# Counting On in the Middle Years.

Allan Leslie White
*University of Western Sydney*
al.white@uws.edu.au

The 2009 *Counting On* program has evolved from a series that began in 1999 and which continued to expand and change until the current manifestation. The program has always had a twin learning focus upon both students and teachers. Thus it seeks to improve student mathematical outcomes while building capacity within the teachers by improving their professional situated mathematical knowledge which is the knowledge teachers need to effectively teach the early mathematical concepts to their students in a classroom context. *Counting On* 2009 was evaluated and this paper will use the findings of the evaluation report (White, 2010 in press) to examine whether the program was successful in changing student learning outcomes.

The 2009 *Counting On* program has evolved from a series of *Counting On* programs that continued to expand and change into the current manifestation. The program has always had a twin learning focus upon both students and teachers. Thus it seeks to improve student mathematical outcomes while building capacity within the teachers by improving their professional situated mathematical knowledge which is the knowledge teachers need to effectively teach the early mathematical concepts to their students in a classroom context.

This evolutionary process that started in 1999 saw the inclusion of a greater range of students (from Year 7 to Years 4 - 9), the inclusion of the feeder primary schools, and also a change in content and process. Until 2007 many of the basics of the diagnostic assessment had tended to remain essentially the same. Thus students were individually interviewed and videotaped for further analysis of their responses and this was a very time intensive process. In 2007 the program underwent significant modification that included a simplified assessment instrument and sorting process, where the interview was reserved for only the targeted students. There was also the introduction of Newman's Error Analysis; a revised *Counting On* CD to disseminate information and resources; the formation of School clusters; the use of a facilitator's conference; and a facilitated professional development model. The program began with and has continued to operate using a team approach and more recently school clusters have become Learning Communities and the globally successful Lesson Study model has been promoted as a structured way for Learning Communities and for members of a school team to work together. There was also a *Counting On* website.

The *Counting On* program sought to address the concerns of the numeracy and literacy outcomes of school students detailed in the *State Numeracy Plan 2006 - 2008* (NSWDET, 2005a) and the *State Literacy Plan 2006-2008* (NSWDET, 2005b) as well as the concerns listed under the six priority areas of the *Office of Schools Plan 2009-11* (NSWDET, 2008), by building capacity among teachers while improving the student understanding of early mathematical concepts and procedures.

## Theoretical Basis.

There has been considerable research completed since 1990 in children's early mathematical understanding. For instance, research into mental computation has revealed a rich and complex range of mental strategies that children develop for multi-digit addition

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and subtraction tasks. Thus a sample of the available strategies for answering 47+18 could include: jump (47+18: 47+10 → 57+3 → 60+5 → 65), split (47+18: 40+10 = 50, 7+8 = 15, 50+15 = 65), and compensation (47+18: 47+20 → 67-2 → 65), where the use of these or other mental strategies involves a broad knowledge of number relationships. This complex maze of relationships within early mathematical learning has resulted in a number of early numeracy programs all containing frameworks such as the Victorian Early Numeracy Research Project (ENRP), the New Zealand Numeracy Development Project (NDP) and the New South Wales Count Me In Too (CMIT) program. What these numeracy learning frameworks have in common is a strong link between research, pedagogy, teacher professional learning and a strong focus upon the learning of the student.

The research base for the program is closely related to 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 research base was further supported by an increasing number of Counting On evaluation studies. Mulligan (1999) evaluated a pilot study involving 9 schools, after which 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 and 2007 (Perry & Howard, 2000, 2002a, 2003; White 2008, 2009).

The inclusion of Newman's Error Analysis (NEA, Newman, 1977; 1983) in the 2007 program aimed to assist teachers when confronted with students who experienced difficulties with mathematical word problems. Rather than give students more drill and practice, NEA provided a framework for considering the reasons for 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 classroom pedagogical and problem solving strategies.

This brief and far from comprehensive overview has sought to portray the 2009 Counting On program as an initiative that arose from an initial successful trial program that has continued to adapt and evolve each year to meet the changing challenges, concerns and demands of the students, teachers and system. There were changes incorporated into the 2009 program but 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 2009 program in overall terms of student mathematical learning outcomes.

## Methodology

The 2009 program was implemented in 88 schools across the state. The schools were divided into 21 Learning Communities and each community was assisted by a Regional

Mathematics Consultant. In each school there was a teacher with the title of School Program Facilitator who formed a team of teachers to implement the program. In each school, the facilitator coordinated the process whereby each teacher administered a whole class assessment test covering place value, addition, subtraction, multiplication, division tasks and word problems. The assessment test was closely linked to the learning framework. These data were used by the teacher to identify the student target group. Target students scored few or no correct answers. The target group was then interviewed. Using a pre-test post-test procedure, on two occasions, teachers were asked to conduct a target group assessment process with a minimum of 5 students per class and facilitators were asked to record the student data on an excel spreadsheet supplied to them. The spreadsheet recorded the initial level on the LFIN and NEA items for the targeted students before the 2009 Counting On program was implemented and again following 10 weeks of targeted 2009 Counting On activities. These results were compiled and are reported in the next section.

## Results

A total of 69 schools (78%) submitted data during September, consisting of 52 primary schools, 15 secondary schools and 2 special schools. There were 945 students included on the spreadsheet with 618 primary students (65.4%) and 327 secondary students (34.6%).

Table 1
*Target Student Numbers in Each School Year*

| School Year | Frequency | Percentage Frequency |
|---|---|---|
| 4 | 19 | 2.0% |
| 5 | 330 | 34.9% |
| 6 | 269 | 28.5% |
| 7 | 207 | 21.9% |
| 8 | 110 | 11.6% |
| 9 | 10 | 1.1% |
| Total | 945 | 100.0% |

### *Place Value*

In Table 2 below the initial and final LFIN levels of the 945 students are displayed for place value and a comparison of levels indicates an increase in the overall results from initial to final. There were 17% of students initially identified at the lowest level and that was reduced to 3% by the end of the program.

Table 2
*The Initial and Final Place Value Levels*

| PV Levels | Initial Frequency | Percentage Frequency | Final Frequency | Percentage Frequency |
|---|---|---|---|---|
| 0 | 162 | 17.14% | 30 | 3.17% |
| 1 | 352 | 37.25% | 189 | 20.00% |
| 2 | 335 | 35.45% | 457 | 48.36% |

| | | | | |
|---|---|---|---|---|
| 3 | 68 | 7.20% | 173 | 18.31% |
| 4 | 21 | 2.22% | 66 | 6.98% |
| 5 | 7 | 0.74% | 30 | 3.17% |
| Total | 945 | 100.00% | 945 | 100.00% |

Table 3 shows the degree of student 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 (58.1%), with a sizeable group improving two levels (13.0%). A small number of students improved by 3 and 4 levels, and a small number declined by 1 or 2 levels.

Table 3
*The Difference in Place Value Levels*

| Difference | Frequency | Percentage Frequency |
|---|---|---|
| - 2 | 2 | 0.2% |
| - 1 | 12 | 1.3% |
| 0 | 382 | 40.4% |
| 1 | 409 | 43.3% |
| 2 | 123 | 13.0% |
| 3 | 16 | 1.7% |
| 4 | 1 | 0.1% |
| Total | 945 | 100% |

The descriptive statistics record an increase in the mean from 1.42 for the initial level (SD = 0.977) to 2.15 for the final level (SD = 1.026). Using a paired sample T-Test, the results indicate that the improvement in the student place value learning outcome levels at the start and finish of the 10 week 2009 Counting On program was statistically significant.

### *Multiplication and Division*

Table 4 displays the initial and final LFIN levels for multiplication / division for the 945 students and also indicates an increase in the overall levels. It shows an overall improvement in the levels and where initially there were nearly 15% of students identified at the highest level, this increased to 35% by the completion of the program. When the differences in levels are further examined in Table 5 they show that the majority of students have improved by 1 or more levels (57.6%), with a sizeable group improving two levels (13.8%). A small number of students improved by 3 and 4 levels, and a small number declined by 1, 2 or more levels.

The descriptive statistics record an increase in the mean from 2.93 for the initial level (SD = 1.323) to 3.77 for the final level (SD = 1.186). Using a paired sample T-Test, the results indicate that the improvement in the student multiplication / division learning outcome levels at the start and finish of the 10 week 2009 Counting On program was statistically significant.

Table 4
*The Initial and Final Multiplication/Division Levels*

| PV Levels | Initial Level Frequency | Percentage Frequency | Final Level Frequency | Percentage Frequency |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| 1 | 175 | 18.52% | 42 | 4.44% |
| 2 | 198 | 20.95% | 124 | 13.12% |
| 3 | 228 | 24.13% | 175 | 18.52% |
| 4 | 206 | 21.80% | 274 | 28.99% |
| 5 | 138 | 14.60% | 330 | 34.92% |
| Total | 945 | 100.00% | 945 | 100.00% |

Table 5
*The Difference in Multiplication/Division Levels*

| Difference | Frequency | Percentage Frequency |
|---|---|---|
| - 3 | 2 | 0.2% |
| - 2 | 3 | 0.3% |
| - 1 | 26 | 2.8% |
| 0 | 370 | 39.2% |
| 1 | 341 | 36.1% |
| 2 | 130 | 13.8% |
| 3 | 63 | 6.7% |
| 4 | 10 | 1.1% |
| Total | 945 | 100.00% |

### *Mathematical Word Problems - Newman's Error Analysis*

While there were two questions used involving Newman's Error Analysis in the assessment instrument' only the NEA result for the 'Natalie paddling the Murray River' item in both the initial and final assessments were recorded for each student. The NEA scale from 1 to 5 was used with a category 6 added to represent those who could complete the word problem successfully.

Table 6
*The Initial and Final Newman's Error Analysis Levels*

| NEA Levels | Initial Level Frequency | Percentage Frequency | Final Level Frequency | Percentage Frequency |
|---|---|---|---|---|
| 1 | 142 | 15.03% | 63 | 6.67% |
| 2 | 352 | 37.25% | 202 | 21.38% |
| 3 | 279 | 29.52% | 291 | 30.79% |
| 4 | 115 | 12.17% | 228 | 24.13% |
| 5 | 29 | 3.07% | 78 | 8.25% |
| 6 | 28 | 2.96% | 83 | 8.78% |
| Total | 945 | 15.03% | 945 | 100.00% |

Table 6 displays the initial and final NEA levels and indicates an improvement in the overall levels from the initial to the final student assessments. When explored further, Table 7 shows that the majority of students have improved by 1 or more levels (53.8%), with a sizeable group improving two levels (15.6%). Initially there were 67% of students

identified as experiencing difficulties with the two NEA levels of Comprehension and Transformation and this was reduced to 52% by the end of the program. A small number of students improved by 3 and 4 levels, and a small number declined by 1, 2 or more levels.

Table 7
*The Difference in Newman's Error Analysis Levels*

| Difference | Frequency | Percentage Frequency |
|---|---|---|
| - 4 | 2 | 0.2% |
| - 3 | 2 | 0.2% |
| - 2 | 6 | 0.6% |
| - 1 | 45 | 4.8% |
| 0 | 382 | 40.4% |
| 1 | 317 | 33.5% |
| 2 | 147 | 15.6% |
| 3 | 32 | 3.4% |
| 4 | 12 | 1.3% |
| Total | 945 | 100.00% |

The descriptive statistics record an increase in the mean from 2.60 for the initial level (SD = 1.151) to 3.32 for the final level (SD = 1.319). Using a paired sample T-Test, the results indicate that the improvement in the student outcomes for mathematical word problem levels at the start and finish of the 10 week 2009 Counting On program was statistically significant. There is a difficulty here in that these statistics rely on the assumption of the NEA levels being either a ratio or interval scale which is questionable regarding the equality of the distances between any two of the levels.

## Discussion

The 2009 Counting On program had a positive impact upon students' early mathematics learning through its twin learning focus upon both students and teachers There is a growing body of evidence claiming that teacher quality is one of the most important school factors influencing student achievement, ahead of class size and school size (Darling-Hammond, 2003; Cuttance, 2001). It is proposed but not proven that the student learning outcomes improved partly because teachers, through the support and resources of the program, had the opportunity to think, plan and reflect on their teaching, which produced a wider range of classroom strategies and a greater use of concrete materials.

The full effects of improved teacher professional learning are often delayed and reveal themselves later as the teacher completes the process of integrating the new learning into current practice. So while it may be impossible to measure the full effects at this time, it is possible to gather some indicators. The data collected indicated that a statistically significant improvement existed in student learning outcomes in all three specific areas measured. It is argued that repetition of the test would not influence the results as the students received no feedback on the initial test and there was at least a ten week gap between assessments. The use of a testing procedure raises the issue of whether a correct answer equates to understanding and that tests do not necessarily reflect their level of understanding of mathematical concepts and relationships (Ellerton & Olson, 2005).

Research has 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 this program 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.

In a short program such as this, the results are quite remarkable. For some students, it is unrealistic to expect they will register an immediate improvement as they have been struggling for some time with their mathematical and literacy levels and have developed judgements of their own ability. To improve one level on either the LFIN or the NEA scale in such a small time frame is quite remarkable and points to educational significance. There is an expectation that these gains will continue as the students build upon their success and a longitudinal study of these students would be of interest but is beyond the scope of this paper.

There are alternative reasons for a lack of student progress or in some cases a regression in the levels. Some students have become fixated on inefficient correct procedures while others have 'fossilised' misconceptions (Vaiyatvutjamai & Clements, 2004). Also, the 2007 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.

This paper concludes that the 2009 *Counting On* program was successful in assisting the learning outcomes of middle years students who struggled with their early mathematics knowledge. The author wishes to acknowledge the support of the New South Wales Department of Education and Training, particularly Peter Gould, Chris Francis and Ray MacArthur of the Curriculum Support Directorate. The opinions expressed in this paper are those of the author and do not necessarily reflect those of the Department.

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