Title	Early intervention of Malay preschool teachers in promoting children's mathematics learning
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FINAL WRITTEN REPORT

Early Intervention of Malay Preschool Teachers in Promoting Children's Mathematics Learning

By

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Executive Summary

The study focused on improving kindergarten teachers' ability to nurture early numeracy development and learning in K2 children. An intervention involving the experimental group included teachers who had already attended in-service training, as part of the initial pilot project, to assist them to understand pedagogical principles, practices and strategies to assist children's development of numeracy skills, problem solving and reasoning. Further teacher guidelines, detailed lesson plans and mentorship were also provided on how to implement this in the classroom

The research adopted a pre-test and post-test mixed-methods design involving an experimental group and a control group, comprising preschool children from five classes (N=221). Intact classes were matched to treatment and control conditions on the basis of Mendaki selection and centre choice of participation.

Findings from the Math reasoning subtest of the (WIAT) Wechsler Individual Achievement (Test 2) and the (NCT) Numeracy Concept Test – a non-standardised test, showed that even though that at pre-test, the experimental groups were better on the WIAT and that they were similar on the NCT, both groups improved on the WIAT at post-test but the experimental groups maintained their superior performance on the post NCT. Improvements within experimental groups were also noted.

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Introduction
Overview and Background of the Proposal

Research in the UK and the USA has shown that high quality preschool education leads to positive effects for children, families and communities, particularly for minorities and disadvantaged groups (DfEE, 1998, 1999. Melhuish et al. 2008)). The research underpinning the *Sure Start* initiative in the UK (Craig, et al., 2007) shows that two years of high quality early childhood education can give children a four- to six-month advantage at entry to school, and improve the chances for academic success of children from at-risk or disadvantaged backgrounds. Hence, although Malay preschool children may not be at risk or disadvantaged, if we are to improve their primary one mathematics performance, we will need to ensure the quality of their preschool mathematics experiences.

It is well known from studies of babies and very young children that their mathematical development occurs as they seek out patterns make connections and recognise relationships through playing with quantities and sets of items and objects. Such play leads to children knowing about numbers and counting, sorting and matching and understanding shape, space and measuring (Bryant, 1995; Durkin, 1993; Nunes & Bryant, 1996). Hence, becoming numerate involves thinking mathematically about problems and their solutions, using numbers to make connections and realising numerical relationships through real life situations (Kamii, 1989; Young-Loveridge, 1989). This involves using and understanding a system of signs and symbols (Boulton-Lewis & Tait, 1994).

A developmental approach to numeracy education stresses building on children's natural ways of representing their ideas about numbers, by guiding them on from perceptually dominated experiences to thinking logically about numbers and their relationships (Kamii, 1989). Children need to be given opportunities to investigate, discover and apply their own solutions to mathematical problems (Sharpe, 2001, 2009). Using such an approach, a framework for a developmental kindergarten curriculum (Preschool Education Unit, MOE, 2003) was constructed, where active discovery learning and holistic development became key features. The effects of this curriculum on children's learning and development, especially in the domain of numeracy, were found to be very positive (Ministry of Education, 2003).

This investigation builds on some of the ideas and processes which have been shown to reap positive results in Singapore (Ministry of Education, 2003). In particular, it focuses on the important role of the teacher in supporting and extending numeracy development in children to prepare them for the primary mathematics syllabus. Teachers need to provide sufficient time, space and encouragement for children to discover and use mathematical

vocabulary and ideas, and to explore real-life problems (Munn, 2004; Young-Loveridge, Peters & Carr, 1998).

The awareness of the important role of the teacher in promoting numeracy development in young children has been recognised by Mendaki Singapore, who has expressed concerns about the poor performance of some Malay preschool children in the area of mathematics learning and their subsequent poor performance in mathematics in primary school. Although there is a dearth of published evidence as to the cause and extent of these difficulties, it is envisaged that, with careful and sensitive teaching by competent and knowledgeable teachers, such deficits might be overcome so that the short falls in performance can be alleviated before these children begin formal schooling (cf. Aubrey, 1997; Kleinberg & Menmuir, 1995).

It is noteworthy that, unlike the children in the *Sure Start* studies in the UK, where children begin formal schooling at five years of age, children in Singapore start formal schooling two years later than their British counterparts. In addition, because preschool education is not compulsory in Singapore, some children do not receive any schooling until they reach the age of 7. Some children who do have preschool experiences are taught by teachers who fall within the 10th percentile of academic qualifications (i.e., they have less than 5 'O' levels) and generally hold only Certificates or Diplomas of Preschool Teaching, the duration of which varies from 350 to 1,500 hours only. As such, the quality of education for preschool children in Singapore can be low, and children do not receive the best schooling at the point in their development when they are most receptive to numeracy learning (i.e., ages 5 to 7, and before).

In short, Singapore preschool children's experiences often have inadequately prepared them for the demands of primary school. There have been wasted opportunities for children to develop numeracy readiness in the most formative years of their development (cf. Munn, 1994, DCSF 2008). In this regard, an American study has shown the positive effects on pre-school children's later performance in mathematics once these children had been exposed to a research-based pre-school mathematics programme called 'Building Blocks' (Clements & Sarama, 2008). The children in this study developed a firm mathematical foundation as a result of the high quality mathematics environment which constitutes 'Building Blocks'. Furthermore, Ginsburg et al. (2008), point up three essential elements of effective mathematics education for pre-school children, namely: children are capable of learning more than is assumed; the programme needs opportunities for informal play and in addition to some structure; teaching is often poor and there is an urgent need to improve and support initial and in-service training of pre-school mathematics teachers.

The study described here is unique and significant in that there is a dearth of research on the early mathematical achievements of Malay children in Singapore, or methods to improve children's achievements as a result of teacher in-service training, and *in situ* mentorship of teachers to enhance children's mathematical development and learning.

Several data sources were used to monitor the success of the eleven-month intervention: observations of teachers; semi-structured and focus group interviews with teachers; documentation of children's learning in the K2 classes; testing of children's problem-solving, reasoning and numeracy knowledge and skills; documentation of K2/school contextual factors and interviews with parents.

Data was analysed both qualitatively and quantitively to track teacher success in assisting K2 children's numeracy development/learning and children's numeracy-based progress throughout the intervention period. Comparisons were made between the experimental and control groups using ANOVA. Qualitative data (e.g., interviews, learning artefacts and teachers' plans) were analysed through content analysis and triangulated with the related

quantitative data sources (e.g., Teacher Observation and Child Observation Scale/Shedules) to assess the effects of the intervention programme.

Outcomes of this research have direct application to Mendaki Singapore (the initiators of this research) and will lead Mendaki's further implementation of the teacher-improvement approach used in this study.

Thus, in order to better prepare children in Singapore for the required content of the primary school mathematics syllabus, it is important to raise the standards of mathematics teaching in the kindergarten, Initially such an objective may be achieved only on a small scale through this preliminary research, but with time, the outcomes may have a positive and far reaching effect. Hence, the aim of this study is to begin the process of early mathematical intervention, with the aim of Mendaki sustaining the processes of this research on a larger scale, and to ultimately reach increasing numbers of kindergarten teachers and children in Singapore over time.

Objectives:

1. To actively provide support for groups of K2 Malay children in their early mathematical learning (i.e., problem-solving, reasoning and numeracy) to maximise their readiness for optimal performance when they enter the lower primary school year's mathematics programme
2. To support the trained teachers in their understanding of how: (a) children think and learn as they become numerate, (b) to select appropriate pedagogies to engage and challenge children's numeracy within and outside the kindergarten, (c) to observe children's progress and provide appropriate strategies, activities and materials to scaffold their learning and (d) to involve parents in practices of supporting their children's numeracy learning through relevant activities at home and in naturalistic contexts, and through continued dialogue and progress reports to the teachers
3. To mentor the trained teachers in pedagogy and practice in K2 children's numeracy development, and document classroom contexts, teachers' and children's learning artefacts and parent's participation in their children's learning

Research Questions:

1. How successful is the intervention in helping to assist teachers and parents to scaffold children's early mathematical learning (e.g., in-service training, regular mentoring)?
2. Were teachers able to apply their previous and newly developed knowledge in relation to their pedagogical practices in order to support children's learning?
3. Were there observable gains in children's numeracy learning progress (based on a standardised cognitive test, research-developed measurements on numeracy concepts tasks, researcher observations and parents' perspectives)?

Deliverables:

- The dissemination of results of the project which compared experimental and control groups' performance and the effect of the intervention programme in assisting K2 children's numeracy learning, through journal publications and conference presentations and proceedings.
- The submission of the numeracy content, teacher guidelines and lesson plans to Mendaki for further training of their teachers

Research Methodology

Participants

The research design comprised five Experimental Groups (EG) and five Control Groups (CG) of K2 children (N=221), their teachers and parents. The classrooms were purposively sampled on the advice of Mendaki and CRPP, based on settings comprising Malay children only. Intact classes were matched to treatment and control conditions on the basis of Mendaki selection and centre choice of participation. The target of 100 children from each of the EG and CG participants was sought so that quantitative analyses could be used; approximately 5 sets of parents from each of the EG and CG classrooms were asked to volunteer for individual interviews. It was impossible to have parents to agree to attend focus group meetings for two reasons: they were unable or unwilling to make the time for these.

The CG received whatever professional development they would normally receive and served as a means for comparison to ensure the results would not be affected by unforeseen anomalies, such as high levels of teacher performance even without in-service training, or particularly supportive contextual factors (e.g., principal-teacher mentorship, high levels of parental participation).

Intervention (EG Only)

The intervention consisted of three approaches: The detailed lesson plans and materials provision prepared by the Consultant, in-service teacher training from the Consultant, Mentor and Co-PI, which took place between October 2008 and March 2009, with two additional workshops in June and August 2009 and, on-site and off-site mentorship from Mentor and Consultant, with the teachers using the lesson plans, some of which had already been trialled by the teachers.

1. Provision of detailed sequential lesson plans and materials provision

The content of the lesson plans was based on the steps and strides of numeracy development described in 'Nurturing Early Learners: A Framework for a Kindergarten Curriculum in Singapore' (Preschool Education Unit, MOE, 2003). [The bibliography includes a list of associated websites associated with this curriculum]. Key topics were also addressed in the in-service teacher training included:

(a) The relationship between the use of numbers as labels, and numbers used for counting.
(b) The elements of counting as the basis of early numeracy development.
(c) Conservation of number and its relationship to counting.
(d) Number values and their role in handling data involved with measurement, and shape.
(e) Scaffolding techniques central to encouraging and extending children's number knowledge.
(f) Language associated with the use of numbers and its importance for children to explain and understand what they know about numbers and their relationships.
(g) Children's development of an awareness of the relationship between numbers and quantities and how numbers can be combined and compared to solve simple problems.
(h) Ways in which coins might be used to help children combine and compare number values.
(i) The relationship between number values in addition and subtraction and measurement.
(j) Children's development of an understanding of "time" (e.g., events in time) and the language associated with this understanding.

(k) Children's numeracy development when discovering patterns, making connections and recognising relationships through investigations during play and in daily routines.
(l) Activities where children can develop simple classification skills and see relationships between objects, and ideas.
(m) Ways to display children's work and record their progress.
(n) Ways to assist parents in supporting their children's numeracy development and learning in naturalistic contexts, and to involve parents in relevant activities, dialogue and reflection about their children's numeracy gains.

The lesson plans also included advice for parents and differentiated activities for children at each of the three levels of ability. The criteria for selection to each level of differentiation are described after the section about the numeracy concepts test below. (See appendix 1 for samples of these lesson plans, the fourth set of which there were seven sets in total, and lists of materials and resources)

2. In-service Teacher Training.

The intervention programme also involved 24 hours of in-service training for EG teachers, by the Consultant, Mentor and Co-PI, and consisted of lectures, discussions, workshop activities and the use of audio-visual materials, to assist teachers to:

7. Understand and appreciate how children think and learn as they become numerate,
8. understand pedagogical principles, practices and strategies to assist K2 children's numeracy knowledge, skills, development and learning the elements of numeracy (i.e., numeracy skills, problem-solving and reasoning),
9. plan activities for their kindergarten contexts to meet the specific requirements of children in their classrooms (i.e., children of three different levels of numeracy development),
10. observe children's progress and provide appropriate strategies, activities and materials to scaffold their learning (e.g., questioning, demonstrating, explaining, modelling and the use of play-based learning centres),
11. select developmentally appropriate strategies and activities to engage and challenge children's numeracy within and outside the kindergarten,
12. use techniques to assist parents to support their children's numeracy development and learning through home-based and naturalistic community-based learning experiences, and involve parents in relevant activities, continued dialogue and progress reports to the teachers.

In order for them to become familiar with the content of the in-service training the Research Assistants (RAs) also attended. Prior to the intervention, the RAs and Mentor made site visits to the EG and CG group schools to familiarize themselves with the kindergartens, principals, teachers, children, parents and the school/classroom contexts of their assigned groups. In addition, they collected consent forms from the participants indicating their willingness to be involved in the project.

2. Mentorship (onsite and offsite).

Building on the in-service training, the EG teachers were supported throughout the intervention by means of coaching and mentoring, based on the teachers' feedback to the Mentor (M) and Consultant (C). The M and C were in regular contact to continuously monitor the type and level of mentorship provided to the EC teachers, using two inter-related approaches:

The M made a total of 21 site visits to each EG setting and coached and observed the EG teachers in their classroom practice. She kept field notes of her perceptions of the teachers'

progress and the issues raised by the teachers in relation to the following teacher-dimensions:

(a) appropriate establishment of conducive learning environments,
(b) communication (scaffolding techniques, use of appropriate mathematical terminology),
(c) responsiveness to children's developmental abilities,
(d) appropriate use of materials and resources,
(e) provision of opportunities for children to recall, practise and apply mathematical knowledge,
(f) implementation of appropriate forms of formative assessment, and
(g) appropriate use of strategies to assist parents to support their children's mathematical learning and development in the home and naturalistic contexts.

The Consultant engaged the EC teachers and Mentor in email correspondence and collaborative enquiry-based group sessions each month in relation to the above dimensions and any matters emerging in relation to these. In March 2009, the Consultant, Mentor and Co-PI, conducted a Focus Group Interview (FGI) with the EG teachers to solicit their feedback on the effectiveness of the intervention within the first few weeks of the research project. Using a collaborative enquiry approach, this feedback helped guide the directions for future development to meet the needs of the EG teachers and to establish appropriate ways for the C and M to mentor individual teachers throughout the intervention.

The M and C selected excerpts from email correspondence, transcripts from the FGI and field notes to triangulate the data in relation to the teachers' progress throughout the intervention. These data were further triangulated with the following data sources involving both EC and CG teachers.

Monitoring progress throughout the period of the study (Both EC and CG)

Several data sources were used to monitor the progress of the teachers and children throughout the project, and feedback was also collected from parents about their perceptions of the progress of their children's mathematical development throughout the period and their role in assisting this development. The data collection sources included:

Type	Source
Quantitative and qualitative	Teacher Observations Child Observations
Qualitative	Semi-structured Individual Interviews with Teachers, Focus Group Interviews with Teachers, Individual interviews with Parents, and Documentation of the Kindergarten Contexts
Quantitative	Wechsler Individual Achievement and Numeracy Concepts Tests

The two quantitative (Wechsler Individual Achievement and Numeracy Concepts Tests) and two quantitative-qualitative sources (Teacher Observations, Child Observations) were triangulated with qualitative data (Semi-structured individual teacher Interviews, focus group Interviews with teachers and individual parental interviews, and documentation of the kindergarten contexts). The triangulation of these data sources has provided a breadth of information to illustrate the teachers' abilities, or lack of them, to nurture early numeracy development and learning in K2 children and to assist parents in supporting their children's numeracy learning outside the classroom. Each data source is described in more detail below along with methods for data collection and analysis.

Quantitative and Qualitative Data Source

Teacher Observations

The RAs made a total of six visits to each of the EG and CG settings between May 2009 and September 2009.The purpose was to track the teachers' progress throughout the research period using video documentation and a consistently applied Teacher Observation Scale (developed by the Consultant with the Principal Investigator) which included observable parameters and performance criteria (ranked 1-4) (see Table 1).

Table 1: Teacher Observation Scale

Teacher: _____
Date of Observation: _____
Setting: _____
Observer: _____

Dimension.	**1**	**2**	**3**	**4**	**Q #**
The *physical* environment (set up, materials) supports children's numeracy learning					
The *social* environment (groupings, interactions) supports children's numeracy learning					
The *psychological* environment (opportunities to take risks and problem solve) supports children's numeracy learning					
Teacher's clarity of *communication* (instructions, questions)					
Teacher's effective use of scaffolding techniques (questioning, prompting, demonstrating…) to support children's *numeracy skills*					
Teacher's effective use of scaffolding techniques (questioning, prompting, demonstrating…) to support children's *problem solving*					
Teacher's effective use of scaffolding techniques (questioning, prompting, demonstrating…) to support children's *reasoning through justification*					
Teacher's appropriate use of *mathematic language and concepts* (e.g., more/less than, same, altogether, bigger-but-wider…)					
Teacher's responsiveness to children who require *more time, assistance and practise*					
Teacher's responsiveness to children who require *more challenges and, opportunities to work independently*					
Teacher's appropriate use of *materials and resources* to enhance children's numeracy learning and development					
Teachers' provision of opportunities for children to *recall and practise* previously learned concepts					
Teachers' provision of opportunities for children to *apply knowledge of concepts* to new contexts					
Teachers' appropriate application of *formative assessment* to individuals and the class as a whole					
Teacher's appropriate techniques to assist parents to support their children's numeracy development and learning through *home-based experiences* (activity sheets, incidental and naturalistic occurrences)					
Teacher's appropriate techniques to assist parents to support their children's numeracy development and learning through local *environmental experiences* (incidental occurrences in naturalistic contexts)					

The Teacher Observation Scale included a coding box in relation to each of the dimensions for the RA's to insert links to qualitative data sources (e.g., video documentation, children's artefacts, teacher interviews and field notes [RA's perceptions and documentation of contextual factors]). Each of these sources is described in greater detail below. These data sources were systematically coded in relation to each of the various sources. For example, 'Individual Interview, Teacher, Date' may be coded as 'I1, T1, 06-08-08'.

The Consultant trained the RAs in establishing a standard and reliable set of codes and to clarify the methods for collecting these data. The Consultant trained the RAs in the implementation of the Teacher Observation Scale, and the monitoring of the inter-rater reliability between the RAs in March and October 2009.

The qualitative and quantitative data from the Teacher Observation Scale was triangulated to provide a rich description of each dimension. Examples from the qualitative data sources will be used for illustrative purposes. These data will be further triangulated with the following qualitative data sources.

Qualitative Data Sources

Documentation.
The RAs took field notes and collected relevant documentation for both EGs and CGs in relation to the following dimensions:
1) school and classroom contexts (e.g., photographs of space and resources)
2) school brochures and other information-sharing sources (e.g., newsletters)
3) samples of teachers' plans, evaluations and reflective notes
4) samples of children's numeracy-based artefacts (e.g., activity sheets, homework)
5) samples of parents' input in relation to their children's mathematical development

Child Observations in Classrooms
The RAs videoed and documented the progress of the EC and CG children through site visits in July through to October. These observations focused on the children's learning processes at the learning centres such as:
group interactions and conversations
1. child-made constructions
2. problem-solving solutions
3. numeracy concept development

Semi-Structured Individual Interviews with Teachers.
The Consultant, and Mentor conducted semi-structured individual interviews with the EC and CG teachers in between March and October 2009, to ascertain the teachers' perceptions of their successes, challenges, constraints and needs, probing further into selected parameters described above. The Consultant devised an interview questionnaire for this purpose so as to standardise the kinds of information and responses collected from both the EG and CG teachers. The Consultant also devised a self assessment questionnaire for teachers to comment on their own progress and mathematical competencies. (Appendix 2 shows the questions designed for the EG teachers. The questions for CG teachers were similar but referred only to the control group contexts). The data from these interviews was triangulated with teachers' observed practices rated in the Teacher Observation Scale and the qualitative data sources which provided indicators of evidence of teachers espoused beliefs and perceptions. Comparisons are made between the teachers' early, mid-year and end-of-year

interview responses and correlated data sources. A teachers' profile comprising all the interview data for each teacher was then constructed by the Consultant, the documentation of which is too bulky for inclusion in this report.

Focus Group Interviews with Teachers.
Separate EC and CG Focus Group Interviews (FGI) were held with the teachers, conducted by the C, M, and Co-PI, in March 2009 and January and March 2010. The content focused on the teachers' perceptions of their successes, challenges, constraints and needs in relation to developing, implementing and evaluating their maths programs for young children and probed deeper into the parameters of the observation schedule and personal insights gleaned from input from the Research Team. Again, comparisons were made between the teachers' early, mid-year and end-of-year interview responses and correlated data sources.

Interviews with Parents.
It was not possible to conduct Focus Group meetings with parents since procedures for such meetings were not in place in both sets of settings and parents were on the whole reluctant to talk to the research team citing lack of time as the main objection. Instead, parents were asked to volunteer to meet with one of the RAs, the Mentor and the Consultant. The Consultant constructed an interview questionnaire for this purpose. Five sets of parents from each of the EG and CG teachers' classrooms volunteered to be interviewed at the end of the intervention in November 2009. The interview questions focused on their:
Article I. level and type of participation in their children's mathematical learning throughout the year
Article II. perceptions of their children's progress in mathematics during the year.

Responses from these interviews were analysed in relation to the level and type of guidance and support that the teachers provided for the parents of the children in their classrooms to achieve numeracy gains throughout the year (e.g., home-based experiences [activity sheets, incidental and naturalistic occurrences] and local environmental experiences [incidental occurrences in naturalistic contexts]). Appendix 3 provides details of the parental interview questions and, as with the teachers' profiles, the documentation of these is too bulky for inclusion in this report.

Quantitative Data Source

The (WIAT-II) Wechsler Individual Achievement (Test 2) math reasoning sub-test and the (NCT) Numeracy Concept Test were used.

Numeracy Concepts Tasks.
Individual interviews with the children in each of the EG and CG classrooms were conducted by the Mentor and RAs before the intervention (April 2009) and at the end of it (November 2009). Several tasks were devised to measure the children's ability in counting, addition and subtraction using things to count (e.g., blocks, coins and small toys).

The Pre-Intervention Test served as a baseline for comparison with results on the Post-Intervention Test. The Pre-Test was also used to identify how children performed at three different levels in order to maximise the effectiveness of the intervention programme. Based on these levels, the EG children were assigned to groups 1, 2 or 3 (the criteria for grouping of the children are then described after Table 2). The Consultant modified the EG teachers' selection of activities, style of teaching and teacher-child or teacher-group interactions to accommodate the various levels of children's understanding and number competence, which differed across the groups at each level.

The tasks are described in Table 2 and the response was scored either right (1) or wrong (0). Most of the items on the Pre- and Post-Tests are the same except the following, for developmental reasons:

The 'Counting' tasks on the Pre-Test are included because these are pre-requisite skills for the rest of the items, and some of the children would only have been developing these fundamental skills (i.e., this helped identify children who would be at level 1). The 'Counting' tasks were not included in the Post-Test as it was anticipated that all children will have acquired these by the end of the school year.
The 'Value of Coins' tasks were not be included in the Pre-Test as many children will not have been developmentally ready to do this. Hence, these tasks were included in the Post-Test only. This meant that items 7 to 17 in the Pre-Test were the same and became items 1 to 11 in the Post-Test.

Table 2: Numeracy Concepts Tasks

Child: _____; Date of Observation: _____; Observer: _____

Concept	**Task**	**Measurement**	0 or 1
Pre-Test			
Counting			
1.Count an array	'How many blocks are here?'	Able to count and know that the last number name represents the cardinal value of the set	
2.Produce a specified quantity	'Give me 7 blocks.'	Able to count the specified quantity to produce the requested value (e.g., 7)	
3.Create an equivalent set	'Give me as many blue blocks as there are of red blocks.'	Able to create an equivalent set of blue and red blocks	
4.One-to-one correspondence	'Put out the same number of blocks as mine'	Able to pair the blocks in a one to one sequence	

Addition/Subtraction			
5.Addition using multilink cubes	'You have 3, I give you 3 more. How many altogether?'	Able to count all up from the set **OR** give the answer without counting	
6. Subtraction using multilink cubes	'You have 6, you give me 2. How many are left?'	Able to count all down from the set **OR** give the answer without counting	
Totals of Sets			
7.Count on from a set	Put 5 one-cent counts in a dolls purse. 'If we give the doll 3 more coins, how many will it have altogether?'	Able to count all up from the set **OR** give the answer without counting	
8.Recognise longer lengths of cubes	Give a stick of connected multilink cubes to the child. Present a stick which is larger. 'Which has more cubes?'		
9.Recognise shorter lengths of cubes	Give a stick of connected multilink cubes to the child. Present a stick which is smaller. 'Which has less cubes?'		
10.Know greater-than quantity	'How many more than you do I have?'		
11.Know lesser-than quantity	'How many less than you do I have?'		
12.Pair three sets of cards	Animals, dots, numerals	Able to recognise cardinal values represented in different ways	
13.Order numbers	Show a set of numbers. 'Which number is bigger?'; 'Which number is smaller?'; 'Place the numbers in order from the smallest to the biggest.'	Able to recognise bigger and smaller; can order the numbers in sequence (small to large)	
Word problems			
14.Addition	Use cubes to represent coins. Have an apple and an orange. 'You have 8 cents. This apple costs 2 cents, and this orange cost 4 cents. How much will the apple and the orange cost together?'	Able to arrive at the answer with confidence either mentally or using fingers	
15.Subtraction	'If you buy both the apple and the orange, how much will you have left from your 8 cents?'		

Post-Test Additions			
Totals of Sets			
16.Count on from a set	Put 5 one-cent counts in a dolls purse. 'If we give the doll 3 more coins, how many will it have altogether?'	Able to count all up from the set **OR** give the answer without counting	
17.Recognise longer lengths of cubes	Give a stick of connected multilink cubes to the child. Present a stick which is larger. 'Which has more cubes?'		
18.Recognise shorter lengths of cubes	Give a stick of connected multilink cubes to the child. Present a stick which is smaller. 'Which has less cubes?'		
19.Know greater-	'How many more than you do I		

than quantity	have?'		
20.Know lesser-than quantity	'How many less than you do I have?'		
21.Pair three sets of cards	Animals, dots, numerals	Able to recognise cardinal values represented in different ways	
22.Order numbers	Show a set of numbers. 'Which number is bigger'; 'Which number is smaller'' 'Place the numbers in order from the smallest to the biggest.'	Able to recognise bigger and smaller; order the numbers in sequence (small to large)	
23.Addition	Have an apple and an orange. 'You have 8 cents. This apple costs 2 cents and this orange costs 4 cents. How much will the apple and the orange cost together?'	Able to arrive at the answer with confidence either mentally or using fingers	
24.Subtraction	'If you buy both the apple and the orange, how much will you have left from your 8 cents?'		
Value of Coins			
25.Using 1, 5, 10, 20 and 50 cent coins and 1 dollar, the children will 'purchase' items	'The noodles cost 73 cents, which coins will you use to buy them?'	Able to accomplish addition subtraction and decomposition	
	'Show me again, with the fewest number of coins.'		
	'These toys have prices on their labels. Which can you buy with just two coins?'		
	'Which 2 toys can you buy with exactly 30 cents?'		
	'Which toys can you buy with $1?'		
	'Here is $1. If you spend 70 cents, how much will you have left?'		

The grouping of the children for the intervention programme was assigned after the pre-test according to the following criteria:

Level 3: These children are able to complete successfully some of the tasks. The upper limit would be the more complex skills required for either the coin tasks involving buying the fruit or, the task involving the doll, where they are expected to count on from a set. Children assigned to this level would not be expected to be able to complete the tasks requiring them to say how many more or less the sets of cubes are when compared. Furthermore, all the children at this level would use fingers and/or things to count.

Level 2: These children are able to complete successfully most of the tasks. The exceptions would be the tasks requiring them to say how many more or less the sets of cubes are when compared , and the task requiring a subtraction strategy in order to indicate how much would be left from 8 cents. All of these children would be expected to use fingers and/or things to count, rather than solve the tasks mentally.

Level 1: These children are able to complete successfully most of the tasks mentally with a few exceptions resorting to fingers or things to count.

The Consultant trained the RAs and Mentor in establishing a standard set of procedures for administering the tasks for collecting these data and for scoring the results. Raw scores were compared for the pre- and post-test results for children in each of the three groups (1, 2 or 3) to measure levels of improvement before and after the intervention. In addition to raw scores, verbatim records of children's gestures and comments were also recorded to supplement the quantitative data.

Analyses

Quantitative data was analysed through ANOVA for comparisons across groups (Experimental versus Control), gender (M, F), class/school (4 E, 4 C) and teacher (4 E, 4 C). Qualitative data was analysed through a range of qualitative techniques, which are described below.

Teacher Observations

Quantitative data from observations of teachers was triangulated with qualitative data from the observations and the following data sources:

Interviews

Transcriptions of the semi-structured individual interviews and focus group Interviews with teachers was analysed using the technique of content analysis. The themes from the interviews centred on the content of the questions and sub-themes that arose in relation to teachers' espoused beliefs and practices, triangulated with the teachers' classroom practices (i.e., the Teacher Observation Schedule). Transcriptions of Parents' Interviews were used for triangulation of the data with the teachers' interviews and observations, and to monitor the success of parental support in relation to children's test results and classroom performance.

Child Observations

Quantitative data from the observations of children in the experimental group was triangulated with qualitative data (e.g., documentation of learning artefacts, social interactions, problem-solving and concept development). Transcriptions were selectively sampled to provide support documentation of children's numeracy learning in the classroom. These excerpts were analysed in relation to the content of the teachers' semi-structured interviews, to look for patterns of consistency/divergence between teachers' espoused beliefs and actual classroom practices.

Documentation

Samples from the school and classroom contexts (e.g., video footage of space and resources) and school brochures and other information-sharing sources (e.g., newsletters) were used to provide a general description of the research site. Samples of CG teachers' plans, evaluations and reflective notes were used to substantiate and enrich the examples of teachers' beliefs and practices. Samples of children's numeracy-based artefacts (e.g., activity sheets, homework) in and outside of school, and parents' input in relation to these will be used to illustrate the teachers' effective use of techniques to assist parents to support their children's numeracy development and learning through home-based and naturalistic community-based learning experiences.

Findings and discussion

Findings from the WIAT (math reasoning subtest of Wechsler Individual Achievement Test 2) and the NCT – Numeracy Concept Test, were subjected to analysis of variance measures ANOVA. Repeated measures of ANOVA were selected to be used to analyze the data for several reasons. First, multivariate analysis MANOVA is not suited for the analysis combining the dependent variables related to WIAT and NCT because both these variables measure almost exactly the same mathematical knowledge and skills, and are correlated to a large extent. This makes MANOVA an unfavourable analytical method since dependent variables should be non-commensurate. Second, even though repeated measures of ANOVA have the often-violated assumption of sphericity, this violation is less critical with only 2 levels of the within-subject variable (1 df).

The distribution of the dependent variables were found to be all fairly normal. ANOVA is also known to be robust to violation of the normality assumption. The homogeneity of variances assumption is met for analyses using ANOVA. The between-subject factor is GROUP and the within-subject factor is TIME (PRE-TEST and POST-TEST). Separate ANOVAs were conducted for dependent variables scores on the WIAT and scores on the NCT.

On the WIAT scores, there was a significant TIME main effect, $F(1,218) = 323.93$, $p < .01$, $\eta^2 = .60$. This means that the mean score on the WIAT for all the children was different at Pre-Test and at Post-Test. Overall, children scored better on the WIAT on Post-Test than on Pre-Test. The effect was a large one as shown by the partial eta square estimate of .6.

The main effect of GROUP was also significant, $F(1,218) = 6.31$, $p < .01$, $\eta^2 = .03$. The experimental group consistently scored better than the control group at both Pre-Test and Post-Test.

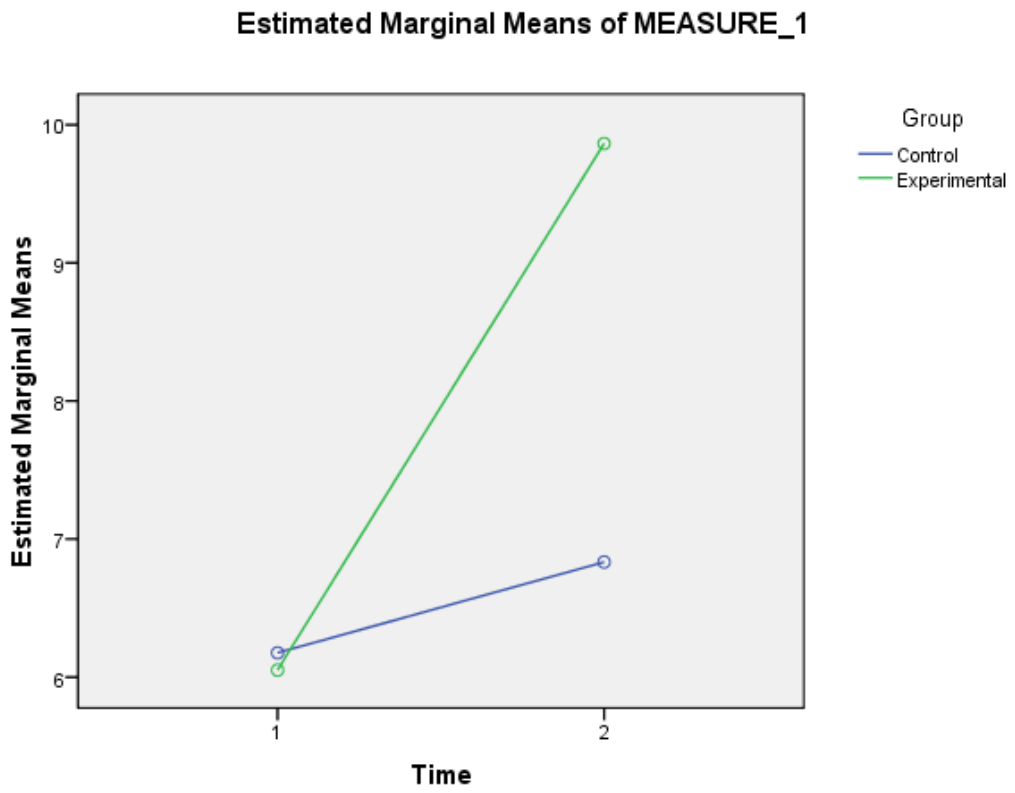
The TIME x GROUP interaction was not significant, $F(1,218) = .67$, $p = .41$, $\eta^2 = .00$. In other words, the experimental and control groups did not differ in their performance at the pretest and posttest. No experimental effect was found. Perhaps the reason for this is that children are checked for accuracy and the testing stops if children fail to answer 6 consecutive questions. There are 40 questions in all and verbal responses to oral questions and oral questioning about pictures can be quite tedious and uninspiring.

The findings from the NCT were more encouraging. There was a significant TIME main effect, $F(1,218) = 239.89$, $p < .01$, $\eta^2 = .52$. This means that the mean score on the NCT for all the children was different at Pre-test and at Post-Test. Overall, the children scored better at Pre-Test than at Post-Test. The reason for this was that as noted earlier that the tasks were slightly different in the Post-Test: The 'Counting' tasks on the Pre-Test were included because these are pre-requisite skills for the rest of the items, and some of the children would only have been developing these fundamental skills (i.e., this helped identify children who would be at level 1). The 'Counting' tasks were not included in the Post-Test as it was anticipated that all children will have acquired these by the end of the school year. The 'Value of Coins' tasks were not included in the Pre-Test as many children would not have been developmentally competent with these tasks. Hence, these tasks were included in the Post-Test only. This meant that items 7 to 17 in the Pre-Test were the same and became items 1 to 11 in the Post-Test.

The main effect of GROUP was also significant, $F(1,218) = 32.69$, $p < .01$, $\eta^2 = .13$. Overall, the experimental group performed better than the control group on the NCT.
The TIME x GROUP interaction was significant, $F(1,218) = .214.12$, $p < .01$, $\eta^2 = .50$. In other words, the experimental and control groups differed in their performance at the Pre-Test and Post-Test. This interaction was due to the experimental group maintaining its performance at Pre-Test and Post-Test, while the control group performed worse from Pre-

Test to Post-Test. The reasoning behind this finding is both the effects of the intervention and the different expectations of the task Pre to Post- Test as explained above.

In order to shed more light on the findings from the NCT an additional ANOVA was conducted to compare the EG and CG results with only items 7 to 16 on the Pre-Test and items 1 to 11 on the Post-Test.



The results show the ANOVA on the NCT scores (Pre-Test items 7 to17 versus the Post-Test items1 to11). There was a significant TIME main effect, $F(1,218) = 381$, $p < .01$, $\eta^2 = .64$. This means that the mean score on the NCT for all the children was different at Pre-Test and at Post-Test. Overall, the children scored better at Post-Test than at Pre-Test.

The main effect of GROUP was also significant, $F(1,218) = 31.70$, $p < .01$, $\eta^2 = .13$. Overall, the experimental group performed better than the control group on the NCT.

Importantly, the TIME x GROUP interaction was significant, $F(1,218) = 190$, $p < .01$, $\eta^2 = .47$. In other words, the experimental and control groups differed in their performance at the pretest and posttest. Examining the graph, it shows an experimental effect where the experimental group performed much better than the control group at posttest.

An additional analysis was conducted in order to ascertain any improvements for the within group performance of the experimental groups. Frequency counts of the changes to within group performance levels are revealed in Table 3 for Part One of the Post-test and Table 4 shows changes for the whole of the Post-Test:

Table 3: Changes to within group performance levels of EG children at Part One of Post-Test

Setting	Al-Is	Assy	DM	JN	PPIS	Total	Sub-Total
Total Tested	24	17	36	11	31	119	
Up L2 to L1	12	4	9	5	23	53	84
Up L3 to L1	1	6	8	1	5	21	
Up L3 to L2	4	2	4			10	
Remained at L1	1	5	7		2	15	33
Remained at L2	3		3	1		7	
Remained at L3	1		5	4	1	11	
Fell L2 to L3	2						2

Table 4: Changes to within group performance levels of EG children for Total Scores at Post-Test

Settings	Al-Is	Assy	DM	JN	PPIS	Total	Sub-Total
Total Tested	24	17	36	11	31	119	
Up L2 to L1	3	1	3		7	14	
Up L3 to L1		1			1	2	41
Up L3 to L2	2	7	11	1	4	25	
Remained at L1	2	2	4		1	9	
Remained at L2	10	3	9	6	16	44	68
Remained at L3	4		6	4	1	15	
Fell L1 to L2		3	3		1	7	10
Fell L2 to L3	3					3	

These tables clearly show the improvements made by the experimental group children especially for items 1 to 11 on the Post-Test where 84 out of 119 (Table 3) children moved up a level and 15 children remained at level 1 (there was no other level to move to and they didn't move down) and so it can be assumed that 99 out of 119 benefitted from the intervention programme. Numerals in red highlight positive improvements in these settings although comparisons between settings are not being sought.

Taking the results for the Post-Test as a whole, where more complex items were included in the analysis, 41 children moved up a level with 9 remaining at level 1. Hence 50 children appear to have benefitted from the intervention which focused on the more complex

concepts such as items with bigger number values and of those children at or remaining at level 1, 25 children successfully completed the coin tasks which would be expected at level 1.

The Teachers' Observation Scale TOS

In order to further explain the superiority of the experimental group children's' experiences over those of the control groups, it will be useful to consider the results of the Teachers' Observation Scale, TOS. This observational tool, completed over the period of the intervention programme by two RAs assessed: the physical, social, and psychological environment; scaffolding techniques involving questions prompts and demonstrations; teacher competence especially in relation to eliciting appropriate responses, the use of mathematical language, provision of appropriate materials and resources, opportunities for recall and application of taught concepts and elicited ideas; formative assessment in the form of time, assistance and opportunities for children to apply and practice previously learned knowledge and skills.

Tests of reliability between the two raters of the averaged ratings over the intervention period were highly correlated: r= 0.736 and the findings reveal the superior environmental provision of the experimental group teachers over the control group teachers. Dimensions were rated from 1 – poor to 4 – very good:

The average ratings from TOS data for EGs
PPIS was rated 3 and 4 on all measures.
Assy was rated mostly 3 with two domains rated at 2 (assistance to individuals at free choice activities and challenges and opportunities to work independently).
Al-Is rated 3 on all measures but one (monitoring children in large and small group activities).
JN - received ratings of 3 on two thirds of the domains but rated 2 on the other third of the domains. (The centre scored better on whole class teaching).
DM –was mostly 3 except for assisting with free choice activities and posing appropriate questions where it was rated at 2.

The average ratings from TOS data for CGs
DS – (Two teachers) was mostly rated at 3 but there were some ratings of 2 for explanations, arousing and maintaining attention, furniture for easy access, monitoring of group work and using inappropriate materials.
An-N – was rated 3 on all domains.
Al-A – mostly 3 except for provision for displays and resources and monitoring of free choice activities.
HS – Mostly 2 for all measures except child interactions and use of space

These two sets of ratings from the TOS data appear to confirm that the environmental provision in the experimental group settings has supported the improvements in the children's numeracy development and learning. In addition as is further explained below, the data collected during the individual teacher interviews and the focus group meetings adds further weight to this assertion.

All of the teachers in the study had obtained or were in the process of obtaining their teaching diploma in early childhood care and education, DECCE-T, a progamme ranging in duration from 350 to 1,200 hours depending on when the diploma was awarded. All the teachers had 5 to 10 years experience in the field. The combined threads from the individual teacher interviews and the focus group meetings are summarized here:

Findings from the individual teacher interviews and focus group meetings: Experimental Group Teachers

As noted elsewhere, all of the EG teachers had attended at least three project workshops, and received at least twenty-one mentoring or feedback or interview visits by the Mentor. Such visits served to reinforce, support and offer further guidance in following the lesson plans and creating and improving conducive learning environments for the EG children. Mentor and Consultant interviews provided feedback for further lesson planning, reinforcement, and lesson modification. After analyzing these there was a clear need for more activity sheets to be provided for the children since the teachers complained about lack of time preventing them from making these as directed in the lesson plans. As noted earlier this questionnaire included a self rating questionnaire about each teacher's mathematical competencies. The following list is a summary of the main threads from these individual interviews and the two focus group meetings:

Most teachers were reluctant to follow assigned lessons at first because they were considered to be too easy for their children. One of the teachers DM-M, continued to include some P1 material throughout the intervention even though we had frequently asked her no to do so.

There appeared to be resistance to oral questioning at first, largely because such questioning was unfamiliar. This did however improve over the period of the intervention.

An analysis of the self rating questionnaire about the teachers' own mathematical competencies revealed that most teachers were not too confident with their own mathematical knowledge. This could be explained by the fact that they being asked to follow lesson plans about concepts they had found they knew little about, which some did admit to.

At first, all the settings timetabled maths at just once a week for the whole three hour session. As the intervention progressed, this was increased to two and a half days in addition to incidental time.

As the intervention programme progressed, all the teachers made use of the 'steps and strides' numeracy concept checklist. This was used both to guide the implementation of the lesson plans and to monitor the progress of individual children, which was necessary when children were working in their group levels.

There were frequent complaints that the teachers had very little time to make the materials: rhyme and song charts and activity sheets. As a result, these were supplied for them by the Consultant.

All the teachers found great difficulty following the lesson plans at first, but with close supervision by the Mentor and as their confidence improved, all teachers were very confident by the end of the intervention progamme and were also confident to make any necessary modifications to suit the individual needs of their children. For example, some coin tasks required children to know the 'value' of items to be purchased. The children were unfamiliar with this term and hence it was changed to 'cost'.

Parents asked for worksheets frequently but teachers became confident enough to explain to them that worksheets (we called them activity sheets) were merely for the reinforcement of concepts and that their children therefore need first to understand these concepts.

Towards the end of the intervention progamme the teachers said that the lesson plans gave them more confidence but they remained stressed about getting them correct throughout the intervention programme.

The teachers quickly learned that they must avoid fitting the teaching and learning of maths concepts to themes and that they must not include primary one material into their lessons (except for DM-M). This is because they eventually realized that unless children are asked check questions and made to justify their solutions orally, teachers would not truly know whether or not children understood the concepts being taught, and importantly, children need a basic foundation in numeracy skills and knowledge before they are able to cope with the demands of the primary mathematics syllabus.

The teachers referred frequently to the fact that their children loved the 'hands-on' approach and that the resulting interactions increased and that there was more and better understanding in the children.
Teachers felt that grouping the children according to the three levels certainly helped the weaker children as they were able to spend more time with them. They were able to both modify the tasks, and they used more mathematical language.
They stressed that the mentoring was a great help by giving them confidence as well as explaining more about the tasks and how to put them over to the children.
It was observed however, and all the teachers agreed that they still need help to develop learning corners and to know how help children more at learning corners.
The observations over time showed and all teachers agreed their maths teaching and understanding had benefitted profoundly from the intervention programme.

Findings from the individual teacher interviews and focus group meetings: Control Group Teachers

Other than the two focus group meetings, individual interviews, and TOS visits, the control teachers were left to themselves to teach their numeracy lessons. However, since the intervention programme ended we have conducted three days of numeracy workshops for them and provided these teachers with all the lesson plans, materials and resources which we had provided for the EG teachers. All but one setting HS, attended and two settings: DS and An-N sent the entire staff to the workshops. One teacher Al-A_M attended alone since she had changed settings.

It should be pointed out here that the first focus group meetings were conducted in order to explain the purposes of the study and to persuade the settings to take part as control group settings. The second focus group meeting was attended by just two of the teachers. Hence the data from the CG focus meeting is sparse compared to that of the EG meetings. Nevertheless, it was possible to collect data from individual teacher interviews and below is a summary list of the main threads from the teachers' individual interviews and focus group meetings:

Most of the teachers said they were fairly confident teachers of maths and had an adequate understanding of what is required to be teachers of young children in the area of numeracy.
All the teachers explained that for numeracy lessons they follow 'themes' as set out by the principal and other teachers. They fit the numeracy concepts being taught to fit the requirements of the themes. This means that they don't follow a developmental sequence for their numeracy teaching.
The teachers select their materials and resources to fit the requirements of the themes, especially the worksheets.
Numeracy lesson stake place just once a week.
The teachers reported that the parents have no interest in their children's numeracy learning. Parents only want to see their children bringing home their worksheets.
All teachers stressed that their K2 curriculum has to fit the P1 maths curriculum because this is what their settings want and what parents demand.
Two teachers reported that their teaching is 'touch and go' and that they need help to introduce/recall concepts at learning corners
Teachers reported that they don't change materials at corners often enough because they don't have enough materials and resources to do this.
Teachers are keen to assist children at corners but time is taken up with weaker pupils.
Teachers reported that they need to know how to use manipulatives to teach number concepts more systematically.

It's clear from these brief summaries that the experimental teachers' increased confidence and improved competencies had contributed to their children's superiority on the NCT

measures. The control group teachers on the other hand, although appearing to be more confident of their mathematical knowledge as stated in the self evaluations are restricted in their numeracy teaching by minimum time devoted to numeracy teaching, an emphasis on themes rather than numeracy concepts, a reliance on worksheets, and a need to focus in K2 on the P1 syllabus.

Additionally, the TOS findings for all but one setting indicated low ratings for: providing adequate explanations of concepts; arousing and maintaining attention; arranging furniture for easy access; monitoring of group work and using inappropriate materials. In two settings there were low ratings for provision for displays and resources and monitoring of free choice activities. However, it is noted that both EG and CG teachers need a system in place for pupils to engage independently freeing up time for weaker pupils, and assistance with learning corners for concept reinforcement and development. A more detailed compilation of the teachers' interview comments, in the form of teachers' profiles, was compiled but is too bulky for inclusion in this report.

Mention has been briefly made by both groups of teachers about the parents' disinterest in their children's progress in numeracy development and learning. The following section will reveal that although there was some reluctance to be interviewed about parental involvement, 35 sets of parents from both EG and CG settings did agree and volunteered to be interviewed. Since there were similarities between parents from both kinds of settings, their views on their involvement are summarized together in the list of threads below.

Threads from parental interviews on their involvement in their children's numeracy development and learning

Most parents said they like to see their children's worksheets in order to check on their progress.
Most of the parents buy assessment and P1 workbooks.
The parents interviewed want to be involved by supporting their child's teacher.
Most speak English at home and find that they are concerned about their children's progress with Malay rather than English, especially when they reach P1.
When asked about hiring a tutor, most expressed that they would do so if or when required.
Many parents reported that whilst they try to help their children with maths at home, the father is the main helper and many said that the help from elder siblings is invaluable since they know which methods to use.
Most of the mothers and some fathers said that they didn't enjoy maths when they were at school. The reasons being that it was a boring subject, the teacher was fierce, or they were no good at it.
Most parents reported that their children enjoy maths in kindergarten and they have no problems.
When asked about usage of coins and notes parents reported that their children can recognise coin values and they know which items are cheap and which are expensive.
When asked about awareness of maths all around us in our environment, most could give examples like when cooking, climbing stairs or in the lift, counting cars and knowing how many plates of food are needed.
Most of the parents said that they have high expectations for their children in maths but that they don't want to pressurize them at such an early age.
When asked about concerns when their children begin primary school, nearly all expressed their concerns but mostly about mixing with other races since the exposure so far has been to other Malay children only.
Even though all parents had consented to their children taking part in the study, few parents asked about it, except for just a few parents of EG children who said their children were excited about the coin activities.

The threads from this summary shed little light on the effects or otherwise of the parents views, opinions or involvement on their children's progress in numeracy in the intervention programme. A more detailed compilation of the parental interview comments was compiled but is too bulky for inclusion in this report. The data from the child observations CO however, in support of the effects of the intervention programme is more illuminating.

Child Observations

The PI, Co-PI, and one RA collected observations of all the children in all settings between July and October 2009. These observations focused on the children's learning processes at the learning centres such as:

group interactions and conversations

4. child-made constructions
5. problem-solving solutions
6. numeracy concept development

It was not possible to make direct comparisons between the learning processes of the CG and EG groups, since the latter group was following the tasks and activities as prescribed in the lesson plans. However, the qualitative observations of the CG children in the video clips collected and reported by one RA, showed that as the CG teachers had reported, the children were mostly engaged in 'touch and go' activities and there appeared to be no observable links to whatever mathematics concepts had been or were being even though there were some interactions, child-made constructions, problem solving activities and practice of numeracy concepts. From the video clips it was unclear how these activities were related to the lesson concepts being taught at the time.

On the other hand the video clips collected by the same RA of the EG children and analyzed independently by another RA, the Mentor and the Consultant with 100% agreement between them, indicated that there was a wealth of activity which could be attributed to the lesson plans and the concepts being taught and learned at the time the video clips were shot. As such it's not possible to make comparisons between the EG settings but nevertheless Table 5 shows the incidences of mathematical activity relating directly to the numeracy concept tasks taking place when the videos were shot:

Table 5: Incidences of numeracy concept tasks at EG settings

	PPIS	Al-Is	DM	JN	Assy
Matching Sorting Pairing	2	7	6	5	5
Ordering & Patterning	3	2	2	17	7
Size & Shape	4	1	3	3	16
Measures	0	0	0	0	3
Counting & Number Value Activities	11	2	19	18	28

Table 6 gives an indication of the extent of group interactions amongst the EG children during the time the video clips were shot.

Table 6: Incidences of group interactions at EG settings

	PPIS	AL-Is	DM	JN	Assy
Maths Games	6	7	8	17	20
Board Games	3	0	2	1	1

Number Sentences	2	0	4	0	1
Wooden Blocks	1	0	0	0	2

Table 7 gives an indication of the involvement of EG children in child-made constructions during the time the video clips were shot.

Table 7: Incidences of child-made constructions by EG children

	PPIS	Al-Is	DM	JN	Assy
Multilink Cubes	0	1	1	0	9
Ice-cream Sticks Counters Beads	5	0	3	13	9
Shapes Bears Coins	4	0	2	15	7

Table 8 gives an indication of the involvement of EG children in problem solving activities during the time the video clips were shot.

Table 8: Incidences of problem solving activities by EG children

	PPIS	Al-Is	DM	JN	Assy
Using Counters	1	0	2	1	1
Using Multilink Cubes	0	0	0	1	3
Using Number Lines			Seen in photos		Seen in photos
Counting in 2s, 5s, 10s	1 and seen in photos	Seen in photos	1	2	4
Matching & Sorting	1 and seen in photos	1	2	2	1
Getting Teacher's Help	0	1	0	0	0
Trial & Error	0	0	0	0	1
Keeping Tallies	0	0	0	0	1

The analysis of the video clips in tables 5 to 8 provides evidence of the involvement of the EG children in the activities as set out in the lesson plans and the RAs also collected a wealth of documented material which showed similar evidence. However, the documented evidence from the EG settings indicated the use of prescribed activity sheets, whilst those collected from CG setting indicated that certain children had misunderstood how to complete tasks, especially in relation to using number lines. This photographic evidence is used during the Consultant's oral presentation of the study to illustrate the inadequacy of some of the materials used for the children in the CG settings.

Documentation

Unfortunately there was minimal documentation available for collection from both settings, other than three newsletters and two sets of worksheets and three sets of control group

lesson plans/notes. The newsletters collected from two CG settings contained useful information for parents about forthcoming events and those which had recently taken place. In addition, there was advice and instructions for parents concerning procedures at each of the settings. As mentioned above, the only other documentation available was in the form of worksheets which indicated that the CG settings relied heavily on those which matched themes rather than concepts. The tasks relating to number lines were of such complexity that only primary school children would be expected to complete them.

The lesson plans collected from the CG settings also lacked teaching points, and merely contained instructions about what was to take place and in which order. Some lesson plans were just titles of themes or concepts with no references to the activities which were to take place. One setting, DS, indicated the songs and rhymes to be used in the lessons but there were no teaching points or references to mathematical language.

Only one EG setting, PPIS provided details of parental involvement events and details of the setting's progamme. Their publication, the Sapphire Times also included activities for parents to engage in with their children. This setting also provided an interactive website for parents to consult. Such was the supportive setting environment and reference to tables 3 and 4 shows the superior performance of children in this setting in terms of upward movement to higher group levels at the NCT post-tests.

Some conclusions

As a result of the findings from this study, it appears that the intervention progamme had positive outcomes for the children and their teachers in the EG settings. However, it appears from the TOS data, the CO data and the teachers' individual interviews, that much needs to be improved if the components of the intervention progamme are to be extended and to be of benefit to more pre-school settings.

The first is the mathematical competencies of teachers. Ginsburg et al. (2008) have highlighted the importance of knowledgeable and skilful mathematics teachers for pre-schools such that pre and in-service training should be improved to accommodate this. In Britain, the 'Williams Report' (DCSF 2008) also stresses the need for better qualified and knowledgeable teachers in early years settings to give children a better start before they begin formal schooling, and where it is stated they should be competent in the foundations of mathematics by the age of 7 years. This report also highlights the importance of parental involvement especially working with teachers to assist their children in the early stages of numeracy development. In addition to these two important prescriptions from overseas, some other themes which are also of relevance to the Singapore context and gleaned from the study presented here are summarized as:

Reconsider the time allocated to numeracy teaching in pre-school and have mathematics everyday as a core subject area and not linked to themes.
Have a lead teacher with good content knowledge of children's early numeracy development and learning needs and provide regular support and in-service courses for teachers.
Work with PQAC and have more time allocated to mathematics in initial teacher training and separate this training from the science component with which it is currently joined with combined hours.
Provide a syllabus based on the 'steps and strides' in numeracy development and the lesson plans which have formed the basis of the intervention programme and which stresses oral activities, hands-on manipulatives, check questioning, and the constant use of mathematical language.
Provide for numeracy lessons in three parts: an introduction with recall of previously learned concepts, a development of the concepts with small group activities, independent activities at learning corners for reinforcement and practise.
Provide activity sheets for reinforcement. These should not be the basis of the lessons.

Provide for differentiation at ability groups with frequent opportunities for children to change groups according to progress.
Have learning corners linked to concepts and not to themes and include activities which reflect previously taught concepts and activities which extend and challenge children.
Improved management support so that time for teaching, support for learning, and improved provision for resources and materials is paramount.
Instigate a system of networking between settings, similar to the cluster system fro primary schools.

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