Specialised Programs for Students Who Are Low Attaining in Mathematics: Do They Help?

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A part of the *Victorian Early Numeracy Research Project (ENRP),* 21 'trial' schools implemented the *Extending Mathematical Understanding (EMU) Program* for students in the first three years of school who were low attaining in mathematics. This paper reports on the effect of the EMU program for students in their second and third years of school with respect to the *Addition and Subtraction* domain. Results suggest that Grade 2 children who participate in a small group specialised assistance program make more progress than children who participate in an individual program, and that the program is more effective for Grade 2 students than for Grade 1 students.

One effect of the general community and government disquiet about the number of students who have not reached an acceptable level of literacy and numeracy by the end of compulsory schooling, has been to focus attention on improving learning and teaching in the early years of schooling. It is anticipated that students who begin school successfully will continue to do so in later years. A review of the effects of programs designed to prevent early school failure concluded that optimising learning for young students depends on providing good preschool and kindergarten experiences, improved curriculum and instruction at school, brief tutoring at critical junctures, and family support (Slavin, Karweit, & Wasik, 1992).

The idea of providing specialised tutoring or assistance for students experiencing difficulty is widely supported by schools, but it is expensive. Key issues for schools are: obtaining evidence to decide whether the expense of providing a specialised program is warranted in the long term because of its contribution to preventing school failure; knowing what form of assistance has the greatest benefits for students; and ensuring the early identification of students who are 'at risk.' Despite its high cost, *Reading Recovery* (Clay, 1993) is one program that has gained widespread international support from teachers and parents as an effective program for identifying and assisting 'at risk' students in the area of literacy. However, there is not agreement about effective structures for providing assistance in mathematics. One aspect of the *Early Numeracy Research Project* (e.g., Clarke, Gervasoni, & Sullivan, 2000) is to investigate how students who are experiencing difficulty learning mathematics may best be assisted. This paper reports on work in progress in this regard with respect to the effect of a specialised assistance program for students in their second and third years of school.

Identifying Students Who Are Low Attaining in Mathematics

The key to identifying students who may benefit from a specialised assistance program is collecting rich, reliable assessment data that provides insight into children's mathematical development. Sometimes schools draw on results of national tests to identify low attaining students. This method was used by Askew, Bibby and Brown (1998) for a study that investigated the effects of a mathematics intervention program for 8 year-old students. Participants were those who were operating below or just below the expected level of

attainment for their age as specified by national tests, and who were considered to be low attainers in mathematics rather than having special education needs in mathematics.

The *Mathematics Recovery* (Wright, Cowper, Stafford & Stewart, 1994) and *Mathematics Intervention* (Merrifield & Pearn, 1999) programs use clinical interviews to gain assessment information and understand children's mathematical constructs and thinking. The interviews include tasks that help ascertain students' Early Arithmetic Stages (Steffe, von Glasersfeld, Richards, & Cobb, 1983) and determine the facility of students' verbal counting skills, and knowledge of the number word sequence (Wright et al., 1994; Pearn & Merrifield, 1995). Following the assessment phase, both programs use the Early Arithmetic Stages to identify participants for their programs. Participants in *Mathematics Recovery* are those who were initially assessed as prenumerical because they had not attained Stage 3, *count-on,* of the Stages of Early Arithmetic Learning. Children who participate in *Mathematics Intervention* are those who display difficulties with most tasks and are at Stage 0 or Stage 1 of the Stages of Early Arithmetic Learning and use procedural strategies such as *count-all*. Again, these are children who have not yet reached the *count-on* stage. This method of identification, based on interviews and reference to stages of development, provides more information about children's mathematical constructs, thinking and development than scores produced following traditional paper and pencil tests. Teachers are therefore more informed about the particular instructional needs of each student.

The interview and learning and assessment framework of growth points developed by the Early Numeracy Research Project (ENRP) (Clarke et al., 2000) provides another method for identifying students who are low attaining in mathematics. The 30-40 minute interview provides the opportunity for teachers to learn about their students' thinking and determine the mathematical growth points students have reached in nine areas of mathematics: counting, place value, addition and subtraction strategies, multiplication and division strategies, measuring time, measuring length, measuring mass, classification of shape, and visualisation. Growth points are considered as major 'stepping stones' that describe young children's mathematical learning.

To identify students who may benefit from specialised assistance, student profiles are developed comprising the growth points reached by students in the four number aspects of the learning and assessment framework (see Gervasoni, 2000). For example, the first four growth points for the ENRP Addition and Subtraction domain are:

1. Count-all
   Counts all to find the total of two collections.
2. Count-on
   Counts on from one number to find the total of two collections.
3. Count-back/count-down-to/count-up-from
   Given a subtraction situation, chooses appropriately from strategies including count back, count down to and count up from.
4. Basic strategies (doubles, commutativity, adding 10, tens facts, other known facts)
   Given an addition or subtraction problem, strategies such as doubles, commutativity, adding 10, tens facts, and other known facts are evident.

The *Addition and Subtraction Strategies* growth point corresponding to the mean for 1503 Grade 1 students at the beginning of 2000 was using *count-all* to find the total of two collections (growth point 1). In order to be assessed as having reached growth point 1,

students need to successfully complete the first *addition and subtraction* task in the ENRP assessment interview using a *count-all* strategy. In this task, students are first shown collections of 9 and 3 small plastic teddies and then asked to work out the total after the 9 teddies are hidden by a screen. If a child is not successful, then the interviewer removes the screen so that all teddies may be seen, and the question is repeated.

Not reaching growth point 1 provides one piece of evidence to suggest that a Grade 1 child may be experiencing difficulty learning mathematics. If children are below the mean growth points in several areas of number, they are recommended for a specialised assistance program. For example, a profile summarised by the digits *1-0-0-0* (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) means that a child has reached growth point 1 for counting, and is yet to reach the first growth point for place value, addition and subtraction, and multiplication and division. This child is below the March mean growth points for all number areas and is recommended for a specialised assistance program. Although a child's learning in the measurement and spatial areas of mathematics is most important also, an analysis of 1999 ENRP interview data for over 1600 students indicated that the number domains provided the best initial indication that a child was 'at risk' in mathematics and may benefit from a specialised assistance program (Gervasoni, 2000).

Approaches to Assisting Low Attaining Students in Mathematics

Assistance programs for low attaining students are based on underlying assumptions regarding theories of learning, and appropriate ages for intervention, content, and organisational structure. However, there is a lack of research data that compares the effectiveness of different approaches to assistance. Research in this area seems to focus on comparing the effect of a particular approach to assistance with a comparison group.

Differences in providing assistance for young children who are low attaining in mathematics are exemplified by two similar programs: *Mathematics Recovery* (Wright et al., 1994) and *Mathematics Intervention* (Pearn & Merrifield, 1995). Both programs focus on number, target Grade 1 students and rely on specialist teachers who teach students for 30 minutes each day for 10-20 weeks. However, *Mathematics Recovery* is a program for individual students, whereas *Mathematics Intervention* is for small groups of students. Further, one is a recovery program that aims to advance students to an average level, the other is an intervention program which aims to assist students before they experience failure. The question remains as to whether one approach is more effective than another. It is anticipated that the study described in this paper will ultimately produce comparative data that may begin to answer this question, although the results reported here are at the early stage of the data analysis process and are limited to the addition and subtraction domain of mathematics. The question addressed in this paper is whether the Extending Mathematical Understanding (EMU) Program, designed to assist young children who are low attaining in mathematics, is effective for Grade 1 and Grade 2 students in the area of addition and subtraction.

Methodology

At the end of 1999, Early Numeracy Research Project (ENRP) 'trial' schools were invited to nominate specialist teachers to be trained to implement an assistance program, *Extending Mathematical Understanding* (EMU), for their students who were low attaining in mathematics. Twenty-one of the thirty-five ENRP 'trial' schools accepted. Schools decided whether to implement the program using an individual or small group structure in students second or third year of school. This meant that a comparison could be made between the effectiveness of the different implementations. This paper concentrates on some outcomes of the EMU program for the 44 Grade 1 (six-year-old) students and 67 Grade 2 (seven year old) students who participated in the program, and results are reported for the *Addition and Subtraction* aspect of the program.

Following the ENRP assessment phase at the beginning of the 2000 school year, student profiles were developed. The profiles were examined by the specialist teachers to identify students in their school who were below the March mean growth points in several areas of number. The specialist teachers next consulted classroom teachers to confirm that these students would benefit from the EMU program, and to prioritise the order in which students would participate in the program. Each specialist teacher conducted two 30 minute programs per day, five times per week for between 10 and 20 weeks, depending on the progress of students. They worked with groups of three or four students or individuals.

The EMU sessions included further diagnosis of individual difficulties using the *Extending Mathematical Understanding (EMU) Assessment Interview* and activities focussing on the counting, place value, addition and subtraction and multiplication and division aspects of the ENRP Learning Framework. These activities targeted individual's learning needs, required the maximum involvement of each child and emphasised communication and the sharing and demonstration of the different strategies used by group members. Typically, each session was structured to include 10 minutes of activities focusing on counting and place value, 15 minutes of rich learning activities focusing on problem solving (often with an addition and subtraction, or multiplication and division focus), and 5 minutes reflection about the key aspects that were covered in the session. The specialist teacher developed an individual learning plan for each student and met with the classroom teacher at least twice per term to discuss each child's progress both in the classroom and in the specialist program.

In order to determine whether the EMU program was effective, the progress of students participating in the EMU program was compared to students in a comparison group who were not participating in the EMU program. March and November ENRP assessment interview data were used for this purpose. The composition of the comparison group was achieved firstly by identifying the March growth point profiles in *number* for the Grade 1 and Grade 2 students participating in the EMU program, and then identifying all other Grade 1 or Grade 2 students in ENRP 'trial' schools with the same profiles.

In order to compare the progress of the two groups, the March and November mean Addition and Subtraction growth points for each group were calculated. Mean growth point gains for Addition and Subtraction were also produced.

Results

The *Addition and Subtraction* growth point corresponding to the March 2000 mean for all Grade 1 students in ENRP 'trial' schools was Growth Point 1 (see Table 1), being able to successfully *count-all* to find the total of two collections. In contrast, the mean growth point for Grade 1 students who participated in the EMU Program was Growth Point 0. After one year at school, many of these students were not yet able to find the total of two small collections. This suggests that these students would have difficulty participating in the regular classroom program that is based on the premise that students are able to solve number problems using at least a *count-all* strategy.

Tables 2 and 3 presents the distribution of Addition and Subtraction growth points for all Grade 1 and Grade 2 'trial' school students, for those who participated in the EMU Program and for the comparison groups. The spread of growth points for the low attaining students differs markedly between the EMU and comparison groups even though both groups have the same collection of profiles. After one year at school, 39 per cent of Grade 1 students participating in the EMU program had not yet reached Addition and Subtraction Growth Point 1, the Grade 1 March mean growth. In contrast, only 20 per cent of the comparison group were below the March mean growth point. This indicates that, for *Addition and Subtraction,* the EMU students were lower attainers than the comparison group, in that there were almost twice as many students in the EMU group below the first growth point in *Addition and Subtraction.* However, the situation had changed by November. By this time the growth point corresponding to the mean for all students was growth point 2, *count-on.* By November, about one-third of students in both the EMU and comparison groups remained below the mean growth point. This represents a decrease in the number of EMU students and an increase in the number of students in the comparison group.

Table 1
Addition and Subtraction Growth Points Means and Mean Growth

Additional assistance participant 2000		Grade 1			Grade 2		
		March	Nov.	Mean growth	March	Nov.	Mean growth
All trial school students	*M*	1.37	2.54	1.15	2.53	3.56	1.05
	SD	1.23	1.31	1.32	1.28	1.21	1.12
	N	1503	1511	1392	1540	1539	1436
Trial school comparison group	*M*	0.31	1.84	1.53	1.63	2.74	1.10
	SD	0.29	1.24	1.23	1.06	1.25	1.27
	N	525	469	469	393	364	364
Small-group EMU program	*M*	0.31	1.84	1.53	1.01	2.72	1.66
	SD	0.57	1.21	1.22	1.04	0.99	1.24
	N	35	33	33	57	54	54
Individual EMU program	*M*	0.57	1.74	1.17	1.06	1.87	0.99
	SD	0.78	1.28	1.284	1.06	1.83	2.21
	N	8	8	8	9	8	8
All EMU programs	*M*	0.36	1.79	1.43	1.00	2.63	1.61
	SD	0.60	1.22	1.23	1.04	1.15	1.41

	N	44	42	42	67	63	63

A similar situation exists for Grade 2 students. After two years at school, 67 per cent of students participating in the EMU program had not yet reached Growth Point 2, the Grade 2 March mean growth point for *Addition and Subtraction* (see Table 3). In contrast, only 39 per cent of the comparison group were below the March mean growth point. This indicates that, for *Addition and Subtraction,* the Grade 2 EMU students were lower attainers than the comparison group, in that there were proportionally many more students in the EMU group on the first two growth points in *Addition and Subtraction*. By November the growth point corresponding to the mean for all Grade 2 students was growth point 3. At this time, the number of students participating in the EMU program who were below this mean remained about the same as in March, but 54 percent of the Grade 2 comparison group were now below the mean. Therefore, for both Grade 1 and Grade 2 students, changes in growth point distributions from March to November suggest that students in the comparison groups are making less progress than the students participating in the EMU program.

Table 2
Percentage of all Grade 1 Students and Low Attaining Students Reaching Each of the ENRP Addition & Subtraction Growth Points in March and November 2000

Growth points	All Yr 1 students		Low attaining Yr 1 students			
			EMU Group		Comparison Group	
	March (*N*=1503)	Nov. (*N*=1511)	March (*N*=44)	Nov. (*N*=42)	March (*N*=525)	Nov. (*N*=469)
0	11.9	1.9	38.6	11.9	20.4	3.2
1	42.0	18.5	54.5	23.8	78.3	34.1
2	37.9	41.2	6.8	52.4	1.3	45.4
3	5.8	16.2	0	9.5	0	12.6
4	1.9	16.7	0	2.4	0	4.3
5+	0.5	5.5	0	0	0	0.4

Table 3
Percentage of All Grade 2 Students and Low Attaining Students Reaching Each of the ENRP Addition & Subtraction Growth Points in March and November 2000

Growth points	All Yr 2 students		Low attaining Yr 2 students			
			EMU Group		Comparison Group	
	March (*N*=1540)	Nov. (*N*=1539)	March (*N*=67)	Nov. (*N*=67)	March (*N*=393)	Nov. (*N*=364)
0	3.0	0.8	11.9	1.6	4.3	1.9
1	16.2	5.3	55.2	12.7	34.6	13.7
2	44.9	21.9	32.8	49.2	61.1	37.6

3	15.7	14.2	0	14.3	0	18.7
4	14.7	29.9	0	19.0	0	22.3
5+	5.2	28.0	0	3.2	0	5.8

Further examination of the data highlights some important differences between the progress of Grade 1 and Grade 2 students participating in the EMU program. Tables 2 and 3 show that about 40 percent of the Grade 1 students were at growth point 0 in March compared to about 10 percent of Grade 2 students. When examining the progress of these students from March to November (Tables 4 and 5) it is evident that about one third of the Grade 1 students who began on growth point 0 failed to make progress over the year, whereas all of the Grade 2 students who began on growth point 0 made progress. Further, twice as many of these Grade 2 students progressed to at least the *count-on* growth point (2) than did Grade 1 students. This suggests that Grade 2 students on growth point 0 in March are more likely to progress than Grade 1 students.

With respect to the students who had reached the *count-on* stage in March, it is important to note that none of the Grade 1 students progressed from this growth point by November (see Table 4). In comparison, nearly one third of these Grade 2 students had progressed to at least growth point 4, *basic strategies*, by November (see Table 5). However, thirteen of the twenty-one Grade 2 students also failed to progress beyond *count-on* by November. It appears that moving beyond growth point 2 is difficult for many students, and that Grade 2 students are more likely to progress beyond this growth point.

About 80 percent of students in both grades who had reached growth point 1 in March had reached growth point 2 by November. However, Grade 2 students were more likely to progress beyond growth point 2. Again this suggests that Grade 2 students participating in the EMU program make more progress in addition and subtraction than Grade 1 students.

Table 4
Progress in Addition and Subtraction for All Grade 1 Students Participating in the EMU Program

Addition & subtraction growth points (March)	Addition & subtraction growth points (November)					Total
	0	1	2	3	4	
0	5	4	7	1	0	17
1	0	6	12	3	1	22
2	0	0	3	0	0	3

Table 5
Progress in Addition and Subtraction for All Grade 2 Students Participating in the EMU Program.

Addition & subtraction growth points (March)	Addition & subtraction growth points (November)						Total
	0	1	2	3	4	5	
0	0	1	2	2	2	0	7

1	1	6	17	6	4	1	35
2	0	1	12	1	6	1	21

This suggestion is reinforced when comparing the mean growth from March to November for Grade 1 and Grade 2 students in the EMU program compared with that of the comparison groups (see Table 1). For example, progress as measured by mean growth point gains is identical for both the Grade 1 students in the EMU small group program and low attaining students in the comparison group. However, mean growth point gains for Grade 2 students participating in the small group EMU Program are 50 percent greater than for their counterparts in the comparison group. Interestingly, it appears that low-attaining Grade 1 students make greater gains in *Addition and Subtraction Strategies* than higher-attaining students, regardless of their participation in a Small Group EMU Program. However, the 16 Grade 1 and Grade 2 students who participated in an individual EMU program made no more progress in *Addition and Subtraction* than the mean gain for all 'trial' school students. Although 16 students is a small sample, this finding raises the possibility that specialised programs for individual students may not be any more effective in the area of *Addition and Subtraction* than participation in the regular classroom program. Indeed, the mean gains for each group suggest that participation in an additional assistance program in Grade 1 may not be any more effective than participation in the regular classroom program. However, participation in the small group EMU program in Grade 2 is clearly effective for Grade 2 students. Further, an Analysis of Variance showed that the small group EMU program was significantly more effective in Grade 2 than in Grade 1 ($F = 6.895$, $p = 0.010$).

Conclusion

Results from this study suggest that, in respect to the development of addition and subtraction strategies, a small group specialised assistance program in Grade 2 is more effective than a specialised program for individual students. Further, the results suggest that a specialised assistance program in Grade 1 may be no more effective than participation in the regular classroom program. However, this finding needs to be treated with some caution. *Addition and Subtraction* represents only one aspect of children's mathematical learning. The *Extending Mathematical Understanding (EMU)* program provides a much broader mathematical focus than only addition and subtraction. It may be that in determining the effectiveness of specialised assistance programs, results need to be considered in a more holistic way. Indeed, results from this study yet to be reported suggest that Grade 1 students who participate in an EMU Program make more progress in *Counting* than Grade 2 students, and that a program for individual Grade 1 students is the most effective approach for *Counting*. Certainly, determining the most effective form of specialised assistance in mathematics for young children is complex and requires further investigation.

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