Mathematics Intervention: An Overview of the First Two Years.

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A Mathematics Intervention Program, commenced in 1993, was designed to assist those children in Years 1 and 2 at risk of not coping with the mathematics curriculum. Children were clinically interviewed, using tasks based on the stages of construction of the number sequence, developed by Steffe and co-workers at the University of Georgia. Details of the development of the program will be documented.

In 1993 a pilot Mathematics Intervention program was trialed at Bulleen Primary in Melbourne (Pearn, 1994; Pearn, Merrifield & Mihalic, 1994a; Pearn, Merrifield & Mihalic, 1994b). It was a collaborative project involving the Principal and staff of Bulleen and mathematics educators from La Trobe University. The main aim of the project was to identify, then assist, those children in Years 1 and 2 at risk of not coping with the mathematics curriculum as documented in the National Statement on Mathematics for Australian Schools (Australian Education Council, 1991). The Mathematics Intervention Program features elements of both Reading Recovery (Clay, 1987) and Mathematics Recovery (Wright, 1991, 1994). Mathematics Intervention offers children the chance to experience success in mathematics by developing the basic concepts of number upon which children build their understandings of mathematics.

Pilot Program at Bulleen

The main aim of the pilot Mathematics Intervention Program at Bulleen was to develop a process for identifying "at risk" children in Years 1 and 2 and then to establish a suitable program to enable them to learn in a regular class. This program was to be supported by school staff, Principal and mathematics educators from La Trobe University.

After consulting the class teachers, the Mathematics Intervention teachers decided to clinically interview all children in Years 1 and 2 using tasks based on the five counting stages developed by Steffe, Cobb, von Glasersfeld and Richards (1983, 1988). These five stages are:

1 *Perceptual.* Children are limited to counting those items they can perceive, for example, see, feel and hear.

2 *Figurative.* Children count from one when solving addition problems with screened collections. They appear to visualise the items and all movements are important. (Often typified by hand waving over hidden objects.)

3 *Initial number sequence.* Children can now count-on to solve addition and missing addend problems with screened collections. Children no longer count from one but begin from the appropriate number.

4 *Implicitly nested number sequence.* Children are able to focus on the collection of unit items. They can count-on and count-down, choosing the most appropriate to solve problems. They generally count-down to solve subtraction problems.

5 *Explicitly nested number sequence.* Children are simultaneously aware of two number sequences and can disembed smaller composite units from the composite unit that contains it, and then compare them. They

understand that addition and subtraction are inverse operations.

The Clinical Interview Tasks

A clinical interview is described in Hunting and Doig (1992) as:

> *...a dialogue or conversation ... held between an adult interviewer and a subject. The dialogue is centred around a problem or a task which has been chosen to give the subject every opportunity to display behaviour from which mental mechanisms used in thinking about that task or solving that problem can be inferred (p203).*

All three teachers involved with the program had attended a course in Clinical Mathematics Methods at La Trobe University (Gibson, Doig & Hunting, 1993; Hunting & Doig, 1992; Hunting, Doig & Gibson, 1993) to develop and refine their observational and interpretative skills. Both the initial assessment and the Mathematics Intervention program require the teacher to observe and interpret the child's actions. The initial interview required the teacher to assess the extent of the child's mathematical knowledge while the program relied on the teacher's ability to interpret the child's mathematical knowledge and then design or adapt tasks and problems that enable the child to progress mathematically.

The initial interview, developed by the three Mathematics Intervention teachers, included tasks used to ascertain the child's verbal counting skills by ones, twos, fives and tens, both backwards and forwards. For example,

"Can you start at 8 and count forwards from there?" (Stop at 25)

"Can you count backwards beginning at 43?" (Stop at 25)

Commonly used terms were also tested to determine the children's knowledge of the number sequence.

"What number comes *after* 4?"

"What number comes *before* 15?"

There were also five tasks based on the five counting stages. The interviewer was asked to observe and note the strategies used by each child to solve the tasks.

The first task had six counters displayed and three hidden.

"There are six counters on the table. Can you count them?"

"Under this paper are three counters." (Lift paper briefly).

"How many counters do I have altogether?"

Fifty Year 1 and 2 children were individually clinically interviewed by one of the three teachers associated with the project. The children were withdrawn from their classes and spent an average of 20 minutes with the teacher interviewing them. By carefully observing the children's solution strategies the teachers ensured that they were aware of the strategies being used and if needed the following prompts were given: "How did you work that out?" or "How did you do that?" The children enjoyed coming out of class and working on a one-to-one basis with a teacher.

Using the results of the clinical interviews we identified six Year 2 children who could not count by twos, fives, or tens and could only count the counters they could see. This meant they were assessed as being at least two stages below their peers.

Table 1: Number of children at each counting stage. (Steffe et al, 1983)

Counting Stages	1	2	3	4	5
Year 1	4	9	11	0	3
Year 2	6	0	7	4	6

As indicated by Table 1, six Year 2 children were performing at a much lower level than 23 Year 1 children and 17 Year 2 children. All six Year 2 children were currently, or had recently been involved, in a reading-recovery type program. The

four Year 1 children, assessed at being at Stage 1 of the counting stages, were also independently assessed as in need of a reading-recovery type program.

This finding of the link between children needing both Mathematics Intervention and Reading Recovery indicates a need for further research and the necessity for a more integrated approach in teaching mathematics.

As limited time was available, the Mathematics Intervention teachers decided to work with the Year 2 children first. Later in the year, if time permitted, the teachers would work with the four Year 1 children who were identified as being at Stage 1.

The 1993 Intervention Program

Because the six children identified as needing the Mathematics Intervention program were also receiving additional assistance in a reading recovery-type program, we decided that the Mathematics Intervention program would need to emphasise oral counting activities. The program depends on the teacher making an instant appraisal of the child's needs and providing the appropriate activities. This is in line with the National Statement (A. E. C., 1991):

> *Whatever their particular needs or abilities,* all *students have the right to learn mathematics in a way that is personally challenging and stretches their capabilities. Achievable and satisfying tasks are an important prerequisite for success (p.10).*

The children worked in small groups to assist with the development of their mathematical language skills and co-operation strategies. The teachers divided the six Year 2 children into two groups. These children were withdrawn from their classes for three half-hour sessions per week for twenty weeks. Two part-time teachers taught the program: the children worked with one teacher for two sessions per week, and the other teacher for one session. The teachers were also responsible for the reading-recovery type program. While the sharing of teachers for the program was not ideal, it was the only way the program could be run given the limited resources. When necessary, assistance was sought from the mathematics education personnel from La Trobe University.

Emphasis was placed on the verbal interaction between teacher and students, and between students. Each session was planned to build on previous understandings as interpreted by the teacher during the session. Many games were adapted to ensure that concepts were presented in an informal but engaging way. Very little written work was done. Each lesson included:

* counting activities using concrete materials such as blocks, counters, bead frames, straws.
* games designed to highlight and correct a perceived weakness.
* oral work, using concrete materials, based on the four processes
* questions that expected the children to reflect on their strategies.
* the expectation that all children would explain their strategies and would listen when some-one else was explaining solutions and/or strategies.

Early in the program the Mathematics Intervention teachers observed that the children were experiencing difficulties with the number sequence due to poor speech. To emphasise and reinforce the difference in numbers like seventeen and seventy, a memory game was introduced.(see Figure 1)

Figure 1 Game of Memory used in Mathematics Intervention program.

Memory.
Two cards were produced of each of the numbers:
12, 21, 13, 31, 14, 41, 16, 61,17, 71, 18, 81,19, 91.
These 32 cards were shuffled and placed face down.
The children took it in turns to choose two cards and display them.
The children were expected to name the cards as they were displayed.
If unable to do so they could seek assistance from someone else.
If the upturned cards were a match they kept the pair.
The object of the game was to match as many pairs as possible.

This game assisted with numerical recognition, and the children became very proficient in counting by twos to determine the number of cards they had won. The variety of the games depended on the imagination and skill of the teachers.

After twenty weeks in the program all the children had improved their verbal counting skills and had progressed at least one counting stage. We also re-tested three students who had been assessed as being at Stage three on the initial test and had not been part of the program. They had not progressed either with their verbal counting or in the counting stages.

At this time, three of the Year 2 children returned to the normal class and three Year 1 children formed the second group. After eight weeks of instruction the Year 1 students had improved their verbal counting skills and had progressed at least one counting stage. The remaining Year 2's had progressed to stage 5 and could complete all the verbal counting tasks (Pearn, 1994; Pearn, Merrifield, & Mihalic, 1994a; Pearn, Merrifield & Mihalic, 1994b).

All children involved in the Bulleen pilot program improved substantially in their counting, arithmetical skills and mathematical understanding. By participating in the Mathematics Intervention Program, these children developed a repertoire of skills and concepts essential for full participation in the mathematics syllabus.

The 1994 Mathematics Intervention Program

At the end of 1993 Bulleen Primary was forced to close due to State Government rationalisation, so the pilot program was taken, with the majority of the Bulleen students, to a neighbouring school - Boroondara Park. One of the part time Mathematics Intervention teachers was employed to maintain the program. In February 1994, a modified version of the screening interview was given to all children in Years 1 and 2.

In 1994 the initial clinical interview was modified because it was too long for one teacher to administer to 80 children. After analysing the results from the initial interview in 1993 the Mathematics Intervention teachers decided that an easier and shorter test could be administered to identify the children who needed to participate in a Mathematics Intervention program. The modified interview included simplified verbal counting tasks:

"Can you count out loud for me, beginning at one, until I tell you to stop?"

"Can you count forwards by 10's starting with 10?"

Two tasks were added to the modified 1993 interview :

"Can you count out fourteen beads?"

Cards were shown of the following numbers and the children were asked to name them: 13, 31, 15, 51, 14, 41.

In the modified interview there were only two tasks based on the counting stages. The first one was designed to

determine whether the child can count-back.

"There are twelve counters under this cover."

Remove three counters and display.

"How many counters are still under the cover?"

The second task was designed to determine whether the child can count-on. It is an easier task than the previous one and allows the child to leave the interview feeling positive.

Ten counters are displayed.

"Here are some counters. Count them."

(Cover all the counters, remove two and display).

"How many counters are under the paper?"

This modified clinical interview was administered to all students in Years 1 and 2 at Boroondara Park. Children who were unsuccessful with both counting tasks were considered for inclusion in the program as they could neither count-on nor count-down when counting screened collections. Year 2 children identified as needing to be included in the program were given the more comprehensive clinical interview developed at Bulleen. This was to ensure that the teacher was aware of each child's exact stage of development and understanding.

The 1994 Results

The 1994 testing identified ten children in need of the Mathematics Intervention Program. It also confirmed our previous findings that these students require assistance with both Reading Recovery and Mathematics Intervention. Six Year 1 students were identified as needing Mathematics Intervention and, independently, as needing a reading recovery-type program. Of the four Year 2 students, one child had been in a reading recovery-type program while the remaining three were independently assessed as requiring further reading assistance. Only one of the children from Bulleen who had been in the program in 1993 was identified as needing extra time in the program in 1994.

In July 1994, due to a change in school needs, the teacher responsible for the program was placed in a classroom. Because the Boroondara Park Primary School Council was determined to maintain the program, it employed a primary teacher with Mathematics qualifications to run the program. This teacher had also completed the Clinical Mathematics Methods professional development program at La Trobe University.

The eleven children in the program continued to work with the Mathematics Intervention teacher for half an hour per day on three consecutive days. There were three groups: two groups of three Year 1 and one group of five Year 2 children. These children also participated in classroom mathematics lessons as these were not usually timetabled at the same time as the Mathematics Intervention program.

The children's counting skills and mathematical understanding improved significantly. Table 2 shows the progress made by the children in the Intervention program in 1994.

Table 2: Number of children at each counting stages in 1994 (Steffe et al, 1983).

Counting Stages	1	2	3	4	5
February: Year 1	6				
Year 2	3	1			
June: Year 1	2	2	2		
Year 2		2	3		
November: Year 1		2	2	1	1
Year 2			1	1	3

The teachers commented on the improvement in both the attitude and skills of the children in the program. In a class mathematics test, the five Year 2 children from the Mathematics Intervention program performed better

than some of their classmates who had not been in the program.

The major difference between the 1993 and 1994 programs was the greater emphasis on written work for the Year 2 group in 1994. This was specifically in response to a request from the Year 2 teachers and assisted the transition back into the classroom Mathematics program.

Implications

The importance of this program to students "mathematically at risk" cannot be over-emphasised. As stated by the National Statement (A. E. C., 1991):

> *Whether a particular student gains the full benefit from mathematics may be influenced by a range of personal characteristics and circumstances. It will also depend on the quality of the mathematics offered' (p.8).*

The Mathematics Intervention Program is designed to enable children to succeed at mathematics activities. In small groups they play mathematical games devised to address specific weaknesses. Teaching moments are spontaneous, arising from children's questions and difficulties. Because the program depends on the verbal interaction between children and teacher, Mathematics Intervention teachers need to be confident and competent in mathematics. The teachers need to be aware of the children's knowledge and strategies and able to design appropriate activities to extend their mathematical understanding.

If the children currently in the Mathematics Intervention program had not had this assistance they would probably have continued to struggle with mathematics. With the increase in Victorian class sizes, teachers are going to have even less time to spend with these children who are "at risk". If children are unable to count accurately, it will be difficult for them to succeed with other mathematical problems and processes. A clinically trained mathematics teacher, working with a small group of children of similar mathematical ability, is more likely to observe the difficulties experienced by these children and work towards strengthening their basic numerical concepts.

The gains made by the children in the Mathematics Intervention Program, while significant, need to be tested under experimental conditions. That is, by using a control group the improvement in mathematical knowledge could be compared.

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