THE MATHEMATICAL ACHIEVEMENT OF CHILDREN IN THE COUNT ME IN TOO PROGRAM

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This paper reports findings from a study designed to investigate the impact of an early numeracy program on the mathematical achievement of young children. Two groups of Year 1 students were assessed using the Schedule for Early Number Assessment—once in May, prior to the experimental group participating in the numeracy program, and once in November. Results indicate that the experimental group performed significantly better than the control group at the post-test phase.

The first three years of school have been acknowledged as having a profound effect on the rest of a child's mathematical education (Wright, 1994a). While numeracy levels continue to receive attention internationally, it is not until children in NSW government schools are well into their fourth year of schooling that any form of systematic or formal assessment is made (for example, the Basic Skills Test is given to Year 3 and Year 5 students in NSW). By this time, vast differences are already evident in children's mathematical abilities (Fuson, 1988; Wright, 1994a; Young-Loveridge, 1989).

Numeracy, and its identification as a fundamental aspect of education, has been recognised for some time. However, Commonwealth government attention to numeracy and its relation to school education, has only been quite recent. It has now taken on a leading role in ensuring that numeracy, along with literacy, is made a national goal. In 1997, the Commonwealth, State and Territory Ministers agreed to a national literacy and numeracy goal:

> *That every child leaving primary school should be numerate, and be able to read, write and spell at an appropriate level.*

Furthermore, they agreed to the sub goal:

> *That every child commencing school from 1998 will achieve a minimum acceptable literacy and numeracy standard within four years.*

The National plan for literacy and numeracy places "importance on the early years because research indicates that if children have not met appropriate literacy and numeracy standards by the end of primary school, they are unlikely to make up the gap through the rest of schooling" (AAMT, 1997, p.49). The plan therefore calls for early intervention to address the needs of all students and for comprehensive assessment of students by teachers in the first years of schooling.

The NSW Department of Education and Training's early numeracy program, Count Me In Too, addresses these two aspects of the National Literacy and Numeracy plan. While it's focus is on the professional development of teachers so as to enhance their teaching of numeracy to all students, comprehensive assessment is an integral component of the program. The purpose of the investigation reported in this paper was to evaluate the impact of Count Me In Too on the mathematical achievement of young children. While the original investigation included children from both Kindergarten and Year 1, only the results of Year 1 are presented in this paper.

BACKGROUND TO THE STUDY

Count Me In Too (CMIT) is a professional development initiative of the NSW Department of Education and Training (DET) focusing on the early years of mathematics. Its main purpose is "for teachers to better understand children's mathematical strategies and their development from less sophisticated to more sophisticated strategies" (Stewart, Wright & Gould, 1998, p.557). It is researched based, originating from the theory and methods of the Maths Recovery (Wright, Stanger, Cowper & Dyson, 1996) and Reading Recovery Programs (Clay, 1993) incorporating aspects such as the Learning Framework in Number (Wright, 1998) and a clinical interview based assessment instrument—the Schedule for Early Number Assessment or SENA (DET, 1998). Rather than being a packaged program, CMIT is a continually evolving school-based initiative that involves a close liaison between the district consultant and a group of teachers at each school.

The work-based model of professional development operating in CMIT schools varies from school to school, but generally there is much more focus on children's solution strategies, on reasoning, reflection, problem solving and conceptual understanding rather than on the rote memorisation of algorithmic procedures. A video-taped clinical interview referred to as the Schedule for Early Number Assessment (SENA) is an integral component of the program. It is used to diagnose children's strengths and weakness, providing teachers with a 'blueprint' of each child's arithmetical development. Guided by results on the SENA and the Learning Framework in Number, teachers are able to map future lines of development for children on an individual basis. Currently, implementation is focussed on number, however a research base in Space and Measurement is being developed that can be implemented in a similar fashion.

In 1998 the NSW Department of Education and Training (DET) extended CMIT to include seventy-eight DET funded schools, two hundred and fourteen non-funded schools, over one thousand teachers and approximately twenty thousand K-2 students. While the focus of the project is on developing the knowledge of K-2 teachers in early number, the ultimate aim is to improve young children's mathematical abilities.

CMIT employs a work-based model of professional development, with mathematics consultants working in classrooms alongside teachers. Exactly how consultants become involved varies from school to school, but basically their role is to assist tachers with the implementation of the learning framework espoused by the CMIT project. Generally, this is achieved by consultants helping teachers assess the mathematical development of children in their class, and by helping them plan and implement developmentally appropriate learning and teaching experiences.

RESEARCH PLAN

Participants

Participants were largely from middle class families and attended one of two suburban metropolitan Sydney schools. The experimental group consisted of a Year 1 (n = 21) class involved in the CMIT project and the control group consisted of a Year 1 (n = 23) class from a nearby school not involved in CMIT. All teachers whose students were involved in the investigation had three or more years experience teaching in the Kindergarten to Year 2 range. While an effort was made to match the experimental and control groups as closely as possible in regard to socio-economic status, experience of classroom teachers and the like, the ultimate selection rested on each of the schools' willingness to be included in the study.

Materials and Procedure

The SENA was developed over a period of approximately five years and has been used extensively by teachers and researchers to assess the early arithmetical development of young children (Wright, 1996). It involves the presentation of 58 'tasks' or problems to a child in a one-on-one interview. The SENA assesses each child on five aspects of number development—Early Arithmetical Strategies (EAS), Forward Number Word Sequences (FNWS), Backward Number Word Sequences (BNWS), Numeral Identification (NID) and Base 10. It is the role of the interviewer (the classroom teacher) to elicit a child's most sophisticated strategy (or EAS) and then determine where each response might be categorised within a framework of predetermined stages and levels of development (Wright, 1994b). For a more thorough description of the Learning Framework see Wright, (1994b).

Children from both the experimental and control groups were interviewed individually on two occasions—once prior to the CMIT project beginning (May/June 1998) and once at its conclusion (November 1998). Research assistants, who conducted the interviewers, were four experienced teachers who had been trained to administer the SENA.

The SENA took approximately 15 to 30 minutes to conduct, depending on the ability of the child being interviewed. Children with greater mathematical ability were asked to perform more difficult tasks and therefore took longer to complete the interview. Each assessment session began with a brief introduction to the nature of the tasks the child would be asked to perform. If a child became noticeably frustrated by their inability to complete any task, they were stopped and asked to complete a task from a different section of the SENA. For example, if a child could not count five counters from a small pile of counters, they were not asked to count fourteen counters. Once it became obvious that subsequent items on the SENA were beyond the capability of a child, the interview was stopped. Research assistants attempted to elicit each child's most sophisticated strategy. If a strategy was not obvious, the assistant asked a child to explain how they found an answer. All SENA interviews were video-taped and later analysed by the chief investigator so as to determine where each response might be categorised within a framework of predetermined stages and levels of development.

RESULTS AND DISCUSSION

Results on the five early number aspect of the SENA for the Year 1 experimental and control groups are summarised in Table 1. Separate two tailed t-tests on the each of the five aspects of the SENA indicated no significant differences between the performances of the two groups at the pre-test phase. However, at the post-test phase, there were significant differences between the performances of the two groups on each aspect (EAS, $t = 4.7, p < 0.001$; FNWS, $t = 3.2, p < 0.05$; BNWS, $t = 3.6, p < 0.05$; NID, $t = 4.9, p < 0.0001$; Base 10, $t = 3.7; p < 0.05$) indicating that the experimental group performed significantly better than the control group.

Graph 1 presents box plots for the experimental and control groups' performances on each aspect of the SENA at the pre-test phase. Graph 2 presents the results for each group at the post-test phase. Box plots allow more comparisons to be made between the performances of the experimental and control groups. In particular, they provide detailed information regarding the distribution of students' performances at the pre-test and post-test phases of the study. Generally, box plots are composed of five horizontal lines that display the 10th, 25th, 50th, 75th and 90th percentiles of student performances. All scores above the 90th and below the 10th percentiles are plotted separately. The two horizontal lines at each end of the plot (called 'whiskers') indicate where the majority of scores lie. The further apart the whiskers, the more 'spread out' are the scores. The middle 50% of scores are between the upper and lower borders of the box. The longer the box, the more 'spread out' are the scores. The horizontal line inside the box shows the middle score (or median) if all scores were arranged in order from smallest to largest. For instance, in Graph 1, a comparison of the box plots representing performances of students in the experimental and control groups on the Early Arithmetical Strategies aspect of the SENA (EAS E1 and EAS C1, respectively), indicate that at the pre-test phase the range of scores was the same (between Stages 0 and 4). However, the taller box for the control group means that student performances were more spread out—the majority of students performing at either Stages 1, 2 or 3. The absence of a horizontal line in the middle of graph EAS E1 indicates that the majority of students (the middle 50%) in the experimental group performed at Stages 1 and 2.

Table 1
Experimental and control group performances (means and standard deviations) on the SENA and each aspect of the SENA pre-test and post-test

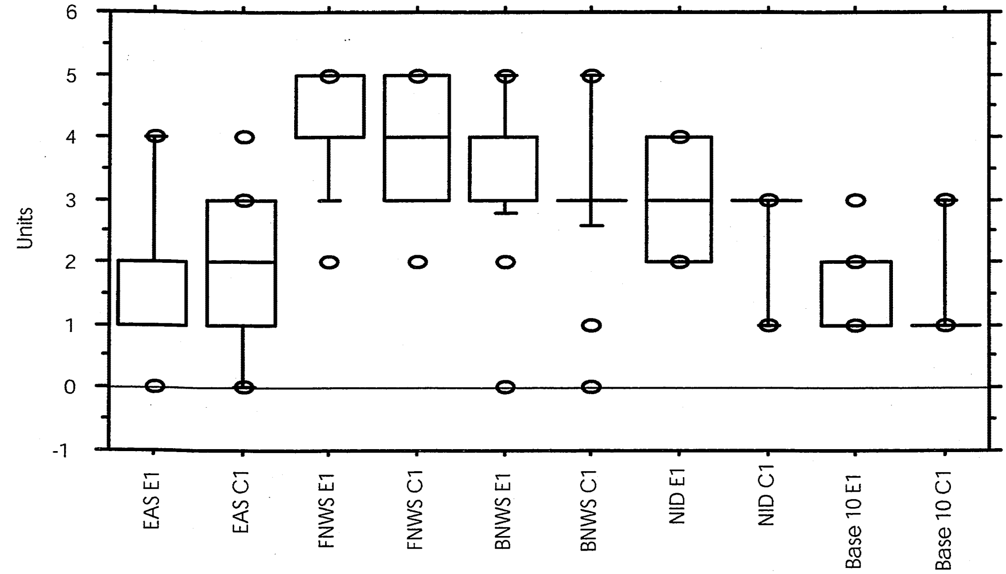
		Experimental Group		Control Group	
		Pre-test	Post-test	Pre-test	Post-test
Aspect		n=23	n=23	n=23	n=23
EAS	Mean	2.0	3.5	1.7	2.4
Max=4	SD	1.1	0.9	1.2	1.0
FNWS	Mean	4.1	4.9	4.0	4.3
Max=5	SD	0.8	0.3	0.9	0.8
BNWS	Mean	3.4	4.5	3.1	3.7
Max=5	SD	1.2	0.8	1.1	1.2
NID	Mean	3.1	3.9	2.7	2.9
Max=4	SD	0.9	0.7	0.7	0.7
Base10	Mean	1.4	2.1	1.3	1.4
Max=3	SD	0.6	0.7	0.7	0.7

EAS Early Arithmetical Strategies BNWS Backward Number Word Sequence
FNWS Forward Number Word Sequence NID Numeral Identification

An advantage of using box plots to represent results is the ability to obtain information 'at a glance' about the full range of academic abilities and to make comparisons. For instance, it is evident from Graph 1 that the two groups were performing at similar levels for each of the five aspects at the pre-test phase. It is particularly interesting to compare the plots EAS E1 and EAS C1 on Graph 1 with EAS E2 and EAS C2 on Graph 2. The box plot EAS C2 (see Graph 2) indicates that while the majority of the lower achieving students (those at Stages 1 and 0 at the pre-test phase) had advanced to Stages 2 and 3, very few high performing students (those at Stage 3 at the pre-test phase) had progressed beyond their initial performances. In contrast, EAS E2 shows that the majority of students from the experimental group were performing at Stages 3 and 4 and that there were no students performing at Stages 0 or 1 at the post-test phase. Furthermore, a comparison of box plots EAS E2 and EAS C2 on Graph 2 reveals that the bottom 25 per cent of students from the experimental group were performing at the same level as the more able students from the control group on the SENA post-test. A possible explanation for the lack of improvement on this aspect for the control group lies in the fact that EAS, or early arithmetical strategies, such as counting-on and counting-back, are not closely related to Syllabus content (they are thinking strategies or processes which children use to solve computational problems) as other aspects, such as Forward and Backward Number Word Sequences, Numeral Identification and Base 10. While most students develop arithmetical strategies without the explicit instruction that occurs in CMIT, many continue to use inefficient strategies (e.g. counting on fingers) well into upper primary and even adulthood. Results from this study indicate that, with explicit teaching, *all* students can learn to use more efficient arithmetical strategies and that they can do so from as early as Year 1.

It is also apparent from Graph 2 that the performances of students from both groups were less 'spread out' at the post-test phase. This is particularly evident for the experimental group. While box plots reveal how children of various academic abilities performed at each phase of the study, caution needs to be exercised when interpreting the plots for the more able students in Year 1. For example, box plot BNWS E2 (Graph 2) looks as if the majority of the Year 1 students from the experimental group were all performing at the

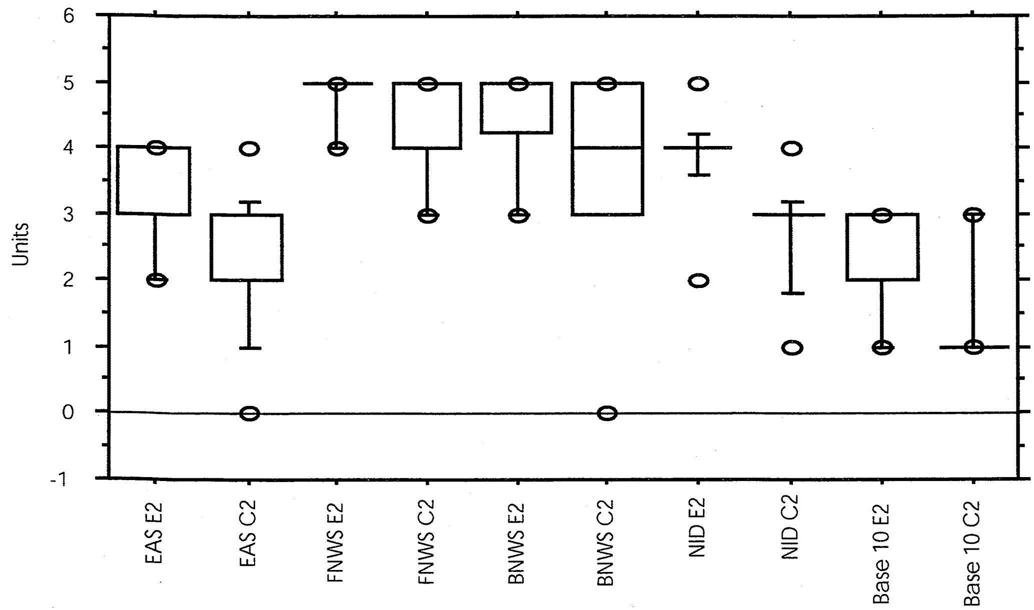
Graph 1
Box plots of experimental (E) and control group (C) performances on each aspect of the SENA for the pre-test



* Units correspond to Stages of development for EAS and Levels of development according to the Learning Framework in Early Number for all other aspects

same level (Level 5). In reality, this may not be the case, since Level 5 is the upper limit described on the Learning Framework and many able students could probably perform at even more advanced levels if the framework were extended. In other cases, such as for the box plot EAS C2 (Graph 2), where students have not reached the upper level of the framework, it is clear as to how students of various abilities performed in relation to each other.

Graph 2
Box plots of experimental (E) and control group (C) performances on each aspect of the SENA for the post-test



* Units correspond to Stages of development for EAS and Levels of development according to the Learning Framework in Early Number for all other aspects

While the clustering of performance scores may be a result of students from both groups reaching the upper limit of levels on the Learning Framework for aspects such as Forward and Backward Number Word Sequences, it cannot explain the smaller variation in performances on Numeral Identification and Base 10 aspects where there were still higher levels to which students could advance. For example, a comparison of box plots NID E1 on Graph 1 and NID E2 on Graph 2 illustrates how performances of students from the experimental group were distributed between Levels 2, 3 and 4 at the pre-test phase, but at the post-test phase almost all the students performed at Level 4.

SUMMARY AND CONCLUSION

The fact that there were no significant differences on the SENA performances overall between the experimental and control groups at the pre-test phase indicates that they were well matched in mathematical ability. The significant advances made by the experimental groups on all aspects of the SENA are clear evidence of the positive impact Count Me In Too can have on the mathematical ability of children involved in the program.

The suggestion that the experimental group may have been unfairly advantaged because the SENA contained tasks requiring skills emphasised by the CMIT program and thus were able to 'practise' them before the post-test phase, is not a viable explanation for the results. Aspects, such as Forward and Backward Number Word Sequences, Numeral Identification and Base 10, are included in the NSW Mathematics Syllabus (Department of Education, 1989) and should therefore be emphasised in all K-2 classrooms and not just ones in which CMIT is operating. Also implausible, is the suggestion that CMIT classrooms devote more time towards the teaching of number and forgo work on the measurement and space strands. Teachers involved in CMIT are required to fulfil Syllabus requirements across all the strands.

An obvious limitation of the study is the small sample size. Future investigations that incorporate larger samples should endeavour to make comparisons between schools with populations drawn from a range of socio-economic and ethnic backgrounds, and from rural and metropolitan schools. While the current study included children mostly from middle-class backgrounds, the findings cannot be extrapolated to the general population without further investigation. It would also be beneficial to monitor the progress of children on a longitudinal basis, say over a period of one or two years. In this way, it might be possible to determine if CMIT gives children a 'head start' in mathematics that continues on in to their upper primary years.

Another limitation of the present study was the fact that many students, particularly in the experimental group, reached the upper limits of many early number aspects being assessed by the SENA. Thus, their true mathematical abilities were not reflected in this study.

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