Counting On 2008: Diagnostic and Remedial Mathematics Program for Middle Years Students.

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The NSW Counting On program was designed to support the professional learning of teachers in identifying and addressing the learning needs of students in the middle years who have difficulties with the early mathematical concepts and skills. It has a strong theoretical and research base and has undergone major changes which have been regularly evaluated. Counting On 2008 was evaluated and this paper will use the findings of the evaluation report (White, 2009 in press) to examine whether the program was successful in changing student learning outcomes.

Background

There is widespread concern by teachers and educators for students who are currently excluded from effective mathematics study in the middle years and beyond because of a lack of understanding and proficiency with early school mathematical knowledge. In the Australian state of New South Wales (NSW) this concern was incorporated into the State Numeracy Plan 2006 – 2008 (NSWDET, 2005, p. 4), where it was mandated that schools will improve numeracy achievement by:

> Implementing the *Count Me In Too* and/or *Counting On* programs, particularly in schools with a high proportion of students in the bottom two bands (10% more than the State average) as reported on state-wide tests.

While the Count Me On Too program targets students in the early school years, the Counting On 2008 (CO 2008) is a program also conducted by the NSW Department of Education and Training to address the needs of the middle years students. In brief it is a ten week intervention program. It contained a range of new and resource supported mathematical pedagogical strategies and learning activities delivered by classroom teachers during their usual classroom teaching program. The targeted underperforming middle years school students learning outcomes were monitored by a pre-test post-test assessment procedure. The focus of this paper is to determine whether the program was successful in changing the student learning outcomes.

The CO 2008 program is a product of the series of Counting On programs that began in 2000 and which have continued to expand and evolve to the current year 2008 manifestation. The program has a twin learning focus upon students and teachers and was evaluated at the end of the program (White, in press). The basis of this paper is the evaluation report although it is impossible to adequately report on both foci and so as mentioned it will concentrate only on the student learning outcomes of the program. The initial Counting On program in the year 2000 was designed for first year secondary school students (Year 7) who had not achieved specific New South Wales Stage 3 mathematics syllabus outcomes by the time they commenced secondary school. It was later extended to include the feeder primary schools and students across the range of years 5-9.

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Theoretical Basis

The research base for the program was provided through the Counting On Numeracy Framework (Thomas, 1999) which was an extension of work by Cobb and Wheatley (1988), Beishuizen (1993), Jones, Thornton, Putt, Hill, Mogill, Rich and van Zoest (1996) and relates to the Count Me In Too Learning Framework in Number (LFIN) (Wright, 1998; Wright, Martland, & Stafford, 2000).

This theoretical base was supported by an increasing research base provided by the regular Counting On evaluation studies. After a pilot study involving 9 schools was evaluated by Mulligan (1999), the Counting On program began in 2000 with 40 schools, more than 600 students, 120 school teachers and 40 district mathematics consultants. Further evaluation reports on the Counting On program were conducted in 2000, 2002, 2003, 2007 and 2008 (Perry & Howard, 2000, 2002a, 2003; White 2008, 2009 in press). During 2001, Counting On was implemented in 76 primary, four central and 75 secondary schools across NSW, involving more than 1400 students, 321 school teachers and 40 district mathematics consultants. The 2002/2003, Counting On programs involved three high schools per district and two feeder primary schools in each of the 40 districts. In 2007 the program underwent a major revision and was implemented in 122 schools across the state grouped into 30 clusters with each cluster supported by a mathematics consultant. It was based on the previous models but included changes designed to simplify and encourage further and ongoing involvement of schools. Features of the revised model included: a simplified assessment instrument; the inclusion of Newman's Error Analysis; a revised Counting On CD; formation of School clusters; a facilitator's conference; and a facilitated professional development model.

The inclusion of Newman's Error Analysis (NEA, Newman, 1977; 1983) in CO 2007 aimed to assist teachers when confronted with students who experienced difficulties with mathematical word problems. Rather than give students 'more of the same' involving drill and practice, NEA provided a framework for considering the reasons that underlay the difficulties and a process that assisted teachers to determine where misunderstandings occurred and where to target effective teaching strategies to overcome them. Moreover, it provided excellent professional learning for teachers and made a nice link between literacy and numeracy.

Newman (1977, 1983) maintained that when a person attempted to answer a standard, written, mathematics word problem then that person had to be able to pass over a number of successive hurdles: Reading (or Decoding), Comprehension, Transformation, Process Skills, and Encoding. Along the way, it was always possible to make a careless error and there were some who gave incorrect answers because they were not motivated to answer to their level of ability. While there are many other theoretical approaches available to teachers, NEA offers one of the easiest to use and adapt and has proven popular among teachers for both the ease of the diagnostic features and also because it is easily used as a classroom pedagogical strategy particularly (but not solely) for remediation.

There were changes incorporated into CO 2008 that were a response to the recommendations and findings of the 2007 Evaluation report (White, 2008). Unlike the major changes of CO 2007 program, the 2008 changes were minor adjustments and concentrated on strengthening the learning communities and upon the training and support of the school program facilitators. It is beyond the scope of this paper to present the evaluation of the whole program and this paper will report only on the success of the CO 2008 program in overall terms of student mathematical learning outcomes. Information regarding the success of the individual changes can be found elsewhere (White, in press).

The focus of this paper is to determine whether the program was successful in changing the student learning outcomes

Methodology

The program CO 2008 program was implemented in 99 schools across the state. The written assessment instrument based on the LFIN (see Table 1) was administered by the class teacher as a whole class test of 6 questions covering place value, addition, subtraction, multiplication, division and word problem tasks. The assessment schedule was closely linked to the learning framework and the data were used by the teacher to identify the student target group. Teachers received a detailed guide to the link between an item, an answer and the correct level.

Table 1
Learning Framework Levels of Conceptual Development in Place Value and Multiplication and Division (Perry & Howard, 2001b, p. 412).

Place value		Multiplication and division	
Level	Descriptor	Level	Descriptor
0	Ten as count	0	Unable to form equal groups
1	Ten as unit	1	Forming equal groups
2	Tens and ones	2	Perceptual multiples
3	Hundred as unit	3	Figurative units
4	Hundreds, tens, & units	4	Repeated abstract composite units
5	Decimal place value	5	Multiplication and division as operations
6	System place value	6	Not used

The whole class results were used to group the students as expert (correct working and answers to 5 or 6 items and clear understanding of correct number concepts needed to solve the problems), intermediate (some correct working and answers and some understanding of number concepts needed to solve the problems but still not fully developed or consistent) and target (few or no correct working or answers and evidence of misconceptions in working and answers). The target group was then interviewed and their levels recorded. They were retested on the same test and interviewed at the finish of the program. The facilitators were asked to record the results of the target group assessment process involving a minimum of 5 students per class on an excel spreadsheet supplied to them. The spreadsheet recorded the initial level on the LFIN and NEA scales for the targeted students before the program was implemented and again following 10 weeks of targeted activities. These results were compiled and are reported in the next section.

Results

A total of 74 schools from the 99 submitted data during September, consisting of 55 primary schools, 16 secondary schools and 3 central schools. There were 1213 students included on the spreadsheet with 954 primary students (78.6%) and 259 secondary students (21.4%). The largest groups were year 5 (42.2%) and year 6 (31.0%).

Place Value

In Table 2 below the initial and final LFIN levels of the 1213 students are displayed for place value and a comparison of levels indicates an increase in the overall results from initial to final.

Table 2
The Initial And Final Place Value Levels

PV Levels	Initial Frequency	Percentage Frequency	Final Frequency	Percentage Frequency
0	222	18.3%	53	4.4%
1	541	44.6%	323	26.6%
2	358	29.5%	553	45.6%
3	69	5.7%	213	17.6%
4	14	1.2%	34	2.8%
5	9	0.7%	37	3.1%
Total	1213	100.0%	1213	100.0%

Table 3 shows the distribution of differences in levels between the initial and final levels for place value. It shows that the majority of students have improved by 1 or more levels (57.3%), with a sizeable group improving two levels (9.6%). There are a small group of students who improved by 3 and 4 levels and there are some who decline by 1 or 2 levels.

Table 3
The Difference In Place Value and Multiplication/Division Levels

Difference	Place Value Frequency	Percentage Frequency	Multiplication/Division Frequency	Percentage Frequency
- 4	0	0 %	1	0.1%
- 3	0	0 %	2	0.2%
- 2	4	0.3%	5	0.4%
- 1	26	2.1%	26	2.1%
0	488	40.2%	455	37.5%
1	557	45.9%	452	37.3%
2	116	9.6%	175	14.4%
3	19	1.6%	70	5.8%
4	3	0.2%	27	2.2%
Total	1213	100.0%	1213	100.0%

The descriptive statistics record an increase in the mean from 1.29 for the initial level (SD = 0.919) to 1.97 for the final level (SD = 1.002). Using a paired sample T-Test ($t = 30.068$, $p<0.05$), the results indicate that the improvement in the student place value learning outcome levels at the start and finish of the 10 week Counting On 2008 program was statistically significant.

Multiplication and Division

Table 4 displays the initial and final LFIN levels for multiplication / division for the 1213 students and also indicates an increase in the overall levels.

Table 4
The Initial And Final Multiplication/Division Levels

PV Levels	Initial Level Frequency	Percentage Frequency	Final Level Frequency	Percentage Frequency
1	290	23.9%	68	5.6%
2	329	27.1%	193	15.9%
3	236	19.5%	291	24.0%
4	180	14.8%	292	24.1%
5	178	14.7%	369	30.4%
Total	1213	100.0%	1213	100.0%

When the distribution of differences are further examined in Table 3 they show that the majority of students have improved by 1 or more levels (59.7%), with a sizeable group improving two levels (14.4%). There are a small group of students who improve by 3 and 4 levels as there are some who decline by 1, 2 or more levels.

The descriptive statistics record an increase in the mean from 2.69 (SD = 1.367) to 3.58 for the final level (SD = 1.228). Using a paired sample T-Test ($t = 29.294$, $p<0.05$), the results indicate that the improvement in the student multiplication/division learning outcome levels was statistically significant.

Mathematical Word Problems - Newman's Error Analysis

Only one of the two questions involving Newman's Error Analysis in the assessment instrument was recorded for each student. The NEA scale from 1 to 5 was used, and a category 6 was added to represent those who could complete the word problem successfully.

Table 5 displays the initial and final NEA levels and indicates an improvement in the overall levels from the initial to the final student assessments. And when explored further, Table 6 shows that the majority of students have improved by 1 or more levels (56.6%), with a sizeable group improving two levels (15.6%). There are a small group of students who improved by 3 and 4 levels as there are some who decline by 1, 2 or more levels.

Table 5
The Initial And Final Newman's Error Analysis Levels

NEA Levels	Initial Level Frequency	Percentage Frequency	Final Level Frequency	Percentage Frequency
1	196	16.2%	51	4.2%
2	452	37.3%	234	19.3%
3	399	32.9%	477	39.3%
4	101	8.3%	220	18.1%
5	37	3.1%	134	11.0%
6	28	2.3%	97	8.0%
Total	1213	100.0%	1213	100.0%

The descriptive statistics record an increase in the mean from 2.52 for the initial level (SD = 1.096) to 3.37 for the final level (SD = 1.254). Using a paired sample T-Test ($t = 24.2405$, $p<0.05$), the results indicate that the improvement in the student outcomes for mathematical word problem levels at the start and finish of the 10 week Counting On 2008 program was statistically significant.

Table 6
The Difference In Newman's Error Analysis Levels

Difference	Frequency	Percentage Frequency
- 4	3	0.2%
- 3	6	0.5%
- 2	14	1.2%
- 1	52	4.3%
0	452	37.3%
1	385	31.7%
2	189	15.6%
3	79	6.5%
4	27	2.2%
5	6	0.5%
Total	1213	100.0%

The increase in the mean is about half a level for place value, and almost a whole level for multiplication and division, as well as for the Newman's Error Analysis levels.

Discussion

The data collected for the student learning outcomes indicated that a statistically significant improvement existed in student learning outcomes in all three content areas of place value, multiplication / division, and mathematical problem-solving involving word problems. The data shows that over half of the students improved 1 or more LFIN levels of conceptual development in place value, and a higher number of students improved 1 or more LFIN levels of conceptual development in multiplication and division, and in NEA levels. It is argued that the use of the same test should not have affected the validity of the post test results as the students received nil feedback on the initial test and there was a minimum ten week gap between assessments.

It is proposed that the student learning outcomes improved because teachers through the support and resources of the CO 2008 program had the opportunity to think, plan and reflect on their teaching and gained: greater knowledge of their students; more strategies that catered for individual differences; greater mathematical content and pedagogic knowledge which produced a wider range of classroom strategies and a greater use of concrete materials; increased collegiality and sharing of ideas and resources.

The use of a testing procedure raises the issue of whether a correct answer equates to understanding. Ellerton and Olson (2005) conducted a study of 83 Grades 7 and 8 American students completing a test comprising items from Illinois Standards Achievement Tests. Their findings reinforced the fact that students' scores on tests do not necessarily reflect their level of understanding of mathematical concepts and relationships. Results indicated a 35% mismatch with students who gave correct answers with little or no understanding and others who gave incorrect answers but possessed some understanding. While these findings cast doubt on the use of large scale testing programs as a means of making comparisons or being used as basis for the allocation of resources, it is less of an issue for CO 2008 as the groups of targeted students are small for each school and teachers make use of instruments LFIN and NEA which are designed to assist teachers in diagnosing the level of student understanding.

There were students whose results did not improve. In a short program such as this, it is unrealistic to expect that all students will register immediate improvement. These

targeted students have been struggling for some time with their mathematical and literacy levels and have developed judgements of their own ability. To improve 1 level on either the LFIN or NEA scale in such a small time frame is quite remarkable and points to educationally significance. There is an expectation that the gains reported in this study will continue to have an impact as the students build upon their success and a longitudinal study of these students would be of interest.

There are other reasons for student lack of progress or in some cases a regression in the levels. The 2007 CO evaluation report explored reasons for the negative regression and listed factors such as the use of different assessors, poor initial teacher understanding of the LFIN and NEA, misdiagnosis, student resistance to assessment and teacher confusion with the different levels for LFIN and NEA. It appeared that the errors originated from the same small number of facilitators and suggested inexperience and lack of understanding with the instruments. However other possible explanations could include students who do not have the capacity to handle the mathematics required, or they have become very resistant due to negative experiences and poor self image. The CO 2007 (White 2008) report mentioned the existence of 'fossilised misconceptions' whereby a student maintains a faulty conception despite having been specifically taught the 'official' defining characteristics of the relevant concept. The use of the term 'misconception' was also challenged by Vaiyatvutjamai and Clements (2004). They claimed the use of the term misconception was incorrect as it is regarded as a fairly stable, but inappropriate, way of thinking whereas their study of low performers revealed 'unstable' conceptions that resulted in students giving different answers at different times and hence it was possible that their test scores would decline. It was not explored in the CO 2008 evaluation report (White, in press) except in a cursory manner.

Conclusion

Between the start and the completion of the CO 2008 program there was an improvement in targeted student learning outcomes. The data revealed a statistically and educationally significant improvement in student learning outcomes in all three specific areas of place value, multiplication/division, and mathematical word problems involving the first two areas. The implications of these gains in the fundamental levels of mathematics are that students should build upon their success and achieve higher mathematical outcomes in the future.

This paper concludes that the CO 2008 program was successful in assisting the learning outcomes of middle years students who struggled with their early mathematics knowledge.

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