

The Progress of Grade 1 Students Who Participated in an Extending Mathematical Understanding Intervention Program

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The *Extending Mathematical Understanding* (EMU) Program is a specialised mathematics program that aims to accelerate the learning of Grade 1 students who struggle with learning school mathematics. Forty-two students participated in an EMU Program in 2010 as part of the *Bridging the Numeracy Gap* (BTNG) project. Analysis of students' mathematics knowledge at the beginning of the EMU Program highlighted how diverse was this group of students. The students' mathematics knowledge was assessed again at the beginning of the following year in order to evaluate the effectiveness of the program for accelerating learning. Overall the students made very good progress and their learning was maintained.

Introduction

It is often observed by teachers that some students appear to struggle with learning school mathematics. Indeed, by the beginning of Grade 1 a wide difference in the whole number knowledge of students can be observed (Gervasoni, 2004). Governments and school communities recognise the value of identifying, early in schooling, the students who are not thriving mathematically and in providing them with more intensive instruction. Indeed, providing additional assistance and intervention programs for students who struggle with learning maths in the classroom is recognised as one of the key factors in a whole school approach for improving learning (Fullen, Hill & Crevola, 2006; Gervasoni, Parish, Upton, Hadden, Turkenburg, Bevan, Livesey, Thompson, Crowell & Southwell, 2010). However, many primary schools do not have teachers on staff with specialist knowledge about how to diagnose students' mathematics difficulties and design instruction that will accelerate students' learning. The *Extending Mathematical Understanding* (EMU) Specialist Teacher Course and the EMU Intervention Program for Grade 1 students was designed to achieve this objective. This paper explores the progress of 42 Grade 1 students who participated in an EMU Program in 2010 as part of the *Bridging the Numeracy Gap Pilot* (Gervasoni, Parish, Hadden, Turkenburg, Bevan, Livesey, & Crowell, 2011). The research questions framing the research reported in this paper are:

What are the growth point profiles of Grade 1 students who are mathematically vulnerable and who participated in an EMU program?

What is the progress of Grade 1 students who participated in an EMU program?

The Bridging the Numeracy Gap Project

The *Bridging the Numeracy Gap* Project (Gervasoni et al., 2011) was a collaboration between 44 school communities, the Catholic Education Offices (CEOs) in three dioceses in south-eastern Australia (Ballarat, Sandhurst and Sale), the CEO Western Australia, and Australian Catholic University. It aimed to improve the mathematics learning of students in the early years of schooling. Key approaches used in this project were: one-to-one interview-based mathematics assessment using the *Early Numeracy Interview* and associated framework of growth points (Clarke, Cheeseman, Gervasoni, Gronn, Horne,

McDonough, Montgomery, Roche, Sullivan, Clarke, & Rowley, 2002; Gervasoni, Turkenburg, & Hadden, 2007); and using the *Extending Mathematical Understanding Program* (Gervasoni, 2004) in the second year of formal schooling to provide intensive specialised instruction for children who were mathematically vulnerable.

The *Early Numeracy Interview* (Department of Education Employment and Training, 2001), developed as part of the Early Numeracy Research Project (ENRP, Clarke et al., 2002), is a clinical interview with an associated research-based framework of growth points that describe key stages in the learning of nine mathematics domains. This interview and the growth points were used to obtain the data examined in this paper so it is important that both are well understood. The principles underlying the construction of the growth points were to: describe the development of mathematical knowledge and understanding in the first three 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., Steffe, von Glasersfeld, Richards, & Cobb, 1983; Fuson, 1992; Mulligan, 1998; Wright, Martland, & Stafford, 2000; Gould, 2000); reflect, where possible, the structure of mathematics; allow the mathematical knowledge of individuals and groups to be described; and enable a consideration of students who may be mathematically vulnerable.

The growth points form a framework for describing development in nine domains, including the four whole number domains that are the focus of this research: Counting, Place value, Addition and Subtraction, and Multiplication and Division. The processes for validating the growth points, the interview items and the comparative achievement of students in project and reference schools are described in full in Clarke et al. (2002).

To illustrate the nature of the growth points, the following are the growth points for Addition and Subtraction. These emphasise the strategies children use to solve tasks.

1. Counts all to find the total of two collections.
2. Counts on from one number to find the total of two collections.
3. Given subtraction situations, chooses appropriately from strategies including count back, count down to & count up from.
4. Uses basic strategies for solving addition and subtraction problems (doubles, commutativity, adding 10, tens facts, other known facts).
5. Uses derived strategies for solving addition and subtraction problems (near doubles, adding 9, build to next ten, fact families, intuitive strategies).
6. Extending and applying. Given a range of tasks (including multi-digit numbers), can use basic, derived and intuitive strategies as appropriate.

Each growth point represents substantial expansion in knowledge along a path to mathematical understanding (Clarke, 2001). Growth points enable teachers to: identify any children who may be vulnerable in a given domain; identify the zone of proximal development for each child in each domain so instruction may be customised and precise; and identify the diversity of mathematical knowledge in a class. The whole number tasks in the interview take between 15-25 minutes for each student and are administered by the classroom teacher. There are about 40 tasks in total, and given success with a task, the teacher continues with the next tasks in a domain (e.g., Place Value) for as long as the child is successful. Teachers report that the *interview* provided them with insights about students' mathematical knowledge that might otherwise remain hidden (Clarke, 2001). This was a key reason for using the Early Numeracy Interview (*ENI*) for the *Bridging the Numeracy Gap* project.

The Extending Mathematical Understanding (EMU) Program

One key aspect of the approach used in the *Bridging the Numeracy Gap Project* was providing the opportunity for students who were mathematically vulnerable to participate in an EMU program (Gervasoni, 2004). This is a series of lessons specifically designed by a specialist teacher for the purpose of accelerating the most vulnerable students' learning. Groups of three students participate in these lessons for 30-minutes per day, 5 days per week for 50-100 lessons depending on student progress. Each lesson centres on whole number learning with specific focuses on quantity or numerosity (including place value and counting), investigations involving addition, subtraction, multiplication and division problems with an emphasis on the development of reasoning strategies, reflection on learning, and a home task. The specially qualified EMU teachers have completed a course (at Masters level) that includes 36 hours of course work, a minimum of 25 hours of field-based learning, and a program of professional reading.

Identifying Eligible Students for an EMU Intervention Program

All students participating in the *Bridging the Numeracy Gap* pilot were assessed by their classroom teachers at the beginning of 2010 and 2011 using the *Early Numeracy Interview*. This assessment was used by teachers to get to know their students mathematically so that they might refine the curriculum and instruction for class groups and individual students. The assessment was also used to identify any students who were mathematically vulnerable in any domains and who may not fully benefit from the classroom mathematics program. A research-based set of growth points were used for this purpose (Gervasoni, 2004). Students who were identified as vulnerable in any domains were prioritised for an EMU intervention program.

The record sheets completed by teachers during the interviews were analysed by independent coders to determine the growth points reached in each domain. These were entered into an SPSS data base along with information about the background of each student, whether or not they participated in an EMU program, and if so, the total number of EMU lessons. This data was further analysed to explore the mathematical knowledge of the students who participated in an EMU program and their progress across one year.

A total of 136 Grade 1 students from 26 schools in Victoria and Western Australia were prioritised for participation in an EMU Program in 2010 as part of the *Bridging the Numeracy Gap* Project. There were 55 boys (40%) and 81 girls. Five students (4%) were Aboriginal or Torres Strait Islanders, and forty-five students (33%) were from families with Health Care Cards or who received an Educational Maintenance Allowance. Eighteen (13%) had non-English speaking backgrounds, six (4%) had a disability and eight (6%) a severe language deficit. Sixteen children (12%) also participated in *Reading Recovery* (13 in 2010, and 3 in 2009). Of these 136 students, only 42 with the highest priority ratings following their ENI assessment participated in an EMU Program for 10-20 weeks (between 50 and 100 thirty-minute lessons). Due to limited resources it is rare for schools to provide intervention programs for all eligible students. Some schools were able to offer additional support for vulnerable students but not with the regularity required for the EMU Program.

Progress of Grade 1 Students Participating in an EMU Program

Forty-two students had the opportunity to participate in an EMU Program in 2010. They were selected because they were the most mathematically vulnerable students in their grade level on the basis of their ENI assessment and growth point profiles. An analysis of these

students' initial growth points suggests that overall they are a diverse group. Table 1 shows the number of students who were vulnerable in each domain.

Table 1
The Number of Grade 1 Students Participating In an EMU Program Who Were Vulnerable In Each Domain.

	No. of Girls (n=24)	No. of Boys (n=18)	No. of Students (n=42)
Vulnerable in Counting	15 (63%)	14 (78%)	29 (69%)
Vulnerable in Place Value	9 (44%)	8 (38%)	17 (41%)
Vulnerable in Addition and Subtraction	8 (33 %)	9 (50%)	17 (41%)
Vulnerable in Multiplication and Division	16 (67%)	14 (78%)	30 (71%)

The data shows clearly that not all students participating in the EMU Program were vulnerable in every domain. Table 2 shows the number and combinations of domains for which students were vulnerable. Two students were not vulnerable in any domains but the school community prioritised them for the EMU Program because of other assessments.

Table 2
Combinations of Whole Number Domains in Which Students Participating in the EMU Program Were Vulnerable in 2010.

Vulnerable Domains	Counting	Place Value	Add & Sub	Mult & Div	No. of Vulnerable Students	Total Students
0						2 (5%)
1					2	9 (21%)
					0	
					4	
					3	
2					1	13 (31%)
					2	
					7	
					0	
					2	
					1	
3					1	14 (33%)
					4	
					8	
					1	
4					4	4 (10%)

A striking feature of the data presented in Table 2 is the broad range of domains and combinations of domains in which children are vulnerable. Some are vulnerable in only one domain, some in two or three domains, but only four students are vulnerable in all four

domains. Clearly there is no one pattern to describe these children who are mathematically vulnerable. This highlights the complexity of teaching and the need for teachers to be expert at assessing students' knowledge and in designing instruction that enables all students to learn.

In order to show the progress of students participating in an EMU Program, their growth point distributions in 2010 and 2011 for each domain were compared with all Grade 1 students. As illustrative examples, Figures 1 and 2 show the growth point distributions for Addition and Subtraction and Multiplication and Division Strategies.

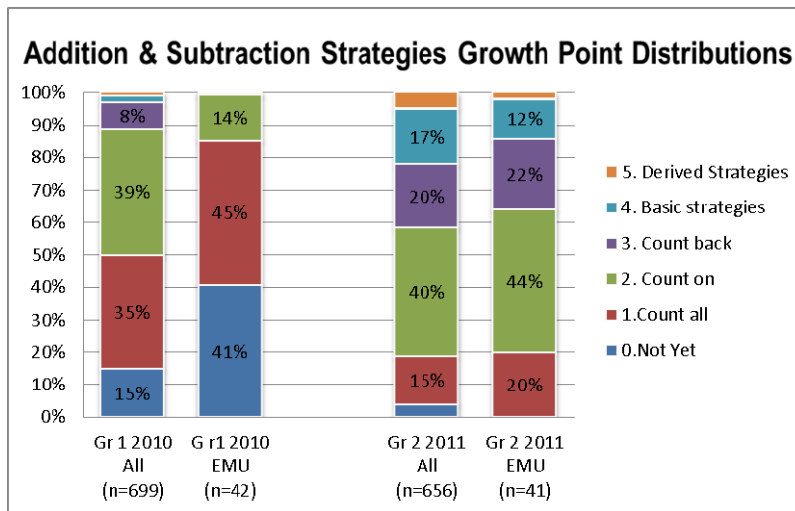


Figure 1. 2010 and 2011 Addition and Subtraction Strategies growth point distributions (beginning of the year) for all Grade 1 students in 2010 and for students who participated in an EMU program in 2010.

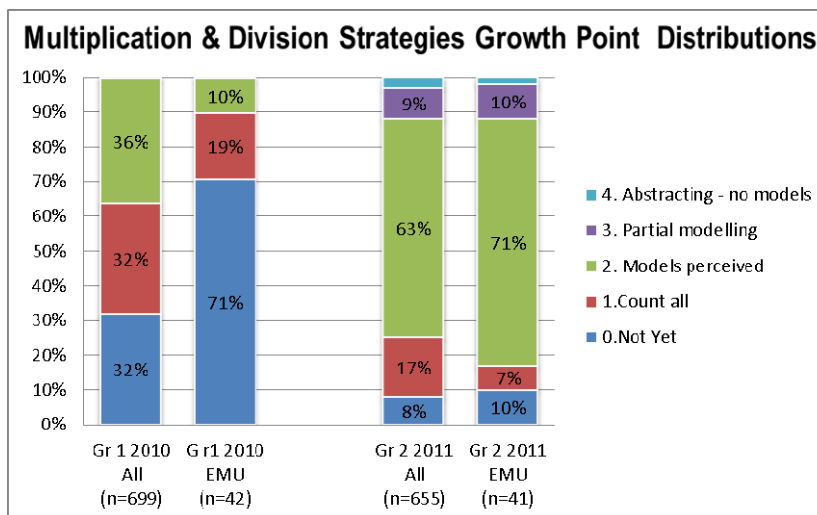


Figure 2. 2010 and 2011 Multiplication and Division growth point distributions (beginning of the year) for all Grade 1

The graphs highlight the growth that occurred across the year for the majority of EMU students. It is striking how similar the growth point distributions are in 2011 for both groups, and this is apparent for all four whole number domains. This suggests that one effect

of the EMU program in 2010 was that learning was accelerated to the point that their growth point distributions mirror the distribution of all students one year later. However, some EMU students remain on the lower growth points despite the fact that others have accelerated and progressed two or three growth points. This is equivalent to two or three years growth compared with mean growth (see Clarke et al., 2002).

An issue highlighted when examining the data for Addition and Subtraction Strategies (Figure 1) is that about 20% of Grade 2 students overall need to *count all* to solve a task. This is a reduction from the previous year but highlights that an important instructional focus for Grade 2 students is developing reasoning based strategies such as doubles, partners for ten and building to ten. An examination of the Multiplication and Division Strategies data (Figure 2) highlights a similar issue. About 25% of beginning Grade 2 students (although fewer in the EMU group) are *counting all* and do not yet use the group structure to assist with solving multiplicative problems. Thus noticing and using the multiplicative structure is a key instructional focus for these students at the beginning of Grade 2, whilst for the majority of others, their instruction needs to initially focus on strategies for solving problems in partial modelling situations.

The progress of EMU students was also analysed by calculating the number of growth points students progressed in each domain. Table 3 shows the findings for Multiplication and Division as an illustrative example. The first column shows the growth point range in 2010, and the remaining columns show progress in 2011. For example, of the 29 students beginning on Growth Point 0 in 2010, 21 had moved to Growth Point 2 by 2011.

Table 3

The Number of EMU Students on Each Multiplication & Division Growth Point in 2011 Compared with Their Growth Point in 2010.

EMU Students Multiplication & Division Growth Point (GP) in 2010	Number of EMU Students on each Multiplication & Division Growth Point in 2011					
	GP0	GP1	GP2	GP3	GP4	Total
GP0	4	2	21	1	1	29
GP1	0	1	6	1	0	8
GP2	0	0	2	2	0	4
Total	4	3	29	4	1	41

The data in Table 3 demonstrates that most students made significant growth over the year. However, 7 of the 41 students remained on their 2010 growth point when they were assessed in 2011. This suggests that some students may require further assistance to enable them to learn mathematics. This finding is apparent for the other domains also.

Discussion and Conclusion

Analysis of the *ENI* data for all Grade 1 students participating in the *Bridging the Numeracy Gap* Pilot highlights the broad range of growth points within this cohort and thus the complexity of classroom teaching. The range of whole number knowledge is extraordinary. It is also clear that there are a number of students on much lower growth points than many of their peers. For example, in contrast to the majority and despite 12 months at school, some Grade 1 students were unable to count a collection of 20 items, or count all to solve addition and subtraction problems, or multiplication and division

problems. This suggests that these students may have difficulty accessing and benefiting from the regular Grade 1 classroom program that typically assumes this knowledge.

Forty-two of the Grade 1 students who were on the lowest growth points had the opportunity to participate in an Extending Mathematical Understanding program designed to accelerate their mathematical learning and assist them to benefit from the classroom program. Analysis of the growth point profiles of these students show that they are a diverse group but that very few were vulnerable in all four whole number domains. Further, some students were vulnerable in only one, two or three domains, and the combinations of domains also varied. Indeed, there was no one pattern to describe these students whole number knowledge or learning needs. The implication of this finding is that their teachers need to be expert at assessing each student's current mathematical knowledge, and at designing highly responsive instruction based on this assessment. It is also important to note that very few of these students had other learning difficulties. Few participated in *Reading Recovery*, had language backgrounds other than English or were assessed with severe language difficulties. Often it is assumed that lower achievers in mathematics have a range of factors affecting their opportunity to thrive in mathematics learning, but this was not typical of many students in this group.

An important focus for this paper was reporting on the progress of students who participated in an EMU program in Grade 1. The students were independently assessed by classroom teachers at the beginning of 2010 and 2011 to provide a measure of their whole number learning across one year. Overall, the forty-two students made very good progress and had achieved significant growth by the beginning of 2011 (and after the extended Christmas holidays). Findings from the *ENRP* (Clarke et al., 2002) suggest that mean growth for Grade 1 students across one year was about one growth point in each domain, and somewhat less in Place Value. The students participating in the EMU program in 2010 progressed between 5 and 11 growth points in the four domains overall. There were some students who did not progress in particular domains, but most students improved two growth points per domain, although this was rare in Place Value. The acceleration of learning is obvious when comparing the growth point distributions of the EMU students when they reached Grade 2 with all Grade 2 students. Indeed, by Grade 2, the growth point distributions of both groups were almost identical compared with one year earlier.

The data analysis also suggests that learning for students who participated in an EMU program is not accelerated for all students in all domains. Further, a small proportion of the students were still mathematically vulnerable the following year. Also clear is that a proportion of the EMU students reached the highest growth points in the distribution.

The EMU program was successful in enabling the majority of participating students to progress their whole number learning beyond what may be anticipated. This is true also for the students who began on the lowest growth points in each domain. The challenge remains to determine why some children make lesser progress than others, and to identify assessment and instruction that may accelerate these students' learning also. It is possible that these students may benefit from specialised instruction beyond Grade 1. It is also important to determine whether the children who participated in an EMU program continue to learn mathematics successfully in subsequent years.

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