The influence of curriculum, assessment, customised instruction and intervention for providing high quality mathematics education in the lower primary years

Ann Gervasoni, Monash University, Australia

Introduction

Research over the past ten years has highlighted that many children starting school are more mathematically capable than what mathematics curricula and textbooks assume (Bobis, 2002; Clarke, Clarke, & Cheeseman, 2006; Ginsburg & Seo, 2000; Hunting et al., 2012). 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 opportunity to thrive mathematically (Perry & Dockett, 2008). This paper explores the impact of curriculum, assessment interviews, customised instruction, and intervention programs for designing high quality mathematics education in the lower primary years.

Australian children's mathematics knowledge just prior to beginning school

In order to provide insight about pre-school children's mathematics understanding prior to beginning school, Gervasoni and Perry (2013) examined mathematics assessment data for 125 children in December 2012, prior to their beginning school in 2013, and compared this knowledge to the new Australian Curriculum – Mathematics (Australian Curriculum, Assessment and Reporting Authority (ACARA), 2013) standard for the first year at school. The children were assessed using the task-based Mathematics Assessment Interview (Gervasoni et al., 2011), formerly known as the *Early Numeracy Interview* (Clarke et al., 2002), the development of which has been widely reported (e.g., Bobis et al., 2002). These children formed the comparison group for the *Let's Count Longitudinal Evaluation* (Gervasoni & Perry, 2013). Children were presented with all of the early mathematics concepts tasks in the 'Foundation Detour' section of the assessment and also with tasks from the Whole Number, Measurement and Geometry sections. Results for an illustrative selection of the number, measurement and spatial tasks are presented in Tables 1-4. These are grouped according to the associated *Australian Curriculum - Mathematics* Foundation Year Standard or Proficiency (ACARA, 2013). Each table shows the percentage of children, who were successful with each task in December 2012, comparison percentages for 1438 children in the February/March 2001 ENRP First Year at School cohort (Clarke et al., 2006), and the associated *Australian Curriculum – Mathematics* Foundation Year Standard or Proficiency. Results from the ENRP cohort provide comparative results that describe the knowledge of a large group of children that was representative of the Victorian population.

The results for the *Let's Count* preschoolers suggest that about three-quarters of these children demonstrate the Standard before they begin school. The ENRP results for children beginning school are similar. The Foundation standard also focuses on students counting to and from 20 and ordering small collections. Several tasks 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 2.

Table 1. Percentage success on tasks with small sets

Tasks	Dec 2012 *n*=125	ENRP 2001 *n*=1438	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 10.
Identify one of two groups as "more"	90	84	
Make a set of 5 teddies when asked	77	85	
Conserve 5 when rearranged by child	79	58	
Combine 5+3 blue teddies and total	75	na	
Make collection of 7 (when shown number 7)	63	na	
Knows one less than 7 when 1 teddy removed	61	na	
Knows one less than 7 without recounting	25	na	

Table 2. Percentage success with counting and ordering numerals

Tasks	Dec 2012 (*n*=125)	ENRP 2001 (*n*=1438)	Australian Curriculum Foundation Standard
Counting Tasks			
Rote count to 10	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 & 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 3 one-digit numbers	47	na	
Orders 3 two-digit numbers	28	na	

The data suggest that the majority of preschoolers can count to 10 and at least one-quarter can forward count to 20, but not back from 20. Few students could count 20 teddies successfully and also identify how many teddies remained when one teddy was removed from the group. This focus on the cardinal value of 20 is a profitable area for instruction in the first year at school, but is not highlighted in the Foundation Standard.

Overall, the results suggest 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 most important when children transition to school. A key challenge for teachers in supporting children's transition to school is obtaining detailed information about what children know so that necessary curriculum adjustments can be made. The data also highlights the broad range of formal mathematics knowledge that many children construct prior to beginning school. While on the one hand these data demonstrate that this is a diverse group of children, it is also apparent that children's everyday home and pre-school experiences prepare most children well for the transition to learning mathematics at school.

The impact of mathematics assessment for designing instruction that enables all students to thrive: 'Victoria' Primary School- An illustrative case

The data presented in the previous section highlight the importance of designing mathematics curriculum that enables all children to thrive when they begin school. Schools participating in the Australian *Bridging the Numeracy Gap Project* in 2010-2011 (Gervasoni et al., 2010) focused explicitly on maximising children's learning in the lower primary school through enhancing five components of a *whole school approach* for improving outcomes for students (Fullen, Hill, and Crevola, 2006). These components were (i) assessment literacy; (ii) leadership and coordination; (iii) professional learning; (iv) classroom teaching, and; (v) intervention and assistance. To investigate the effect of these enhancements on children's mathematics learning, children's growth in whole number learning across the first year at school was measured and compared with a different cohort that was representative of Victorian children. As an illustrative case, the next section compares the whole number learning of 5-year-old children at Victoria Primary School (pseudonym) with the ENRP comparison group. All children were assessed using the *Early Numeracy Interview* (Clarke et al., 2002) described earlier.

Victoria Primary School is situated in a regional Victorian town listed by the State Government as one of the five-most disadvantaged populations in the State. For the previous eight years, the school had been implementing a whole school approach to improving mathematics learning guided by the design elements of the Hill and Crévola model (1999) and most teachers had some opportunities to engage in associated mathematics professional learning. Participation in the *Bridging the Numeracy Gap in Low SES and Indigenous communities Pilot Project* enabled the school to further develop five elements of the whole school approach. They increased the number of Grade 1 students who participated in an EMU Intervention Program, and ensured that the EMU specialist teacher had allocated time to work in partnership with classroom teachers for the purpose of designing and customising instruction based on assessment data.

To determine whether the enhanced school approach was associated with improved mathematics learning, measured by the ENRP growth point framework (Clarke et al., 2002), children's beginning and end-of-year Early Numeracy Interview (ENI) results were examined for Counting, Place Value, Addition and Subtraction Strategies and Multiplication and Division Strategies. The researchers also compared the growth point distributions of Victoria Primary School students to that of ENRP group who were representative of the Victorian student population. Figure 1 describes the Counting growth point distribution of Victoria Primary School Prep students (n=18) compared to the ENRP group (n=1711).

The growth point distributions for students when they begin school indicate a large difference between the two groups, and suggest that Prep students at Victoria Primary School had less experience with counting prior to commencing formal schooling. Examination of the children's growth points at the end of Prep (Figure 3) demonstrate that the Victoria Primary School children made good progress over the year, despite the fact that few students at the beginning could rote count to 20. Overall, the end of the year data for both groups were very similar. This suggests that the Victoria Primary School approach was successful in bridging the initial knowledge gap between the two groups. As a further example, Figure 2 compares the growth point distributions for the Addition and Subtraction Strategies domain at the beginning and end of Prep.

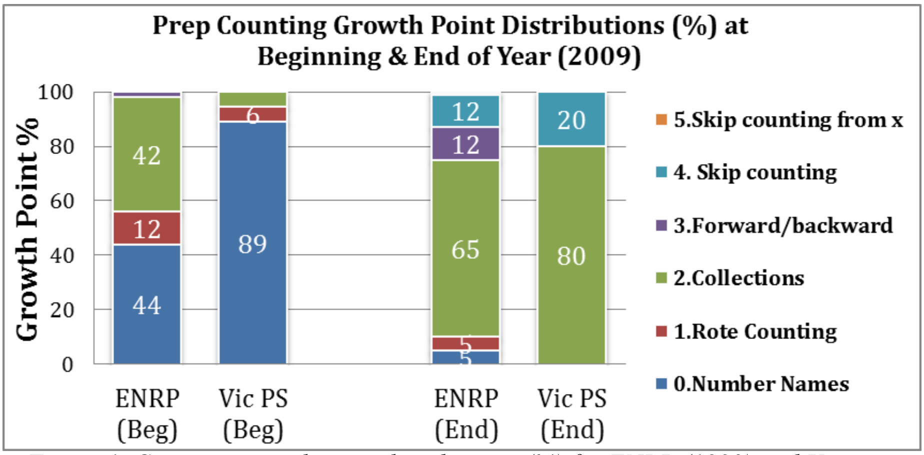

Figure 1. Counting growth point distributions (%) for ENRP (1999) and Victoria Primary School (2009) Prep students at the beginning and end of the year

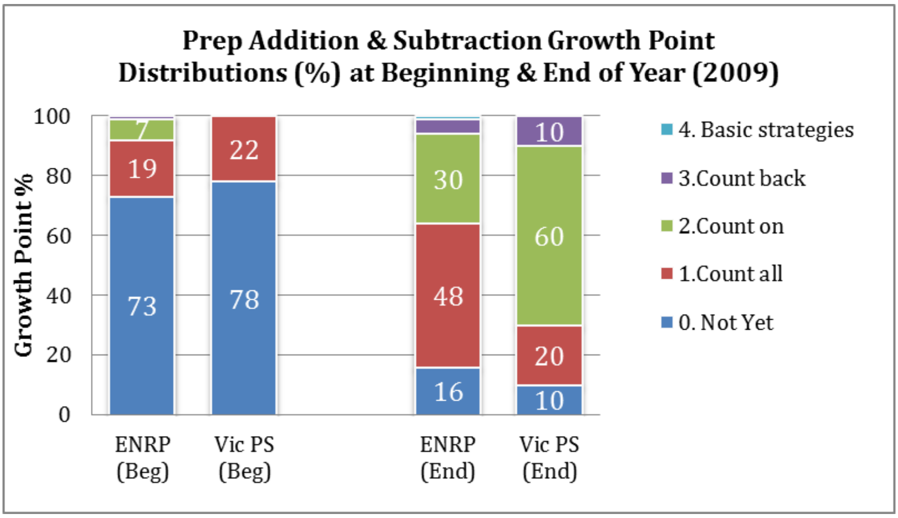

Figure 2. Prep addition & subtraction strategies growth point distributions for ENRP and Victoria Primary School students at the beginning and end of the year

These data suggest that the Victoria Primary School children (n=18) progressed considerably further over the year than did the ENRP group (n=1702). Seventy percent of Victoria Primary School Preps could use at least the count-on strategy in an addition problem (9+4), compared with 35% of ENRP Preps.

Impact of a mathematics intervention program

A key strategy used in the broader *Bridging the Numeracy Gap Project* was providing an intensive intervention program for mathematically vulnerable Grade 1 students. Forty-two students across 11 project schools participated in an EMU intervention program in 2010. They were the most mathematically vulnerable students in their class based on their Mathematics Assessment Interview (MAI) growth point profiles (Gervasoni, 2004). The MAI is a refined version of the ENI that was enhanced during the project. Analysis of these students' initial growth points suggests that they were a diverse group. Some were vulnerable in only one domain (21%), some in two (31%) or three domains (33%), but only four students (10%) were vulnerable in all four domains (Gervasoni et al., 2012). The combination of domains for which the children were vulnerable varied and it was clear that there was no one pattern to describe children who were mathematically vulnerable. In order to investigate the longitudinal progress of students who participated in an EMU Program in 2010, their growth point distributions in 2010-2013 for each domain were calculated and compared with all students in their cohort. As an illustrative example, Figure 3 shows the growth point distributions for the Multiplication and Division Strategies domain. Note that due to the larger project ending in 2011, data for all the 2012 Grade 3 cohort and 2013 Grade 4 cohort were unavailable, so data from 2011 was used as indicative of the distributions that might be expected. An asterix indicates use of 2011 data in Figure 3.

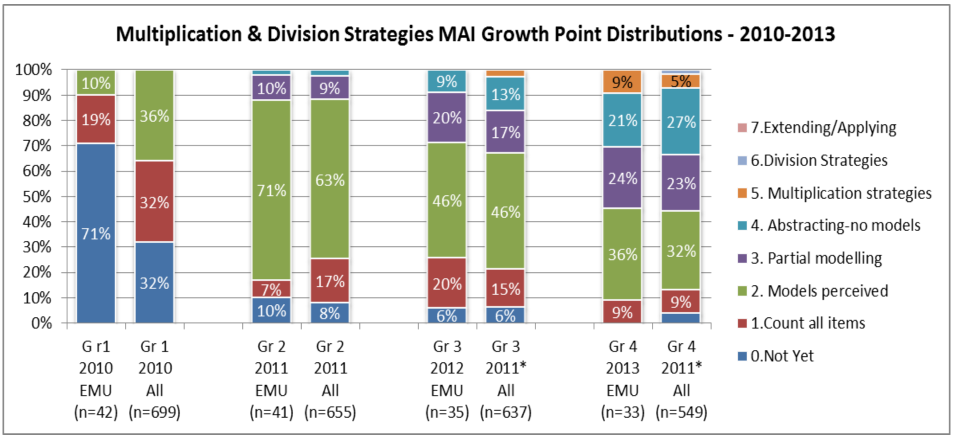

Figure 3. Progressive (2010-2012) multiplication & division growth point distributions (beginning of the year) for the 2010 EMU group and comparison data for all Grade 1-Grade 4 students

Figure 3 highlights that for the 2010 EMU group substantial growth occurred by 2011 during their 2010 EMU year. Further, it is striking how similar the growth point distributions are in the second year (2011) for both the EMU group and the entire cohort. This finding was apparent also for the other whole number domains. These data suggest that one effect of the EMU Program was accelerating whole number learning such that the EMU group's growth point distribution in 2011 mirrored that of all students one year later. The proportion of EMU students who were vulnerable in Multiplication and Division strategies decreased from 71% in 2010 to 17% in 2011. Nevertheless, some EMU students (10%) remained on the lowest growth point while, in contrast, others had progressed two or three growth points across the year. It is useful to note that each growth point represents a significant milestone in a student's development that may take 12 months to achieve, as opposed to smaller steps in learning that are noticeable every day (Clarke et al., 2002).

Although it is evident that most students participating in the EMU intervention program made substantial progress by Grade 2, it is important to consider whether their learning was maintained or faded when they no longer had the opportunity afforded by an intervention program. A comparison of the Grade 2 - Grade 4 Multiplication and Division growth point distributions (Figure 3) for the EMU group and the entire cohort suggest that their learning was mostly maintained. However, the 2013 data suggests that little or no progress occurred for many students in both groups across their Grade 2 year. This finding suggests that the curriculum and instruction experienced by most Grade 2 and Grade 3 children was not sufficiently focused to enable children to thrive.

Conclusion

This paper considered the findings from two research studies to highlight the importance of providing high quality mathematics curriculum and teaching that enables young children to thrive mathematically. First it was shown that many children participating in the *Let's Count Longitudinal Evaluation* had learnt aspects of the Australian Curriculum – Mathematics prior to beginning school. This highlights the critical importance of teachers adjusting the initial school curriculum based on their assessment of children's current knowledge. Second, findings from the *Bridging the Numeracy Gap Project* show that an emphasis on using assessment and growth points to guide instruction, focused mathematics leadership and professional learning, within a whole school approach, enabled Prep children at Victoria Primary School to progress overall more than was apparent for the ENRP comparison group. Finally, longitudinal data showing the progress of Grade 1 children who participated in an EMU intervention program suggests that these children maintained and extended their learning through to Grade 4. However, this data also showed that a large proportion of all children in Grade 2 and Grade 4 stagnate in their whole number learning for considerable periods. This suggests that the curriculum and teaching emphasis for whole number learning in the middle years of primary school currently may not be adequate for most children.

References

Australian Curriculum, Assessment and Reporting Authority (ACARA) (2013). *The Australian curriculum: mathematics v2.4.* Retrieved 17 March 2013: http://www.australiancurriculum.edu.au/Mathematics/Curriculum/F-10

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

Clarke, B. A., Sullivan, P., & McDonough, A. (2002). Measuring and describing learning: The Early Numeracy Research Project. In A. Cockburn & E. Nardi (Eds.), *PME 26: Proceedings of the 26th annual conference (181-185).* Norwich, UK: PME.

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.

Clarke, D., Cheeseman, J., Gervasoni, A., Gronn, D., Horne, M., McDonough, A., Montgomery, P., Roche, A., Sullivan, P., Clarke, B., & Rowley, G. (2002). *ENRP Final Report*. Melbourne: ACU.

Fullan, M., Hill, P., & Crévola, C. (2006). *Breakthrough.* Thousand Oaks: Corwin Press.

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

Gervasoni, A. (2004). *Exploring an intervention strategy for six and seven year old children who are vulnerable in learning school mathematics.* Unpublished PhD thesis, La Trobe University, Bundoora.

Gervasoni, A., Hadden, T., & Turkenburg, K. (2007). Exploring the number knowledge of children to inform the development of a professional learning plan for teachers in the Ballarat diocese as a means of building community capacity. In J. Watson & K. Beswick (Eds.)*, Mathematics: Essential research, essential practice, Proceedings of the 30th annual conference of the Mathematics Education Research Group of Australasia,* pp. 305–314. Hobart: 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 Australian Association of Mathematics Teachers and the 34th annual conference of the Mathematics Education Research Group of Australasia, Vol 1, pp. 315-323). Alice Springs: MERGA/AAMT.

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., & 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.

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

Hill, P.W., & Crévola, C.A. (1999). The role of standards in educational reform for the 21st century. In D. D. Marsh (Ed*.), ASCD Yearbook 1999: Preparing our schools for the 21st century*, 117-142. Alexandria, VA: Association for Supervision and Curriculum Development.

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.

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.

Acknowledgement

The research reported in this paper was funded by the Australian Government as part of the *Bridging the Numeracy Gap in Low SES and Indigenous Communities* Project and by The Smith Family as part of the Let's Count Longitudinal Evaluation. The author acknowledges gratefully the contribution of educators, parents, principals, students and research assistants.

Ann Gervasoni
Faculty of Education
Monash University, Clayton VIC, 3800, Australia
Ann.Gervasoni@monash.edu