A CONNECTION BETWEEN MATHEMATICS AND LANGUAGE DEVELOPMENT IN EARLY MATHEMATICS

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During term 1, 1993 Bulleen Primary School in Melbourne established a Mathematics Intervention Program for children in Year 2, based on the work of Dr Bob Wright. This program was designed to assist those children at risk of not coping with the current Mathematics curriculum as presented in the Mathematics Course Advice -- Primary (1992) and the National Statement (1991) documents. Children were clinically interviewed using tasks based on the stages of construction of the number sequence developed by Steffe, Cobb and co-workers at the University of Georgia (1983; 1988), and documented by Wright (1991; 1994).

The children identified as in need of the Mathematics Intervention program had mathematics difficulties of a significantly different order of magnitude from the other children. The six year 2 children allocated to the Mathematics Recovery program were found to be in, or have been in, a reading recovery-type program. Further, all year 2 students in a reading recovery program were independently assigned to the Mathematics Intervention program. This procedure was repeated in 1994 at Boorondara Park Primary with six Year 1 and three Year 2 children as in need of Mathematics Recovery, and independently as in need of a reading recovery type program. This implies that there is a need for the hand-in-hand development of language and mathematics and the evidence suggests that reading recovery programs are tackling only one part of linguistic comprehension and mental development.

MATHEMATICS INTERVENTION

It is acknowledged that when children first come to school they bring with them vast differences in their mathematical knowledge. Current curriculum guides, such as the Mathematics Course advice--Primary (1992) and the National Statement (1991), attempt to cater for these disparate needs. Regardless of the syllabus followed by the skilled preparatory teacher, there will still be the child who has not developed sufficient mathematical knowledge to facilitate an easy transition to Year one.

During term 1, 1993, Bulleen Primary School in Melbourne established a Mathematics Intervention Program for children in Years 1 and 2. Bulleen's Mathematics Intervention Program is based on both Clay's (1987) Reading Recovery and Wright's (1991) research based Recovery Education in Mathematics. Like Reading Recovery, Mathematics Intervention offers the children a chance to participate in a withdrawal program before experiencing long term failure. Mathematics Intervention is designed to develop the basic concepts of counting upon which the children build their understanding of mathematics.

The main aim of the pilot Mathematics Intervention Project at Bulleen was to develop a selection

 process to detect those children in Years 1 and 2 at risk and then to develop a suitable program to assist these children to advance their knowledge to enable them to learn successfully in a regular class. A support group was formed comprising school staff, including the principal, and mathematics educators from La Trobe University.

All the children in Years 1 and 2 were clinically interviewed using tasks based on stages of the construction of the number sequence and their relationship to specific counting types. These 5 stages were developed in theoretical work by Steffe, Cobb, von Glaserfeld and Richards (1983) and documented by Wright (1991). The stages are:

1. Perceptual

A child is limited to counting those items they can perceive- i.e. see, hear.

2. Figurative

Child counts from one when solving addition problems with screened collections. They appear to visualize the items and movements are important. (Often typified by the hand waving over hidden objects.)

3. Initial Number Sequence

Children now count on to solve addition and missing addend problems with screened collections.

4. Implicitly nested Number Sequence.

Children are able to focus on the collection of unit items as one thing, as well as the abstract 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 2 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 related in an inverse way and can use known facts such as doubles and sums which equal ten.

IDENTIFICATION OF CHILDREN AT RISK

The five stages in the construction of number sequence and their related counting types were used to develop a screening interview that was administered to 27 Year 1 and 23 Year 2 pupils. This interview also included questions to ascertain the children's verbal counting skills, especially their ability to count forwards and backwards by ones, twos, fives and tens.

Common terms were also tested e.g. after, before, between. These were all tested to determine the children's knowledge of the number sequence.

As there were to be three teachers involved in the clinical interviewing considerable time was spent refining the wording of the tasks.This was to ensure each of the interviewers was comfortable about the way the questions were to be asked and their expected responses. The assessment record was also discussed at length as it needed to be easy to use while allowing for individual or unusual responses to be noted. Teachers involved in the program had all attended a course in Clinical Mathematics Methods at La Trobe University (Gibson, Doig, & Hunting, 1993; Hunting & Doig, 1991; Hunting, Doig, & Gibson, 1993) to develop and refine their observational and interpretative skills.

There were five tasks based on the five counting stages. The interviewer was asked to observe the child carefully to determine what strategies were being used to solve the problem. It was imperative to know whether the child was counting physical objects, counting on, counting back or "just knew it". Each of the five tasks was given to each child and all responses noted.

The first task had six counters displayed and three hidden. The child was asked "How many counters do I have altogether?" The second and third tasks involved covering collections of counters, then removing and displaying some, with the child having to estimate the number of counters left under the cover. The second task allowed the child to count the counters before they were covered, while in the third task the teacher just told the child how many counters were covered, before removing some. The fourth task presented the child with the following algorithms:

$27 + \ = 36$ and $22 - 17 =$

If the child attempted these problems they were asked to explain how they worked it out. The final task was designed to test whether the child was able to compare the two number sequences i.e. to check whether the child was at the fifth stage of the explicitly nested number sequence.

RESULTS FROM THE IDENTIFICATION PROCESS

After clinically interviewing 50 children we discovered:

* Common problems- difficulties in bridging numbers e.g. counting on by ones from 29 to 30

* Language difficulties- Some of the children could not tell us the numbers between 6 and 12

because they did not know the meaning of "between ", while others confused after and before.

* Some children were a long way behind their peers while some children were performing at a much higher level than their peers. Eleven Year 1 children were at the third counting stage, with a further six at stage 2 compared with six Year 2 children who were at stage 1.This means there were 17 Year 1 children functioning at higher stages than these lower achieving Year 2's.

* Children who had interesting strategies for solving problems. One of the girls counted the holes in index dividers to assist counting to 22.

* Children who had positive attitudes to mathematics. One of the boys as he sat down said"This will be easy because I like maths."

Once the clinical interviews were completed we had to decide on the criteria for selecting children to participate in the mathematics intervention program. As this was a pilot program and there were no guidelines we decided we would have to analyze the results before making any decisions.

We identified six of the 23 children in Year 2 who were operating at a much lower level than the other 17 year 2 children and 17 Year 1 children. They were able to count by 1's to 109 and could only count backwards from 9. They were unable to count verbally by 2's, 5's or 10's and were at the stage 1 level of counting. This meant they were only able to count those items they could perceive i.e. see, hear. Of the remainder of their class, six children had reached level 5, four had reached level 4, while the remaining seven were at level 3 of the counting stages. This meant that 17 year 2 children could count on, 10 could count on and count down and 6 could compare two number sequences. These 17 Year 2 children were proficient counting forwards and backwards by 1's, 2's, 5's and 10's.

A surprising outcome was that the children selected were all children who had been or who were currently in a reading recovery type program.

There were four children in Year 1 identified as being below the rest of their year level but as there was limited time available it was decided that it was imperative to work with the Year 2 children first and if time permitted to work with the year 1's later in the year. These Year 1 children had also been independently assessed as in need of a reading recovery type program.

IMPLEMENTATION OF THE PROGRAM

The six Year 2 children identified as being at risk of not coping with the mathematics syllabus at

the Year 2 level were considered for placement in the program. Discussions were held with parents to explain the program and their assistance was requested in completing tasks sent home. It was deemed important that the program was a joint venture of teachers, students and parents.

As the children's verbal counting was so limited and to maximize the impact of the teacher's time allotment the children worked in two groups of three. It was felt that this was the most efficient way to assist the development of their mathematical language skills and co-operation stategies. Some adjustments had to be made to the composition of these groups to ensure that all children gained maximum benefit. One of the students verbally harassed one of the others but this was solved when he was moved to the other group. These children were withdrawn from their classes for three half hour morning sessions per week , to be reviewed at the end of every term.

Throughout this time the children were given a series of activities designed to promote the development of their counting skills and concepts. This included use of varied concrete materials especially for counting activities and many mathematical games, both teacher and commercially produced. Counting of beads on a bead frame became an important part of the program. Emphasis was placed on the correct pronunciation of the number sequence as it was discovered that the children were confusing numbers like nineteen and ninety because of poor speech. A large amount of time was also spent counting collections of beads, counters, pencils, blocks, windows, straws, sounds, and actions to highlight one-to-one correspondence. There seemed to be a great reluctance to actually count things. The counting sequence was just a rescitation and had nothing to do with those objects they were supposed to count. The children had to be encouraged to actually touch each item to be counted.e.g. The contents of a cup would be tipped out and the child asked to count them as they put them back.

To reinforce the difference in numbers like seventeen and seventy a memory game was introduced. Cards were produced with the numbers that were being confused- 12,21, 13,31, 14,41, 15,51, 16,61, 17,71, 18,81, 19,91. There were two cards of each number. These 32 cards were shuffled and placed face down. The teacher and the children took it in turns to choose two cards and turn them face up. When a match was made the child was encouraged to name the number displayed and if unable to do so could request assistance from some-one else. The highlight of one of the sessions was one of the less able children explaining to another that he had chosen 14 and 41 and that these were not a match, then continuing to explain that 41 was bigger than 14. Another game to aid in the recognition of numbers was Bingo. The cards varied in size and the children became very skilful in identifying the numbers quickly. This was one of

 the games sent home for family participation over school holidays.

The six children were re-tested after ten weeks in the program. The testing revealed that their verbal counting had improved and they were now able to count by 2's, 5's and 10's and all had progressed by at least one counting stage. This meant they could all now solve addition problems with some children able to count on.

After twenty weeks in the program they had all reached the third level i.e.able to count on, with three on level four i.e. able to count on and count down,and all had improved their verbal counting skills. We also re-tested three students that had been on level three at the initial interview and had not been part of the program, and discovered that they had not progressed either with verbal counting or the counting stages. They were able to count on but unable to count down to solve subtraction problems.

The decision was made at that time that three of the children from the program be returned to the normal class for their mathematics and three Year one children were placed in the second group. After eight weeks of instruction these Year one students had improved their verbal counting skills and had progressed at least one stage. This meant that one was at stage 1, one at stage 2, the other at stage 3. After 28 weeks in the program the remaining three Year 2's had progressed to stage 5 and could complete all the verbal counting tasks. The teacher felt that the Year 1 children progressed faster than the Year 2 children even though the activities were the same. This could be due to the fact that the Year 1's did not have that overwhelming sense of failure already apparent in the Year 2's. It would appear that Year 1 is the best place for intervention before failure is obvious or established.

The results achieved after 28 weeks of the pilot program at Bulleen indicate that all the children involved in the program have improved substantially in their counting and arithmetical skills and understanding. Indeed most of these children are now doing as well as, if not better than their classmates. This pilot study indicates that the early participation, of those pupils at risk of failure, in the Mathematics Intervention Program provided an opportunity for them to develop a repertoire of skills and concepts essential for full participation in the mathematics syllabus.

IMPLICATIONS

The surprise result that all students needing to participate in the Mathematics Intervention program were in or had been in a Reading Recovery type program indicates that difficulties with comprehension might be caused by hand in hand development of language and mathematics. These two programs assessed the children independently and in the pilot Mathematics

Intervention Program it was only when the teacher was shown the list of students that this connection was made. One of the Year 2 children chosen to undertake the Mathematics Intervention program had successfully undertaken Reading Recovery in Year 1. His mother was opposed to his inclusion as she felt that he was mathematically able. He was re-assessed and the teacher realized that although he appeared to count well verbally he frequently made mistakes due to his inability to count on or count back. At the time of the screening test he was reading at a better than average level and appeared to comprehend at a similar level. However no specific comprehension test was undertaken at this time. He participated in the Mathematics Intervention program for twenty weeks.

Bulleen Primary was forced to close due to State Government rationalization so this pilot program was taken with the majority of students to a neighbouring school- Boorondara Park. A modified version of the sceening interview has been given to the children in years one and two. The initial interview used in 1993 was considered too time consuming and the school wanted to see the program operating as soon as possible.The 1994 testing has confirmed our previous findings of the reading/ mathematics link with one exception. There were six Year 1 students identified as in need of Mathematics Recovery and independently as in need of a reading recovery-type program. Of the four Year 2 students also identified as needing the Mathematics Intervention program all but one child is in or has been in a reading recovery type program. Although this child is not considered to be in need of extra assistance for reading, her oral development is superior to her comprehension skills.

At Bulleen there was not one student in their reading recovery -type program who did not need to be in Mathematics Recovery and this connection was also observed at Boorondara Park. It appears that the mathematics clinical interview tasks predicted with a high degree of accuracy the students in need of a reading recovery program.

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