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ABSTRACT

This study examined home and classroom support for early mathematical development. Teachers and parents of preschool children completed questionnaires evaluating young children's readiness for school mathematics. Teachers were selected from licensed preschool programs and Head Start programs. Findings indicated that a minority of teachers and parents did not believe that young children possessed types of mathematical knowledge which research has shown to be in their developmental range; that parents attributed more mathematical knowledge to pre-kindergarten children than their teachers did; and that a minority of teachers believed that children possessed math knowledge outside their developmental range. The surveys also revealed the extent of math activities provided to children in the home and at school, teacher's knowledge of curriculum, and the need for a comprehensive preschool math curriculum. Based on the findings, a pre-kindergarten math curriculum was developed, organized into topical units, each with a set of informal math activities accompanied by concrete materials, and including home and school components. Instructional approaches and professional development activities were included in the curriculum. (JPB)

Supporting Pre-kindergarten Children's Readiness for School Mathematics

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Poster presented at NIECDE Project Directors' meeting, Washington, D.C., June 8-10, 1998. Preparation of this poster was supported by U.S. Department of Education grant R307F60024 to P.S. and A.K. The Berkeley Math Readiness project would not be possible without the involvement and dedication of graduate student researchers Jill Applegarth, Christina Bown, Irene Chang, Linda Charmaraman, Sally Kim, and Ann Wakeley and teacher-consultants Alma Ramirez and Barbara Scales.

Supporting Pre-kindergarten Children's Readiness for School Mathematics

This project addresses issues that lie at the intersection of two National Education Goals: Readiness to Learn, and Mathematics and Science Achievement. Research has revealed cross-national and cross-socioeconomic differences in young children's mathematical development prior to entry into elementary school. Within the United States, informal mathematical knowledge develops at a slower rate in children from low-income families than in middle-class children (Jordan, Huttenlocher, & Levine, 1994; Klein & Starkey, 1995; Saxe, Guberman, & Gearhart, 1987; Starkey & Klein, 1992). Thus, American children enter school at different levels of readiness to learn the school mathematics curriculum.

The overarching goal of our project is to help preschool teachers and parents support pre-kindergarten children's readiness for school mathematics. In order to achieve this goal, the project will be directed at two objectives. The first objective is to conduct a comprehensive study of the ecological context of young children's mathematical development. This study will reveal the extent of support for early mathematical development that is provided to pre-kindergarten children in preschool classrooms and at home. The second objective is to develop a pre-kindergarten math curriculum organized into topical units, each with a set of informal math activities accompanied by concrete materials. The curriculum will include both classroom- and home-based components.

Project Design

The first objective of the project was to study the ecological context of young children's mathematical development in preschool classrooms and at home. We conducted two

surveys – one focusing on preschool teachers and another on parents of pre-kindergarten children. A Teacher Questionnaire and a Parent Questionnaire were developed to collect data on a range of topics related to young children's readiness for school mathematics. The Teacher and Parent Questionnaires were constructed in parallel to permit a comparison between teacher and parent responses on specific questions.

Teacher Questionnaire. Teacher questionnaires were sent to 1,200 randomly selected licensed preschool programs in California and Head Start programs in Region IX (Far West). Questionnaires were completed in Spring 1997. Different types of preschool programs were included in the sample such as private nonprofit, state preschool, and University preschool programs.

Parent Questionnaire. Parent questionnaires were administered to parents of pre-kindergarten children used in evaluating our pre-kindergarten math curriculum. Questionnaires were completed by Baseline parents (Cohort 1) in Spring 1997 and by Field-Test parents (Cohort 1) in Fall 1997.

The second objective of the project was to develop a pre-kindergarten math curriculum for use in the classroom and at home, and to evaluate its effectiveness at enhancing preschool children's mathematical knowledge. Our pre-kindergarten math curriculum is being field tested by teachers and parents in 10 preschool classrooms over two years. This field test comprises a socioeconomically and ethnically diverse sample of participants.

In Field-Test Year 1, the curriculum has been implemented in five preschool classrooms (private nonprofit and University preschool programs) serving middle- to upper-middle-income families. In Field-Test Year 2, it will be implemented in five preschool classrooms (Head Start and California state preschool programs) serving low-

income families. In the year preceding the field test in each classroom, baseline data were collected on the teacher, children, and their parents (Baseline Year 1 and Year 2). Thus, each classroom served as its own comparison group in the project design. Our partner preschools are Step One Nursery School and UC Berkeley Child Care Services for Baseline and Field-Test Year 1, and the Berkeley Unified School District State Preschool and Southern Alameda County Head Start for Baseline and Field-Test Year 2.

Results

Ecological context of development. What is the nature of the ecological context of young children's mathematical development? To begin answering this question, questionnaires were administered to teachers and parents of pre-kindergarten children. A subset of the questions and a summary of responses given by teachers (N=300) and parents (N=47) are presented below.

Teachers and parents were asked, "Which mathematical abilities or skills do children typically develop by the end of preschool?"

Abilities within the Developmental Range of Pre-kindergarten Children	Teacher Responses	Parent Responses
Count a row of 10 objects	93%	98%
Show which doll in a row of 5 is second	76%	92%
Solve small addition or subtraction problems presented with objects	75%	81%
Share 12 crackers equally among 3 friends	48%	57%
Make a simple pattern with colored beads	94%	96%
Determine that two identical triangles in different orientations match	69%	83%
Measure the length of a pencil using string	64%	72%
Use a computer with age-appropriate software to learn math	61%	75%
Abilities outside the Developmental Range of Pre-kindergarten Children	**Teacher Responses**	**Parent Responses**
Read arithmetic symbols, such as "+", "-"	16%	30%
Solve single-digit addition or subtraction problems presented on flashcards	9%	17%
Use a calculator to solve single-digit addition or subtraction problems	5%	15%
Use the numerals 1-10 to make a number pattern such as odd-even-odd-even	16%	13%
Measure the width of a page using a ruler	16%	28%

Three findings are especially noteworthy. First, a significant minority of teachers and parents did not believe that pre-kindergarten children possess several types of mathematical knowledge that developmental research has shown are within their developmental range. Second, parents attributed more mathematical knowledge to pre-kindergarten children than preschool teachers did. Finally, a minority of teachers believed that pre-kindergarten children possess some types of mathematical knowledge that developmental research has shown are typically outside their developmental range.

Teachers and parents were also asked, "What are the relative contributions of the home and the preschool environments in preparing children for math in kindergarten?"

Relative Contribution	Teachers	Parents
Home contributes more than preschool	9%	38%
Home and preschool contribute equal amounts	17%	32%
Preschool contributes more than home	71%	30%

Most teachers believed the preschool environment contributes more to math readiness, but parents varied widely in their views.

Teachers and parents were also asked, "What do you believe contributes to children's early mathematical development?"

Most Important Factor	Teachers	Parents
The age or maturation of the child	44%	49%
Generally rich learning environment	36%	44%
Specific math experiences	20%	7%

Teachers and parents appeared to undervalue the importance of specific math experiences in mathematical development.

Teachers and parents were asked, "Do you know what is taught in the kindergarten math curriculum?"

	Teachers	Parents
Yes	68%	36%
No	32%	64%

One-third of teachers and two-thirds of parents reported that they did not know what is taught in the kindergarten math curriculum. A follow-up question revealed that even fewer actually knew what is taught.

Teachers were asked: "To what extent do parents provide math activities to pre-kindergarten children at home?"

Do not Know	Not at All or Rarely	Moderately	A Great Deal
24%	26%	42%	8%

Parents were asked: "To what extent do teachers provide math activities to pre-kindergarten children at preschool?"

Do not Know	Not at All or Rarely	Moderately	A Great Deal
21%	4%	43%	32%

Children's developed math abilities. The Child Math Assessment instrument was developed to measure preschool children's mathematical knowledge across a broad range of math concepts. The assessment consists of 14 tasks drawn from the research literature on young children's mathematical development. Young children's numerical and arithmetic knowledge is assessed as well as spatial and geometric knowledge. The tasks encompass a range of difficulty. The assessed numerical and arithmetic knowledge includes knowledge of the number series, counting principles, ordinal number terms, number reproduction, simple addition and subtraction (with and without concrete objects), and two-set addition with hidden sets. The assessed

spatial and geometric knowledge includes pattern duplication and extension, shape names, geometric reasoning and analysis, and spatial location terms.

Tables 1 and 2 summarize the results of the Spring 1997 Child Math Assessment of the Baseline children (Cohort 1) from middle-class families. Some noteworthy findings were first, that there was considerable variation both within and between children in their performance across these mathematical tasks. Second, there was a strong effect of set size: children were more accurate on counting, number reproduction, and simple addition and subtraction tasks with smaller sets than with larger ones. Third, children who exhibited well-developed counting skills on standard counting tasks often did not use these skills to solve other numerical problems such as number reproduction or addition and subtraction with concrete objects. Also, even at the end of their pre-kindergarten year, it was difficult for children to reason about arithmetic operations in the absence of concrete objects. Another noteworthy finding was that children found it much easier to duplicate a pattern than to extend it.

Some general conclusions that can be drawn from these findings are that pre-kindergarten children's performance across the diverse set of mathematical tasks in the Child Math Assessment reveals individual profiles of strengths and weaknesses in children's developing mathematical knowledge. These developmental profiles reveal a need to implement a comprehensive preschool math curriculum in the pre-kindergarten year in order to prepare children for school mathematics.

Table 1

Mean Percent Correct on the Child Math Assessment of Numerical and Arithmetic Knowledge [a]

Standard Counting				Counting a Subset	Number Reproduction	
Set Size						
3	9	15	30 [b]		Set Size 3	Set Size 9
98	88	61	22	94	98	38

Knowledge of Number Series				Ordinal Terms			
Number Order		Number Comparison					
1-after	2-after [b]	1-9	10-20 [b]	First	Second	Third	Fourth
84	6	79	32	88	81	40	43

One-Set Addition and Subtraction		Two-Set Addition	
Objects Present	Objects Absent	Addition -> More	Addition -> Less
66	37	83	65

[a] Percentages are based on a total of 42 children in 5 classrooms.

[b] These items were given only to children who correctly completed easier items on these tasks.

Table 2

Mean Percent Correct on the Child Math Assessment of Spatial and Geometric Knowledge [a]

Pattern Duplication	Pattern Completion
81	16

Shape Naming			
Circle	Square	Triangle	Rectangle
86	88	74	57

Shape Matching
81

Geometric Reasoning Triangle Task
78

Spatial Location Terms
93

Seriation	
Seriate 5 Items	Insert 6th Item
67	60

[a] Percentages are based on a total of 42 children in 5 classrooms.

Curriculum

What comprises a developmentally appropriate math curriculum for pre-kindergarten children? Some of the principles guiding the development of our pre-kindergarten mathematics curriculum are: (1) The curriculum should be designed to promote the development of informal mathematical knowledge in the domains of numerical cognition and spatial cognition, (2) the curriculum should organized into topical units based on developmental research and mathematics frameworks (NCTM and California frameworks), (3) each unit should include multiple sets of activities with concrete materials, (4) the activities should allow for developmentally upward and downward extension, and (5) the curriculum should include a variety of instructional approaches to address individual learning styles.

Topical units of the curriculum. The curriculum is composed of the following units: Unit 1 - Enumeration and Number Sense; Unit 2 - Arithmetic Reasoning; Unit 3 - Spatial Sense; Unit 4 - Geometric Reasoning; Unit 5 - Patterns and Spatial Constructions; Unit 6 - Logical Reasoning; Unit 7 – Measurement; and Unit 8 - Computer Math Activities.

Instructional approaches. In teaching the Classroom-Based Component of the curriculum, three instructional approaches are used. First, there are small group activities consisting of teacher-guided math activities used with groups of 4 to 6 children. There also is a math learning center which is a locus for child-directed activities with materials from the small group sessions and supplemental related materials. Third, there are computer activities. In the Home-based Component of the curriculum, home curriculum classes are provided for parents and children. Home

math kits - materials and curriculum guide sheets – are made available for parents to use at home.

Professional Development Activities

What types of professional development activities are needed for teachers to implement a developmentally appropriate math curriculum? In our project, field-test preschool teachers attend two math curriculum workshops and receive ongoing technical assistance.

Summer Workshop. Teachers learn the first four units of the curriculum and the computer unit. Activities are demonstrated. Teachers read activity scripts in their curriculum manual and practice the presentation of selected activities. Teachers also learn about young children's mathematical development through staff presentations and videotaped examples of young children solving mathematical problems at different points in development. Third, teachers learn how Home Curriculum classes can be used to help parents support their children's mathematical development at home.

Winter Workshop. Teachers learn the remaining three units of the curriculum through the same instructional methods as in the summer workshop. Teachers also discuss their experiences in field testing the math curriculum in their classrooms.

Technical Assistance. Teachers are provided with technical assistance while field testing the curriculum.

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