

Using Growth Point Profiles to Identify Year 1 Students who are at Risk of not Learning School Mathematics Successfully

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

It is important for teachers to identify children who are at risk of not learning mathematics successfully as early as possible in their schooling. This enables school communities to put in place strategies to assist these children before they lose confidence. This paper explores assessment interview data for 1667 Victorian Year 1 primary school students with a view to developing profiles that may be used to identify children who are at risk. These profiles are based on growth points within the Early Numeracy Research Project assessment framework.

An important challenge for school communities is providing mathematics programs and teaching that ensure that all students learn mathematics successfully. Partly, this challenge is about recognising and assisting the children who are at risk of not learning school mathematics successfully as early as possible, before they lose confidence. At present, there is considerable debate about how teachers may identify children in Prep to Year 2 who are at risk. Currently, teachers in Victoria compare children's mathematical progress to the broad standards stated in the Curriculum and Standards Framework (CSF, Board of Studies, 2000) and thus identify the students who are not meeting these standards. However, teachers have no finer measure to determine who are the students at greatest risk and who may benefit from specialised additional assistance in mathematics.

To enhance the mathematical learning of children in the early years of schooling, the Victorian Department of Education, Employment and Training (DEET) has launched a three-year (1999-2001) research project: the *Early Numeracy Research Project* (ENRP, Clarke, 1999). The aim of the ENRP is to identify those teacher, coordinator and school community characteristics that enhance numeracy learning in the early years of schooling (P-2). The project has as its basis the eight design elements used in the Early Literacy Research Project (Hill & Crevola, 1997). One of these elements is intervention and special assistance. The inclusion of this design element recognises the fact that for some children, learning mathematics successfully requires specialised assistance and support beyond that provided by the regular classroom program.

This paper presents a preliminary analysis of ENRP assessment interview data for 1667 Victorian Year 1 primary school students with a view to identifying students who are at risk of not learning school mathematics successfully, and developing profiles of students who may benefit from additional assistance in mathematics.

Identifying Students Who May Benefit from Additional Assistance

Two programs operating in Australia which provide specialised assistance for Year 1 children who are at risk of not learning mathematics successfully are *Mathematics Recovery* (Wright, Cowper, Stafford, Stanger, & Stewart, 1994), and *Mathematics Intervention* (Merrifield & Pearn, 1999). These programs use the Early Arithmetic Stages (Steffe, von Glasersfeld, Richards, & Cobb, 1983) to identify participants for the programs. For example, in a study of *Mathematics Recovery* participants and their counterparts (Wright et al., 1994), students were initially assessed as prenumerical if they had not attained Stage 3 of the Stages

of Early Arithmetic Learning. That is, these students were not yet able to count-on to solve additive and missing addend tasks involving screened collections. In addition to the Early Arithmetic Stages, *Mathematics Recovery* assessment also considers children's facility with the forward and backward number word sequences, ability to identify numerals, and ability to subitise (Wright et al, 1994). Wright (1994) has described the stages that children attain in each of these areas. These stages have been used as the basis of the *Count Me In Too* program initiated by the NSW Department of Education (Stewart, Wright, & Gould, 1998), which, in addition to these areas, also discusses stages in the development of children's multiplicative thinking.

In order to identify the Year 1 students at risk of not learning mathematics successfully, *Mathematics Intervention* uses a clinical interview (Pearn, Merrifield, Mihalic, & Hunting, 1994) which is designed to allow young students to talk about their mathematical strategies. Merrifield & Pearn (1999) consider this to be a more effective method of obtaining information about children's own mathematical constructs and knowledge than traditional paper and pencil testing. The interview includes tasks that determine the facility of children's verbal counting skills; knowledge of the number word sequence, and tasks that would help ascertain their Early Arithmetic Stage. Merrifield & Pearn (1999) suggest a further stage that precedes the rest during which students recite the verbal number word sequence, either successfully or unsuccessfully, but do not seem to realise the purpose for counting. Children who participate in *Mathematics Intervention* are those who display difficulties with most tasks and are at Stage 0 or Stage 1 and use procedural strategies such as count-all. That is, they are children who have not yet reached the count-on stage. This strategy for identifying students at risk of not learning mathematics successfully aligns closely with that used in *Mathematics Recovery*.

It is important to note that the initial assessment for both the *Mathematics Recovery* Program and the *Mathematics Intervention* Program is undertaken by specialist teachers who have participated in extensive professional development which assists them to analyse assessment information and determine the Early Arithmetic Stages children have attained. In general, classroom teachers do not have knowledge of the Early Arithmetic Stages that may identify children who are at risk of not learning mathematics successfully. Two recent professional development programs which have provided classroom teachers with the opportunity to analyse their students' mathematical learning using the Early Arithmetic Stages are the NSW *Count Me In Too* program (Stewart et al, 1998), and the Melbourne Catholic Education Office program *Supporting Children's Early Numeracy Learning* (Gervasoni, 1998).

Using the ENRP Assessment Framework to Identify Students at Risk of not Learning Mathematics Successfully

The key to developing profiles of students at risk of not learning mathematics successfully is collecting rich, reliable assessment data that provides an insight about children's mathematical development. *Mathematics Recovery* Teachers and *Mathematics Intervention* Teachers use clinical interviews to gain assessment information and understand children's mathematical constructs and thinking. The ENRP has also developed an extensive 30-40 minute interview which provides the opportunity for classroom teachers to learn about their students' thinking and determine the mathematical growth points students have reached in nine

mathematical domains: counting, place value, addition and subtraction strategies, multiplication and division strategies, measuring time, measuring length, measuring mass, classification of shape, and visualisation.

As part of the ENRP, project teachers use an interview to assess their students' mathematical learning in both March and November each year. Experienced teachers who have been trained by the ENRP research team interview students in the reference schools. Following the interviews, the ENRP research team collects the assessment information obtained from the interviews for analysis, and determines the growth points each child has reached in each of the mathematics domains assessed. This process provides rich data for over 5000 students. With such a large sample, it is possible to achieve a picture of the mathematical learning of young children. Two analyses of this data are important in developing profiles of Year 1 children who are at risk of not learning mathematics successfully: first, a calculation of the number and percentage of Year 1 students in March who have not reached each of the *on-the-way* growth points for each of the number domains; second, the frequency of each of the number domain profiles for Year 1 students in March who have not yet reached all of the *on-the-way* growth points.

In order to achieve this, 1999 ENRP assessment interview data were analysed for 1667 Year 1 students. These students were between six and seven years of age and beginning their second year of primary school education. They each attended one of 54 Victorian Government Schools that began the ENRP in February 1999. This group comprises 27 project ('trial') schools and 27 control ('reference') schools from the nine DEET regions.

On-the-way Growth Points

It is anticipated that the ENRP Assessment Framework of growth points (Clarke, 1999) may assist teachers to identify the children in their class who are at risk of not learning mathematics successfully, and who may benefit from additional assistance beyond that possible within the regular classroom mathematics program.

In using the growth points to monitor children's learning, it is suggested that there is a growth point for each domain beyond which children may be considered to be learning successfully (the *on-the-way* growth point). Growth points below this may be indicative of students who are at risk and who may benefit from additional assistance or careful classroom monitoring. For example, the growth points for the Counting domain of the ENRP Framework are as follows:

0. Not apparent.
Unable to state the sequence of number names to 20.
1. Rote counting
Rote counts to at least 20, but is unable to reliably count a collection of that size.
2. Counting collections
Confidently counts a collection of around 20 objects.
3. Counting by 1s (forward/backward, including variable starting points; before/after)
Counts forwards and backwards from various starting points between 1 and 100; knows numbers before and after a given number.
4. Counting from 0 by 2s, 5s, and 10s
Can count from 0 by 2s, 5s, and 10s to a given target.
5. Counting from x (where $x > 0$) by 2s, 5s, and 10s
Given a non-zero starting point, can count by 2s, 5s, and 10s to a given target.
6. Extending and applying counting skills
Can count from a non-zero starting point by any single digit number, and can apply counting skills in practical tasks.

It is conjectured that for Year 1 students at the beginning of the year, the *on-the-way* growth point is growth point 2: counting collections of about 20 items. Not reaching this growth point provides one piece of evidence to suggest that a child be at risk of not learning mathematics successfully.

Profiles of Children who may be at Risk

In developing profiles that may identify children who may benefit from additional assistance beyond that provided by the regular classroom program, I have decided to focus on the four number domains of the ENRP framework. Although children's learning in the measurement domains is most important, an understanding of number underpins much of this learning. Also, a preliminary analysis of the ENRP data indicated that very few children had not reached the *on-the-way* growth points in the measurement domains. Therefore, it seemed that profiles based on the number domains would provide the best initial indication that a child was at risk.

The first step in developing profiles of children at risk of not learning mathematics successfully was analysing the ENRP data in order to determine how many children had not reached the *on-the-way growth* points for the number domains in the ENRP framework. Tables 1-4 describe the number of students who have attained the *on-the-way* growth point for the number domains in March, and the number of students who have reached each growth point below this. The percentage of the cohort attaining each of these growth points is shown also. The heavy lines in Tables 1-4 indicate the growth points beyond which children may be considered *on-the-way* to learning mathematics successfully. The shading indicates growth points that suggest children may be at some level of risk.

Counting

It would be hoped that all Year 1 students in March could count a collection of about 20 objects. The data indicates that in March, 88% of Year 1 students can at least count a collection of about 20 objects. Indeed, 23% of Year 1 students can at least count forwards and backwards by one from a given number. The 5% of students who know some number names but cannot yet rote count may require additional assistance. A further 7% of Year 1 students who can rote count but not yet count a collection of about 20 objects may also benefit from targeted assistance.

Place Value

In March, 89% of Year 1 children can read, write, interpret and order one digit numbers, and 16% of children at least can read, write, interpret and order two digit numbers. The 11% of students who in March cannot yet read, write, interpret and order one digit numbers should be carefully monitored by the classroom teacher.

Addition and Subtraction Strategies

Programs such as *Mathematics Recovery* and *Mathematics Intervention* suggest that a key to recognising Year 1 children who are at risk of not learning mathematics successfully is Stage 3 of the Early Arithmetic Stages: count on. This is equivalent to the second growth point in the ENRP addition and subtraction strategies domain. Table 3 shows that 58% of Year 1 students in March had not yet reached this growth point, and that 25% of students had not reached the *on-the-way* growth point of count-all. If these children have not yet reached the *on-the-way* growth points for the other number domains, particularly the counting and place value domains, they are at greater risk.

Multiplication and Division Strategies. More children had not yet reached the *on-the-way* growth point for this domain than for any of the other domains. In March, only 64% of Year 1 students had reached at least the first growth point. This may suggest that young children have fewer opportunities to construct ideas about multiplication and division, or that multiplicative thinking develops later than some other number constructs.

Table 1
The Number of Year 1 Children in 1999 who reached each of the Counting Growth Points on the ENRP Learning and Assessment Framework Below the On-the-way Growth Points.

Counting Year One March 1999 (n=1667)		
Growth Points	Count	%
0. Number Names	89	5
1. Rote Counting	124	7
2. Counting collections & beyond	1454	88

Table 2
The Number of Year 1 Children in 1999 who reached each of the Place Value Growth Points on the ENRP Learning and Assessment Framework Below the On-the-way Growth Points

Place Value Year One March 1999 (n=1658)		
Growth Points	Count	%
0. Some number names	180	11
1. One digit numbers	1207	73
2. Two digit numbers & beyond	271	16

Table 3
The Number of Year 1 Children in 1999 who reached each of the Addition & Subtraction Strategies Growth Points on the ENRP Learning and Assessment Framework Below the On-the-way Growth Points.

Addition & Subtraction Strategies Year One March 1999 (n=1658)		
Growth Points	Count	%
0. Not Yet	420	25
1. Count all	543	33
2. Count on & beyond	695	42

Table 4
The Number of Year 1 Children in 1999 who reached each of the Multiplication & Division Strategies Growth Points on the ENRP Learning and Assessment Framework Below the On-the-way Growth Points.

Multiplication & Division Strategies Year 1 March 1999 (n=1658)		
Growth Points	Count	%
0. Not Yet	597	36
1. Count all	448	27
2. Modelling when groups are perceived & beyond	613	37

March Growth Point Profiles for the Number Domains

One way to identify the children who are at risk of not learning mathematics successfully may be to consider the growth point profiles of the students who have not reached the *on-the-way* growth point in at least one number domain. This gives a more holistic picture of children's number constructs and understandings than considering each number domain in isolation. Of particular interest is determining whether there are any common profiles that are illustrative of children who need additional assistance in mathematics. These may provide a powerful tool for identifying students who are at risk of not learning mathematics successfully.

The March four-digit profiles for the 729 (44% of cohort) children who have not yet reached the *on-the-way* growth points for at least one of the four number domains are shown in Table 5. The first digit in the string relates to the counting growth point, followed by growth points for place value, addition and subtraction strategies, and multiplication and division strategies respectively.

The shading in the Table 5 highlights the profiles of children who have not yet reached the count-on stage which is used by *Mathematics Recovery* and *Mathematics Intervention* as the basis for identifying children at risk. Reference to the count-on growth point in the ENRP framework identifies the majority of children at risk, but misses three groups of children who can count-on: those who cannot yet count a collection of about 20 objects, those who cannot yet read, write, order and interpret one digit numbers, and those who cannot yet count all to solve multiplicative problems. The first two of these groups certainly need to be considered for additional assistance.

There are some 60 profiles listed in Table 5. This shows that there is great diversity in children's understanding of number, and emphasises the difficulties classroom teachers face in meeting the individual needs of children at risk, let alone the needs of all other

Table 5
The ENRP MARCH 1999 Number Domain Growth Point Profiles for YEAR 1 Students who have not yet reached the On-the-way Growth Points.

Growth Point Profile	Total Domains for which children not yet on-the-way				Total for Profile (n)=729	Growth Point Profile	Total Domains for which children not yet on-the-way				Total for Profile (n)=729							
	1	2	3	4			1	2	3	4								
<i>0000</i>				24	24	<i>1120</i>		3			3	<i>2300</i>			1			1
<i>0001</i>			9		9	<i>1121</i>	8				8	<i>2420</i>	1					1
<i>0002</i>			2		2	<i>1122</i>	5				5	<i>3000</i>			1			1
<i>0020</i>			1		1	<i>1130</i>		2			2	<i>3012</i>	1					1
<i>0100</i>				24	24	<i>1132</i>	2				2	<i>3020</i>			1			1
<i>0101</i>		11			11	<i>1201</i>		1			1	<i>3100</i>		15				15
<i>0102</i>		3			3	<i>1202</i>		1			1	<i>3110</i>	3					3
<i>0110</i>		1			1	<i>2000</i>			43		43	<i>3120</i>	20					20
<i>0111</i>	2					<i>2010</i>		7			7	<i>3130</i>	7					7
<i>0120</i>		2			2	<i>2011</i>	32				32	<i>3200</i>		3				3
<i>0121</i>	3				3	<i>2012</i>	8				8	<i>3220</i>	6					6
<i>0122</i>	1				1	<i>2020</i>		7			7	<i>4022</i>	1					1
<i>1000</i>				24	24	<i>2021</i>	6				6	<i>4100</i>		5				5
<i>1001</i>			5		5	<i>2022</i>	2				2	<i>4120</i>	5					5
<i>1011</i>		1			1	<i>2030</i>		3			3	<i>4130</i>	1					1
<i>1021</i>		1			1	<i>2100</i>		189			189	<i>4200</i>		2				2
<i>1022</i>		1			1	<i>2110</i>	33				33	<i>4220</i>	5					5
<i>1100</i>			37		37	<i>2120</i>	89				89	<i>4230</i>	2					2
<i>1101</i>		7			7	<i>2130</i>	7				7	<i>4300</i>		1				1
<i>1102</i>		8			8	<i>2200</i>		4			4	<i>4330</i>	1					1
<i>1110</i>		5			5	<i>2210</i>	1				1	<i>5220</i>	1					1
<i>1111</i>	9				9	<i>2220</i>	9				9	<i>5230</i>	1					1
<i>1112</i>	2				2							Total	274	285	122	48		729

Note. Shading identifies those students who have not yet reached the count-on stage used by *Mathematics Recovery* and *Mathematics Intervention* as the basis for identifying children at risk. Profiles which describe 20 or more students are italicised.

students. However, about 500 of the 729 Year 1 children who have not yet reached the *on-the-way* growth points on the ENRP framework are described by only 9 profiles. Brief descriptions of these profiles follow.

Profiles 0000 and 1000

These children have not yet reached the *on-the-way* growth point in any of the four number domains. They are not yet able to count a collection of about 20 items, or read, write, interpret and order one digit numbers, or count all as a strategy to solve simple addition or multiplication problems.

Profiles 0100 and 1100

These children are able to read, write, interpret and order one digit numbers and are therefore *on-the-way* in place value. However, they have not reached the *on-the-way* growth point in the remaining three number domains. They are not yet able to count a collection of about 20 items, or count all as a strategy to solve simple addition or multiplication problems.

Profile 2000

These children have not yet reached the *on-the-way* growth point in three number domains, with the exception of counting. They are able to count a collection of about 20 items, but are not yet able to read, write, interpret and order one digit numbers, nor count all as a strategy to solve simple addition or multiplication problems.

Profile 2100

This profile described about one quarter of the children at risk. These children have not yet reached the *on-the-way* growth point in two number domains: addition and subtraction, and multiplication and division domains. They are able to count a collection of about 20 items, and read, write, interpret and order one digit numbers. They are not yet able to count all in addition and subtraction, or multiplication and division contexts.

Profiles 2110, 2120 and 3120

These children have not yet reached the *on-the-way* growth point in one number domain: multiplication and division strategies. They are able to count a collection of about 20 items and read, write, interpret and order one digit numbers, and count all to solve simple addition problems. Some students can count-on to solve simple addition problems. They are not yet able to use the count all as a multiplicative strategy.

Levels of Risk

It is possible to use the ENRP profiles to describe children's level of risk of not learning mathematics successfully. This method, however, does not take into account important factors such as children's health, motivation, interest, parental support, culture, and language background etc. Such factors need to be considered also when deciding who may benefit from additional assistance in mathematics. Moreover, the ENRP profile is based on a single interview and needs to be considered in light of other assessment information collected by the classroom teacher. The levels of risk described below may be useful in identifying children who may benefit from additional assistance in mathematics.

The highest level of risk relates to profiles describing children who cannot yet count a collection of about 20 items, interpret one digit numbers, nor count-on. The lowest level of risk relates to those children who do not yet use a count-all strategy in multiplicative situations, but who are *on-the-way* in all other domains.

- Level 5 children who cannot yet count a collection of about 20 items, nor count-on.
- Level 4 children who can count a collection of about 20 items but not yet read, write, interpret one-digit numerals, nor count-on.
- Level 3 children who can at least count a collection of about 20 items, but not yet read, write, interpret two digit numerals, nor count-on.
- Level 2 all other children who cannot yet count-on.
- Level 1 all other students who cannot yet count all in multiplicative situations.

Conclusion

It is possible to use the ENRP assessment framework growth points to develop profiles of children who may be at risk of not learning mathematics successfully. Further, these profiles may be used to suggest the level of risk children may be facing, and to assist teachers decide who in their class may benefit from specialised assistance additional to the regular classroom program. Additional analysis of ENRP data is recommended so that profiles of Prep and Year 2 students who may also be at risk of not learning mathematics successfully may be developed also. It is important to identify these children as early as possible in their schooling, so that they can be assisted before they lose confidence.¹

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¹ *Acknowledgement*. I acknowledge with thanks all teachers involved in ENRP and fellow project staff who have contributed to the data collection process and ideas reflected in this paper.

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