difficult tasks in the subsequent years.

When students' performances in literacy across surveys were measured on a common literacy scale, the performance over time could be compared so that it was possible to measure growth and change on the scale, and to track students' achievement progress over time. The same applied to the numeracy performances and numeracy growth over time.

The students' achievement distributions for literacy and numeracy in the five surveys conducted between March 1999 and May 2001 were shown on a single literacy progress map and a single numeracy progress map. These progress maps show growth in the early years, the first three years of school, when the one-to-one interview assessments described above were used to gather evidence of student achievement. The progress maps make it possible to see the growth over time and to identify general patterns of learning and achievement progress. The progress maps describe how the literacy and numeracy skills of the participating children generally developed over their first three years of school.

Students' performance on the LLANS scale of developing literacy achievement

The literacy achievement distributions of all students in Surveys 1-5 are shown in Figure 2. Descriptions of skills assessed in Surveys 1-5 are shown on the left-hand side of Figure 2. A selected sample of skill descriptions has been used to describe performance at different points on the scale. Each description refers to one item. Only a relatively small selection could be included on Figure 1, and so descriptions have

been selected from the whole range of items in the five surveys. The placement of the skill descriptions shows the estimated level of difficulty of a particular skill relative to other skills. These estimates have been empirically derived from the student achievement data.

The five shaded bands on the right hand side of Figure 2 show the distribution of performance of students participating in the study in Surveys 1-5. The shaded bands represent the middle 80 per cent of students. The darker shading represents the middle 50 per cent. The black line towards the middle of the darker band represents the median score for the whole cohort.

The bands have been arranged so that the time between surveys is indicated by the amount of space between each band. For example, the bands for November 1999 and March 2000, from Term 4 in one school year until Term 1 in the next school year, are closer than the bands between March and November 1999, which refer to the assessments conducted in Term 1 and Term 4 of the same school year, a longer period of time. The space between the bands from November 2000 and May 2001 indicates the time between Term 4 in one school year and Term 2 in the following school year.

Figure 2 shows an increase in the median scores for students across the five surveys. There is also an increase at the 10th percentile between each survey, and at the 90th percentile. Overall the progress map shows a clear pattern of growth in literacy achievement across the first three years of school. It is interesting to note that the amount of growth between Surveys 2 and 3 is less than the amount of growth between Surveys 1 and 2 and Surveys 3 and 4. The shorter period of time between surveys accounts for this difference. Also, the period from November to March includes the long summer vacation, when students are out of school for several weeks. However, although there is less growth, the pattern of growth continues over this period.

The achievement distributions show the considerable range of achievement across the whole cohort of students on each assessment occasion, including the March 1999 assessment at the beginning of the first year of school. Some students performed at a low level on the LLANS scale of developing literacy achievement, and some performed at a very high level on the same scale. Around the median level of achievement in March 1999, at the beginning of school, students were able to *identify a capital letter correctly* and to *retell key aspects after listening to a picture story book.* Around the median level in May 2001, in the third year of school, students were able to *explain character's actions in a simple reading book read independently*. Around the 90th percentile in May 2001, students were able to *write simple sentences joined with simple conjunctions,* e.g., *like, but, then*.

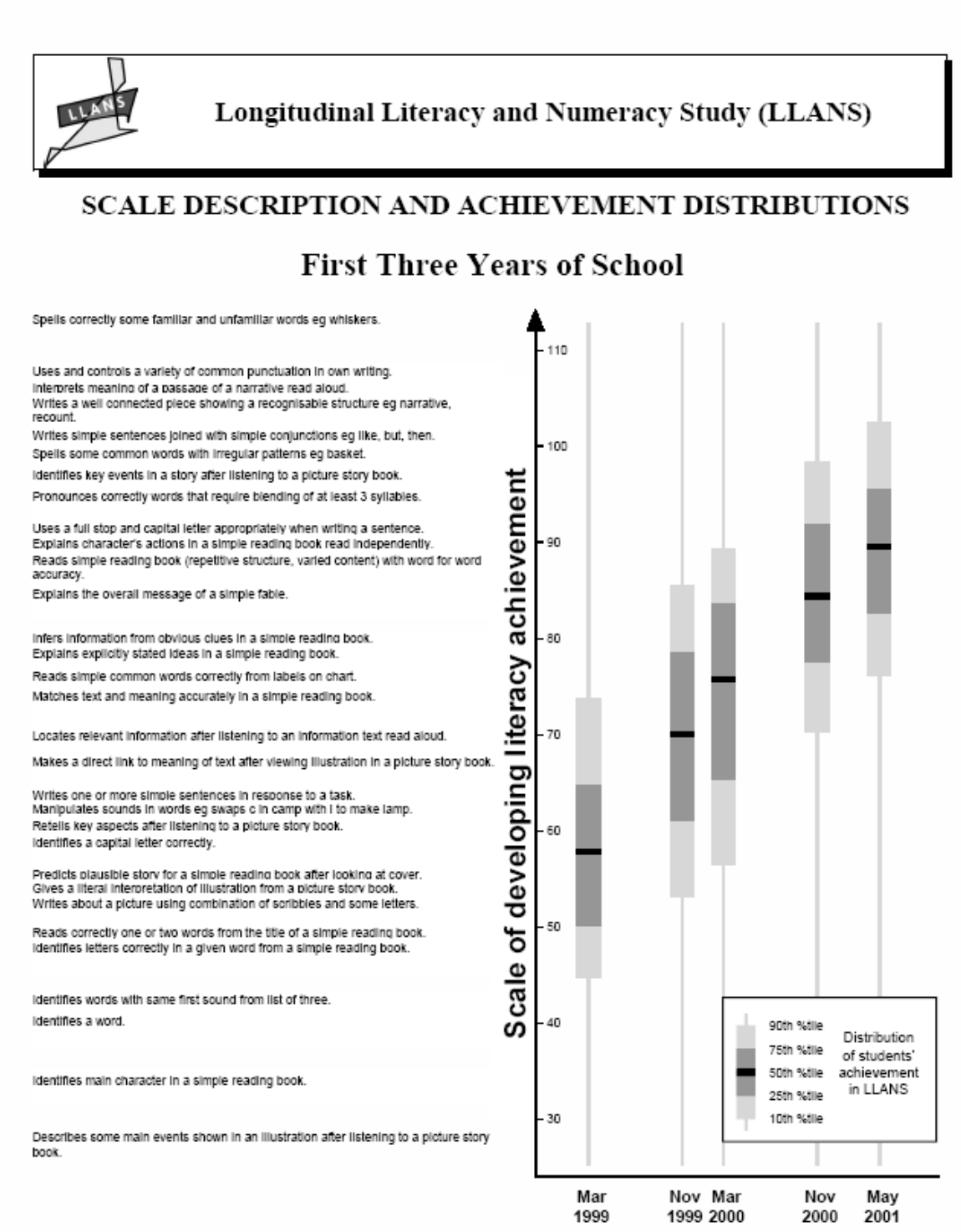


Figure 2: LLANS literacy scale description and achievement distributions for the first three years of school

Students' performance on the LLANS scale of developing numeracy achievement

The achievement distributions of the LLANS cohort in Surveys 1-5 are shown in Figure 3. The numeracy achievement distributions show considerable variation in achievement across the whole cohort of students on each assessment occasion. Around the median level of achievement in November 1999, at the end of the first year of school, students were able to *apply counting by fives to a collection structured in groups of five.* Students around the 90th percentile in March 2000, at the beginning of their second year at school, were able to *add the price of 2 items involving cents only*. Students in the 10th percentile in March 2000 could *count back from 10 by ones*.

Figure 3 shows that on average, children's numeracy skills developed most rapidly during their first year of school and continued to develop across the five surveys. However, it is interesting to note that there is very little difference between the median scores for November 1999 and March 2000, that is, between the end of the first year of school year and the beginning of the second year, a period that included the summer holidays when students do not participate in regular numeracy teaching programs. This is different than in the case of literacy, where although there was less development between surveys in the same period, there was a small increase in median scores.

The achievement distribution for the first survey in March 1999, indicates a wider variation for the middle 80 per cent of students than in the later assessments. This difference indicates the diversity amongst students at the beginning of the first year of school. Although a considerable variation in achievement is also evident in later assessments, the variation is somewhat less than at the commencement of formal schooling.

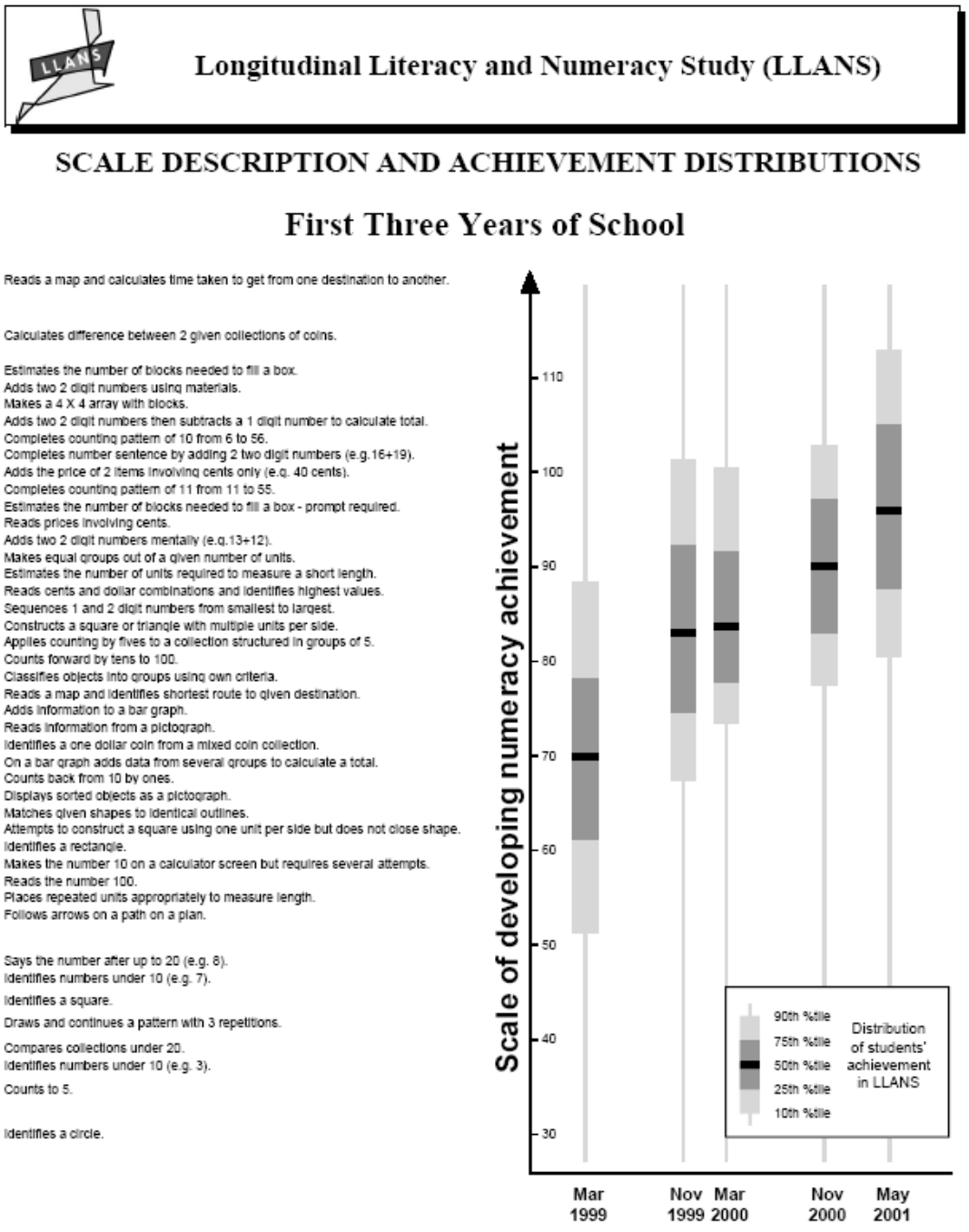


Figure 3: LLANS Numeracy scale description and achievement distributions for the first three years of school

Conclusion

Individual student performances in literacy and numeracy were estimated for each assessment on the LLANS Literacy Scale and on the LLANS Numeracy Scale. Individual differences in student growth trajectories across the first three years of school were also investigated.

It was found that there was significant variation in the students' developmental trajectories in literacy and in numeracy. There was significant individual variation in the performance at school entry and there was significant individual variation in the literacy growth rate and in the numeracy growth rate. Students started at different points and developed at different rates. (Meiers et al, 2006a and 2006b).

A wide distribution of literacy and numeracy achievement was noted at school entry and this continued through the first three years at school. This key finding indicates the complexity of the task of providing appropriate learning opportunities for all students.

The first survey was conducted early in the students' first year at school, and provided a picture of the diversity of literacy skills and knowledge amongst the cohort at school entry. Students around the 50th percentile were likely to be able to *identify a capital letter correctly*. Students who achieved above the 90th percentile were likely to be able to *retell a narrative in a picture story book including some key events*. Students whose achievement fell in the 10th percentile were likely to be able to *locate the front of a picture story book*, and *understand the directional sequence of text*.

There was a considerable variation in numeracy achievement across the whole cohort of students on each assessment occasion in the first three years of school.

In the first survey, which was conducted early in the students' first year at school, students around the 50th percentile were likely to be able *to add data from several pieces to a bar graph*, and *count back from 10 by ones*. Students who achieved above the 90th percentile were likely to be able *to read cents and dollar combinations and identify highest values*. Students whose achievement fell in the 10th percentile were to be able *to identify a different attribute of two objects, identify numbers under 10 correctly,* and *identify a square*.

Contribution to further research

The linked literacy assessment tasks and the LLANS Literacy Scale have proved useful for studying literacy development in the early years. They have been used by a number of other research projects for studying children's growth in literacy and in teacher effectiveness studies.

The LLANS literacy and numeracy assessments tasks have been used in another ACER longitudinal study monitoring growth in literacy and numeracy achievement in a group of Indigenous students who commenced school in 2000 (Frigo *et al.*, 2004).

The LLANS literacy assessments tasks have been used in a national study of effective literacy teaching practices (W. Louden *et al.*, 2005; W. Louden, Rohl., Barratt-Pugh, C., Brown, C., Cairney, T., Elderfield, J., House, H., Meiers, M., Rivalland, J., Rowe, K., 2005). A representative sample of children in the first and second years of school completed the LLANS literacy assessment tasks at the beginning and at the end of the school year. The assessments provided an evidential link between student outcomes and teaching practices in this study. An analysis of growth in performance on the assessment tasks from the beginning to the end of the school year enabled the researchers in this project to identify classrooms where students had made better progress in literacy than expected. A similar methodology using the LLANS linked literacy assessments was employed in a recent study undertaken by a research team at the University of Western Australia, investigating effective literacy teaching practices at Pre-Primary and Year 1 in a sample of Western Australian schools. (Louden, Rohl, Hopkins, 2008)

The LLANS literacy assessment tasks are also being used to assess four cohorts of students at four year levels in schools in the Northern Territory. This is a three-year longitudinal study investigating the effectiveness of four different literacy approaches, including a bilingual program for Indigenous students. This evaluation, managed by the Northern Territory Department of Education, Training and Employment, commenced in 2006 and the final set of assessment data, using the LLANS literacy assessments, will be collected in November 2008.

This longitudinal study provided a range of insights into the nature of development in literacy and numeracy from school entry to Year 6. This paper has focused on findings about growth in literacy and numeracy in the first three years of school. The linked literacy assessment instruments for the five surveys used in the early years have been of particular interest, and have provided useful methodological tools for other studies of literacy teaching and learning.

Further reading

A full account of the first three years of the LLANS can be found in the ACER research monograph**:**

Meiers, M., Khoo, S.T., Rowe, K., Stephanou, A., Anderson, P., Nolan. K. (2006). *Growth in Literacy and Numeracy in the First Three Years of School*. ACER Research Monograph No. 61. Camberwell: Australian Council for Educational Research
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