Playing with mathematics: a pilot intervention to develop basic mathematical skills among preschoolers in Bangladesh

ECD Research Report 2

Aftab Opel, Suborna Camellia, Frances Aboud

Early Childhood Development Resource Centre
BRAC University Institute of Educational Development

ISBN - 984 300 000006 6

For additional information or to obtain the study please contact:
ECDRC, BU-IED, House 113, Road 2, Block A. Niketon, Gulshan 1,
Dhaka 1212, Bangladesh
Phone: (880-2) 988 1265 ext. 2112, Fax: (880-2) 882 9157
Email: mahmuda.akhter@bracuniversity.ac.bd
Web http//:www.ecd-bangladesh.net

Photo: Aftab Opel

Corresponding author: Aftab Opel, Email: aftab.opel@gmail.com

Printed by: Graphosman Reproduction & Printing 9554804

Foreword

We are very pleased to publish this issue in the research report series on early childhood development. This report on early numeracy development is based on experiment conducted at BU-IED in 2006.

With the overall aim of contributing to early childhood development in Bangladesh, BU-IED has taken initiatives to conduct studies and experiment in order to adopt relevant standard child development methods and approaches to the rural and urban contexts of Bangladesh. This report describes an intervention to promote the development of basic mathematical skills among young children in preschools. The positive results of this intervention have encouraged us to plan a trial on a larger scale for incorporating the methodology in the regular curricula of the preschool programme.

Different studies show that in Bangladesh, math concepts and operations are systematically taught to 5-year olds in pre-schools. The didactic approach relies on rote learning where the teacher demonstrates a concept and the children repeat it many times with the same material. Children learn the operation but their nonverbal reasoning, so essential for development of math skills, remains deficient. It was therefore considered essential to provide children with more systematic opportunities to engage themselves in math reasoning while in preschool. In this context the experiment on "playing with mathematics" was undertaken in five randomly selected pre-schools. Statistically significant increase in children's mathematical skills was observed, as the study report shows.

I congratulate the research team for its hard work and thank those, including Plan Bangladesh and Grameen Shikkha, who have given total cooperation and support to the research team.

Manzoor Ahmed
Director
Institute of Educational Development
Brac University

Abstract

The purpose of the study was to examine the efficacy of a 6-weeks mathematics intervention with rural Bangladeshi preschoolers with the intention of increasing their basic mathematics skills. Eighty preschoolers randomly selected from five preschools participated in the program during six weeks in the summer of 2006. Their mathematics skills on counting, patterns, shapes, measurement, sorting, comparing, and operations were tested on 77 items before and after the program and compared with that of control children who participated in the regular program. Both the groups attended daily 40-minute math classes over 6-weeks using a math bag to practice teacher-introduced math concepts. The intervention group participated in math games while the control group did the same tasks in a more teacher-directed way. Results confirmed significantly greater achievement of math skills by the intervention children compared to the control group. The score of the intervention children increased from 24.74% to 59.69% while the control group increased from 29.73% to 42.56%. In conclusion, paraprofessional teachers with little training were able to implement activities that helped children learn big mathematical concepts.

Acknowledgement

The authors would like to acknowledge the support provided by various individuals and organizations. Grameen Shikkha allowed the research team to implement the intervention on their preschools. Dr. Manzoor Ahmed, Professor Nazmul Haque, Dr. Fahmida Tofail and Dr. Cassie Landers reviewed and provided important comments on the research protocol. Dr. Sudhir Chandra Sarker and Mahmuda Akhter provided the administrative support to implement the program. Shashoti Dwean Shorna, Nasrin Akhter Rony, Syeda Tashmia Sultana, Khodeja Akhter Munni, Afroja Sultana Jhuma, Washima Parveen Lopa, Farah Deeba, Shamsunnahar Chonda and Nusrat Sharmin collected the data. Dilshana Parul entered the data and Faizun Nessa supervised the research assistants and the program along with the researchers. Finally, we are grateful to the teachers, students of the preschools and their mothers for their effort to make this program successful.

Table of Contents

Introduction

The importance of preschool education for children's school readiness skills along with cognitive, language, and social development is now well-recognized (Engle, Black, Behrman, Cabral de Mello, Gertler, Kapiriri, Martorell, Eming Young, in press). The preparatory experience for children from families who are poor and lack formal education is even more critical (e.g. Kagitcibasi, Sunar, & Bekman, 2001). However, the quality of these preschools is often not good enough to help children gain sufficient skills (Aboud, 2006). This study evaluated new activities to promote the development of basic mathematical skills among preschoolers (i.e. kindergarteners) in Bangladesh with a view to creating a high-quality math program for Bangladesh and other developing countries.

Children develop a great deal of understanding about counting and comparative quantities (e.g. more and less, big and small) as a result of incidental learning from everyday experience, without direct instruction (Ginsburg et al., 2006). This was also found to be the case with rural Bangaldeshi children who acquired many of the tested school-readiness math concepts without having attended preschool (Aboud, 2006). However, without preschool less than half the children were able to count nine stones or identify which of two bowls held the same number of items. Mathematics activities in the pre-primary grades typically provide only informal opportunities for counting, patterns, and shape identification in the form of general enrichment rather than focused activities (Starkey, Klein, & Wakeley, 2004).

However, with new evidence about children's eagerness to explore math operations and receptivity to logical explanations (Siegel & Svetina, 2006), a more systematic approach to math teaching is taking place. It is based on a cognitive constructivist view that children actively construct an understanding of logical relations when posed challenging problems. The benefits might be particularly crucial for children from disadvantaged backgrounds whose parents do not provide activities and materials for acquiring concepts (Starkey et al., 2004). In Bangladesh, math concepts and operations are systematically taught to 5-year-olds in preschools. However the didactic approach relies on rote learning whereby the teacher demonstrates a concept and the children repeat it many times with the same material (Moore, Akhter & Aboud, 2005). Children learned the operations but their nonverbal reasoning, so essential for later math skills, lagged far behind (Aboud, 2006). It was therefore considered important to provide children with more systematic opportunities to engage deeply in math reasoning while in preschool.

Recognizing the need for a systematic introduction to math, educational researchers have developed and in some cases evaluated preschool programs (e.g. Greenes, Ginsburg, & Balfanz, 2004; Sarama & Clements, 2004; Starkey et al., 2004; Sophian, 2004). Most provide activities to enhance math concepts related to enumeration, shapes, patterns and their rules, measurement, sorting and classifying, and comparison. There is also some introduction to operations such as addition, subtraction, and concepts underlying multiplication and division. With the explicit objective of learning these math skills, the activities entail hands-on playful experiences with objects in a group setting. Positive outcomes

were found for most programs when evaluated in pre-kindergarten or kindergarten classes (e.g. Griffin, 2004: Sophian, 2004; Starkey et al., 2004).

In Bangladesh, preschools for disadvantaged rural children offer literacy and math instruction along with play for half a day. A recent survey in Bangladesh shows that a total of 147 organizations, most of which are non-governmental, have preschool programs attended by about 790,000 children (ECDRC, 2006). They are expanding rapidly and considered essential in order to prepare children for primary school, reduce the drop-out rate, and increase the number of children passing fifth grade competency tests. Prior evaluations indicated that in some respects their quality was moderate (3.5 out of 7 on the Early Childhood Environment Rating Scale; Aboud, 2006). Recommendations to provide more hands-on materials in the form of play materials and math bags led to subsequently higher quality ratings in pilot preschools implementing the changes (Moore, Akhter & Aboud, 2005). Benefits were passed on to the children who attended the pilot preschools in comparison to those who attended the regular program, matched for ECERS score the year before. In particular, pilot children showed greater improvements in Block Design and Matrices, both measuring visual analytic reasoning that would later support math skills (Moore et al., 2005). However, these scores were still very low and children were not improving at the expected rate. Action research indicated that teachers were using the same rote repetition approach only now with more materials. However, children did not have the opportunity to solve problems on their own.

Because the preschools depend on paraprofessional teachers and use low-

cost materials, questions may be raised whether they are capable of implementing a high quality math program. A 4-week dialogic reading intervention showed that if carefully trained and supervised, these paraprofessionals could implement a sophisticated program successfully to improve vocabulary (Opel, Ameer & Aboud, 2006). Math programs require more intensive work because instruction and materials must differ daily to maintain children's interest and encourage wide application of skills. Consequently, a similarly short 6-week math intervention was developed and implemented. Although the math program was homemade, it used the same principles and targeted the same skills underlying more professional programs. The hypothesis was that preschoolers who participated in the math program would acquire more math skills than those who followed the regular preschool program.

Method

Design and sample size estimation

The design was a pre-post assessment of an intervention and control group. Using an alpha of .05 and power of .80, the sample size was 80 per group to find a difference of .5 SD. Therefore there were 5 preschools per group with 16 children in each school. Scientific and ethical approval of the protocol was provided by a review committee of academics and researchers in this field convened by BRAC University's Institute of Educational Development.

Preschool setting

Children were selected from 10 preschools in a rural sub-district of Gazipur in Bangladesh. Out of 62 preschools run by Grameen Shikkha (a sister organization of Grameen Bank), five preschools were randomly selected to be intervention schools and five to be controls. The organization had been operating early childhood programs since 2001 and recently began using the materials provided by Plan International, an international child-focused NGO. Thus, all their current learning materials, operating costs, teacher training, staff development and other technical supports were provided by Plan International. In the usual half-day program, teachers had a daily 40-minute math class. There was a math curriculum with specific objectives, such as counting up to 30, identifying shapes, and adding numbers up to 10. A math bag was provided to each student, as well as an exercise book with pictures and numbers. For example, the children might spend the class learning to count to 15: they would count objects, count flowers drawn by the teacher on the black board, count drawings in their exercise book, and count buttons from their math bag. Similarly, if learning about "the middle", children would watch the teacher identify the middle object in a row of three, line up three buttons from their math bag as demonstrated by the teacher and then point to the middle button, and finally point to the middle in a row of three flowers in their exercise book. This was the regular program used as a comparison for the new program.

The educational attainment of the preschool teachers, who usually came from the village, ranged from Grade 10 to Grade 12. They received 5 days' training at the beginning of the school year on basic knowledge for early childhood learning, child psychology, pre-mathematics, pre-literacy and classroom management. Teachers received another 4-day refresher training in mid-year focused on curriculum, syllabus and teaching techniques. Monthly, they received 1-day

training on how to implement the lesson plans for that month. Most teachers had less than one year's experience in preschool teaching. They received 1000 taka or about US$15 per month as an honorarium, 40% of which was provided by the organization and the remaining 60% by the children's parents. This cost sharing was emphasized by the NGO to ensure community participation for long-term sustainability. This math intervention was implemented in the seventh month of the school year.

Participants

Sixteen students each from the 5 intervention and 5 control schools were randomly selected from a class list of 25-30 children to participate in this study. Consent was obtained from mothers to assess children's mathematical skills before and after the intervention. Mothers were interviewed to obtain information on the child's age, her education and family assets. The remaining children attended classes as usual but were not tested. Of the 80 children enrolled for each group, 78 from the intervention group and 66 from the control group were available to take the posttest. Consequently data from 144 children were analyzed.

Measures and testing procedure

A test was created to assess math skills identified as age-appropriate (Ginsburg et al., 2006) and tested in other programs (Starkey et al. (2004), namely, counting, patterns, shapes, measurement, sorting, comparing, and operations. The test had 77 items and each was scored as correct or incorrect. Examples of some items were: a child was given a handful of buttons and asked him to take 40 buttons. Different number cards were shown to a child one after another (3, 6, 12, 15, 20, 23, 28, 31, 35, 40) and asked the child to name it. Children were pretested during the few

weeks before the intervention and posttested one week after its completion, meaning 8 to 10 weeks after the pretest.

Individual interviews were carried out with each child in a quiet place, at their home or in the school compound. It took approximately 40 to 90 minutes to administer. A group of 10 female research assistants, with university degrees in different disciplines, conducted the pre- and post-tests as well as mother interviews. Four assistants had prior extensive experience assessing preschool children using different verbal and non-verbal measures. They received a half-day training before the pretest and again before the posttest on how to interact with the children, administer items, and record the scores.

Preschool intervention

Activities were selected from a document of "Everyday Math Play Activities" developed for Plan International by Llewellyn (2004). They were organized and embellished in such a way as to address each of the identified math skills. Teachers were to use them in sequence so that children could build on both enumeration and at least one other skill in the same lesson. For example, they might do enumeration of 10-20 objects, measurement, and patterns in the same day. Non-classroom materials were brought in so children would learn to apply math concepts to common village materials. Provision was made to do activities outside of the classroom but this was not possible due to the rains. Control children received their usual math program.

Both intervention and control children used math bags with the following items: 120 buttons (5-6 different colors and 4 different sizes), two 1m long strings, one die, a box with 40 sticks, one cloth mat, 12 small cubes colored red, blue, green and yellow. Four additional items were provided to each of the intervention children: number cards (1-40), pattern cards, blank papers, and a practice workbook.

Most activities were intended to enhance math concepts related to enumeration, shapes, patterns and their rules, measurement, sorting and classifying, and comparison. The two principle factors guiding the choice of activities were: first that children learn through fun and play; second that materials be low-cost and easily accessible. Examples of some of activities are provided below.

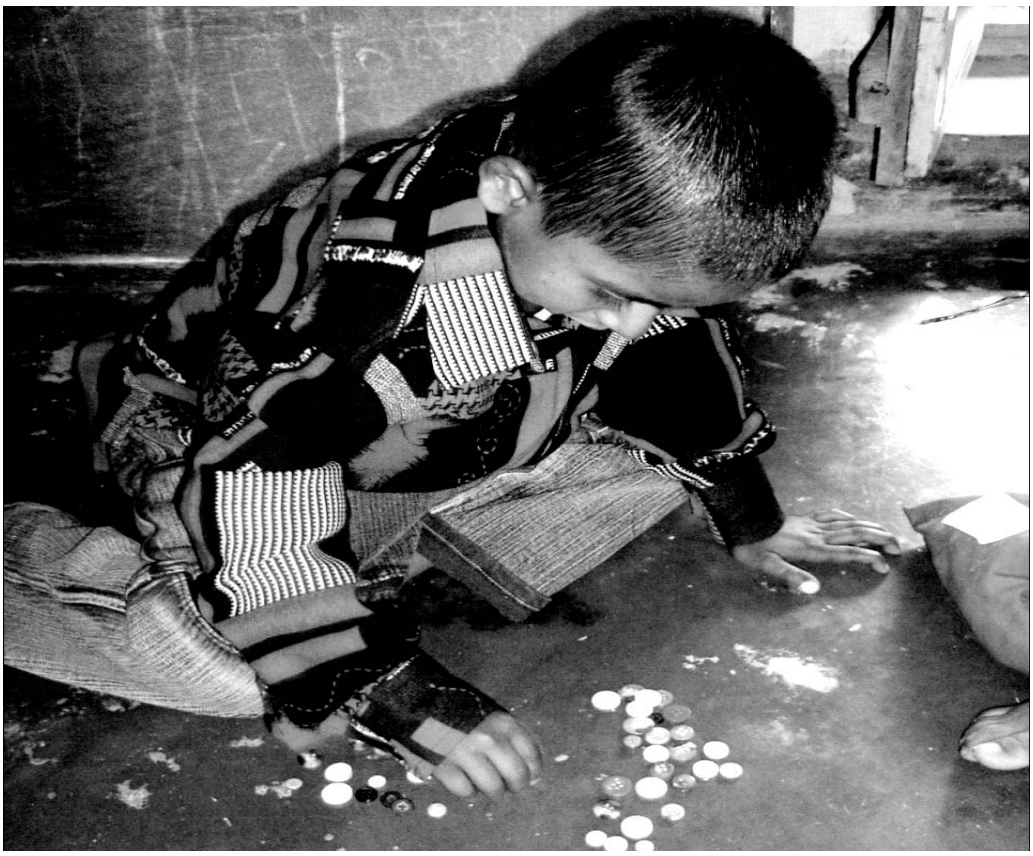
Counting and Enumeration: Counting and writing numbers from 1-40 were taught in multiple ways; the children had learned to count to 20 already so we went beyond that number. In addition, activities allowed for counting objects, recognizing numerals, following oral directions, locating the middle, dividing sets equally, comparing large and small numbers, grouping different items by 5 and 10. The activity of counting 1-40 was divided into four sessions to be conducted in four days but in each session other skills (i.e., number recognition) were incorporated. Four sets of number cards were provided to each child: sets of 1-10, 11-20, 21-30, 31-40. In each session children took out a set of ten number cards and mixed them up so that they were not in order. They were then asked to arrange the cards in order in a column. Once completed, everyone check his/her partner's work. Then the teacher said a number randomly and children held up the corresponding card. Once all the numbers had been covered, she made the task more difficult by asking children to show the number that came before 7 or after 3. This way they practiced counting and number recognition.

No materials were required for some of the counting activities. For example, in one activity, the teacher asked the children to cover their eyes with their

hands and listen. The teacher clapped and children silently counted. When the teacher stopped they called out the number of claps they heard. Then in turn each student was assigned to clap the number whispered to him/her by the teacher. Others covered their eyes and silently counted and called out the answer.

Shapes: Children explored ways that shapes can be partitioned and constructed from other shapes. Children also developed perspectives of three-dimensional buildings from a two-dimensional drawing. Activities were created to increase their ability to recognize shapes and their properties. In one such activity, the teacher asked the children to take out their sticks from the math bag. Teacher drew a triangle on the board and asked the children if they knew the name of the shape. She then asked how many sides the triangle has. She then posed a problem: the children were to make as many triangles they could with their sticks and count them. She then increased the difficulty level by asking children to make triangles that connect to each other so that a new triangle shares one side of the first triangle. They counted these triangles and looked at each other's work. After introducing all the shapes, the teacher introduced activities like sorting by shape. This way, recognition, counting and sorting skills were practiced the children.

Patterns: Activities promoted identifying the rules underlying patterns. Patterns were created using many different materials as well as numbers. Children made their own patterns and extended



patterns created by others. For example, children were asked to make a train that was 12 cubes long and used two colors in a pattern. When finished, they were asked to break the train into sections that were 3 cubes long and to line them up one on top and observe the pattern. They were then asked to put the train back together and break it into sections 4 cubes long. The teacher asked them to explain what happened to the pattern with the two problems.

Measurement: Concepts of measurement included shortest and longest, length and width, and the way of measuring things. Activities were created to help children learn key concepts of measurement practically and use them in the classroom. For example, in one activity the teacher asked children to think about the ways they can measure the classroom. She divided students into groups of 4 and asked each group to find a new way. During the intervention it was observed that children used their hands, foot steps, strings, and books to measure things. She then asked the children to take out a string from their math bag and find 5 things smaller and 5 things longer than the string. This way they not only learn the concepts of measurement and measuring things but also refresh their ability to count things.

Sorting and classifying: Activities were created to help children learn and practice sorting objects by color, size, shape and other attributes. For example, in one such activity, children stood in a big circle with their shoes in the center. The teacher asked students to look at the shoes and see if they can find a way to sort the shoes into groups. As each child sorted the shoes, other students guess how they were sorted. Each way had to be different.

Comparison: Comparisons were used to introduce concepts of equal as well as more or less, big or small, tall or short. Children, for example, compared numbers by lining up buttons for each number.

Operations: Concepts of mental math, addition, subtraction, and division were introduced in the intervention. As usual, other math concepts were also combined with operations. For example in one activity, children were asked to take out 30 buttons from their math bag and divide them into two parts as they wish. When they finished doing this the teacher asked children to divide the 30 buttons into two equal groups and count how many buttons are in each. This way children divided buttons equally into two, three, four and five portions and counted how many buttons were in each.

Teacher training and supervision

Training was provided to the 5 intervention school teachers at two points: 3 half days of training were given immediately before the start of the intervention and another 3 half days in the middle of the program.

A training manual was created describing different math activities and games to be used by teachers when implementing them in the classroom. For each, instructions were provided on how to introduce them to the children and how best to use the available materials. Training was held in an informal way, first introducing the teachers to the concept of math play. Each of the activities was then introduced to the teachers followed by a demonstration; teachers then practiced the activity with the others acting the role of students. During training, modifications were made to the manual according to teachers' suggestions in order to make it easier for them to implement.

Intensive on the job supervision was also provided to the teachers during the 6-week intervention. Each school was visited almost every day to ensure that classes were held regularly, instructions followed and help given the teachers, if needed. In the beginning of the program, most of the teachers had some problems ensuring child participation and using the materials. However, they overcame the problems in a few days.

Results

Characteristics of the sample

Among the intervention children, 56.4% were girls and 43.6% boys. Among the control group this proportion was 57.6% and 42.4% respectively. Table 1 presents the ages of the children, mothers' education and ownership of assets in terms of 11 household items; the last differed significantly with intervention children's families possessing more assets. These three variables will be covaried in the analysis of math scores. Land use and home ownership did not differ.

Table 2 shows the mothers' education for the intervention and control groups. One-quarter of the mothers had never gone to school, while over 40% had some secondary education.

Math skills

The alpha coefficient for the 77 math items was .91. The pre- and posttests had 77 items that were scored either correct (1) or incorrect (0). Consequently each child's score is the sum of points across all 77 items. The pretest and posttest scores are presented in Figure 1. The posttest scores were subjected to an analysis of covariance, covarying first the pretest score, the child's age, mother's education and assets. The pretest covariate was significant ($p < .0001$), as expected, and so was mother's education, $F(1, 138) = 4.86$, $p = .03$. The posttest score yielded a significant effect for group, $F(1, 138) = 90.48$, $p < .0001$, partial $\eta^2 = .40$. The control students had an adjusted mean of 30.47 (SError = 1.32) and the intervention

Table 1
Mean (S.D) and t-values comparing intervention and control preschool students.

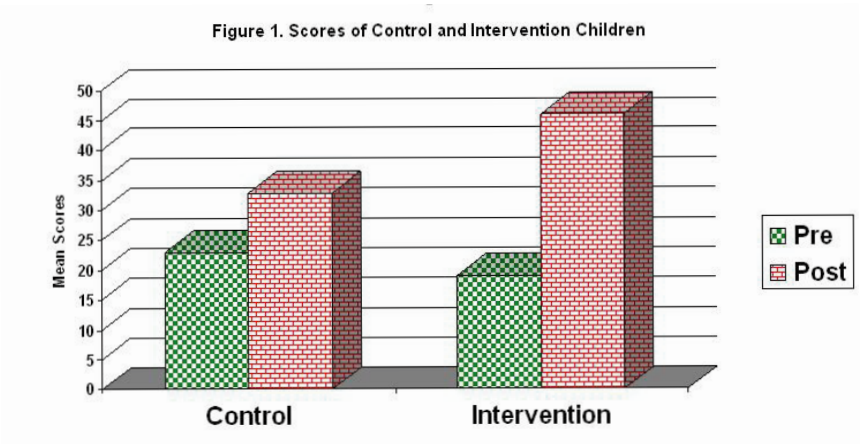
Variable	Intervention	Control	t	p-value
Child's age (months)	68.32 (6.69)	68.89 (7.18)	.49	ns
Mother education (year)	5.59 (3.62)	4.80 (3.66)	1.29	ns
11 Household assets	7.94 (2.46)	6.73 (2.89)	2.71	.008

Table 2
Mother education

Mother education	*Type of School Total*		*Total*
	Control	Intervention	
No education	18 (27.3%)	15 (19.2%)	33 (22.9%)
Primary	23 (34.8%)	23 (29.5%)	46 (31.9%)
Secondary	24 (36.4%)	38 (48.7%)	62 (43.1%)
Higher Secondary	1 (1.5%)	2 (2.6%)	3 (2.1%)
Total	66 (100.0%)	78 (100.0%)	144 (100.0%)

students an adjusted mean of 47.91 (SError = 1.21). The effect size d = 1.05. The improvement as a result of the math intervention was strong.

Figure 1. Scores of Control and Intervention Children



Discussion and implications

The hypothesis was that children who participated in the math activity program would acquire more math skills than children attending the regular math program. This was strongly supported by the findings. The mean score of the intervention children increased from 24.74% to 59.69% while the control group increased from 29.73% to 42.56%. The control children were acquiring some skills as a result of their 6-week instruction but not as many as the intervention children. They may also have benefited from a practice effect.

The findings are consistent with those from the United States demonstrating that more systematic approaches to teaching math skills in the preschool years can yield positive results (Sarama & Clements, 2004; Sophian, 2004; Starkey et al., 2004). Some of these programs (e.g., Sophian, 2004) were conducted with even younger children, suggesting that math concepts can be taught and understood in the early years. Although many children learn such concepts incidentally by playing with different materials and having exposure to a sophisticated environment, young Bangladeshi children do not have such access. They are likely to spend most of their early years at home without complex learning materials. Consequently, many do not possess math readiness skills, such as enumerating objects up to 10, unless they receive stimulation from preschools. Currently the preschools implement structured instruction in math, with exercise books and some manipulatives. This has led to the acquisition of some math skills but not always of the logical reasoning that allows children to apply skills to different problems. This may be because children tend to repeat what the teacher has done rather than test their skill on a new problem. The math games employed here for only 6 weeks benefited children's understanding.

The major effort here was in developing the activities and training the teachers to implement them. The manual developed and revised with the help of participating teachers was relatively easy for them to follow. Concerning teacher training, many of the paraprofessional teachers themselves did not have a good grounding in math. Also they were not accustomed to letting children come up with their own answers and permitting many different but correct answers to a problem. Developing math activities for a full-year program might be too onerous. Fortunately, many of the programs currently developed for preschoolers (e.g., Greenes et al., 2004) are amenable to contexts such as Bangladesh, using local materials such as buttons in place of commercial ones. Given the benefits of this short-term program, it is clear that Bangladeshi children would learn a great deal about mathematical thinking and language from a full-year program. This would lead to improved math and science achievement throughout primary school.

References

Aboud, F (2006), Evaluation of an early childhood preschool program in rural Bangladesh. Early Childhood Research Quarterly, 21, 46-60.

Engle, PL, Black, MM, Behrman,, JR, Cabral de Mello, M, Gertler, PJ, Kapiriri, L, Martorell, R, Eming Young, M, and the International Child Development Steering Committee (in press). Strategies to avoid the loss of developmental potential among over 200 million children in the developing world.

Ginsburg, H. P., (2006). Mathematical thinking and learning. In McCartney, K. and Phillips, D.(Eds.), Blackwell Handbook of Early Childhood Development. Oxford: Blackwell.

Greenes, C., Ginsburg, H. P., & Balfanz, R. (2004). Big math for little kids. Early Childhood Research Quarterly, 19, 159-166.

Griffin, S., (2004). Building number sense with Number Worlds: a mathematics program for young children. Early Childhood Research Quarterly, 19, 173-180.

Kagitcibasi, C., Sunar, D. & Bekman, S. (2001). Long-term effects of early intervention: Turkish low-income mothers and children. Applied Developmental Psychology, 22, 333-361.

Llewellyn D, (2004) Everyday Math Play: A kindergarten curriculum guide for problem solving challenges using low-cost materials. Dhaka: Plan Bangladesh.

Moore, A. C., Akhter, S., and Aboud, F. F., (2005), Evaluation of pilot preschool programs of Plan Bangladesh. Bangladesh Education Journal, 4, 32-39.

Opel, A., Ameer, S. S., Aboud, F. F., (2006), A literacy intervention for preschool children in Bangladesh: the benefits of dialogic reading. BRAC University Institute of Educational Development.

Sarama, J., & Clements, DH. (2004). Building Blocks for early childhood mathematics. Early Childhood Research Quarterly, 19, 181-189.

Siegel, R. S. & Svetina, M (2006). What leads children to adopt new strategies? A microgenetic/cross-sectional study of class inclusion. Child Development, 77, 997-1015.

Sophian, C., (2004), Mathematics for the future: developing a Head Start curriculum to support mathematics learning. Early Childhood Research Quarterly, 19, 59-81.

Starkey, P., Klein, A., & Wakeley, A. (2004). Enhancing young children's mathematical knowledge through a pre-kindergarten mathematics intervention. Early Childhood Research Quarterly, 19, 99-120.

ECD Research Report Series:

1. Opel, A., Ameer, S.S., Aboud. F., A literacy intervention for preschool children in Bangladesh: the benefits of dialogic reading, Dhaka: Early Childhood Development Resource Centre (BU-IED), 2006

2. Opel, A., Camellia, S., Aboud. F., Playing with mathematics: a pilot intervention to develop basic mathematical skills among preschoolers in Bangladesh, Dhaka: Early Childhood Development Resource Centre (BU-IED), 2006