Development of an Early Math Intervention for Public Preschool Programs

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Mathematical Development in Early Childhood

- Research has found that mathematical thinking begins early in life and undergoes extensive development over the first five years of life.

- It is just as natural for young children to think mathematically about their world as it is for them to use language.

- Children's early, informal math knowledge involves concrete objects. It is less abstract than later developing formal math knowledge of school-age children.

Why is early, informal math knowledge important?

1. It serves as a foundation for the development of formal mathematical knowledge in elementary school

Early, informal: **OO and OO make OOOO**

Later, formal: **2 + 2 = 4**□□

Why is **informal mathematical knowledge** important?

2. Mathematical knowledge at school entry is a strong predictor of later school achievement

Meta-Analysis of Research on School Readiness and Later Achievement (Duncan et al. (2007). Developmental Psychology)

- An analysis of 6 longitudinal data sets relating school-entry skills to teacher ratings and test scores of reading and math achievement

Predictors of Later Learning

School Entry Skill Domain	Effect Size
Mathematics	.34
Language & Reading	.17
Attention	.10
Socioemotional	.00

Socioeconomic Differences in Informal Math Knowledge

A growing body of research has revealed a socioeconomic gap in young children's mathematical knowledge

- This gap is broad

The Early Development of Mathematical Cognition in Socioeconomic and Cultural Contexts

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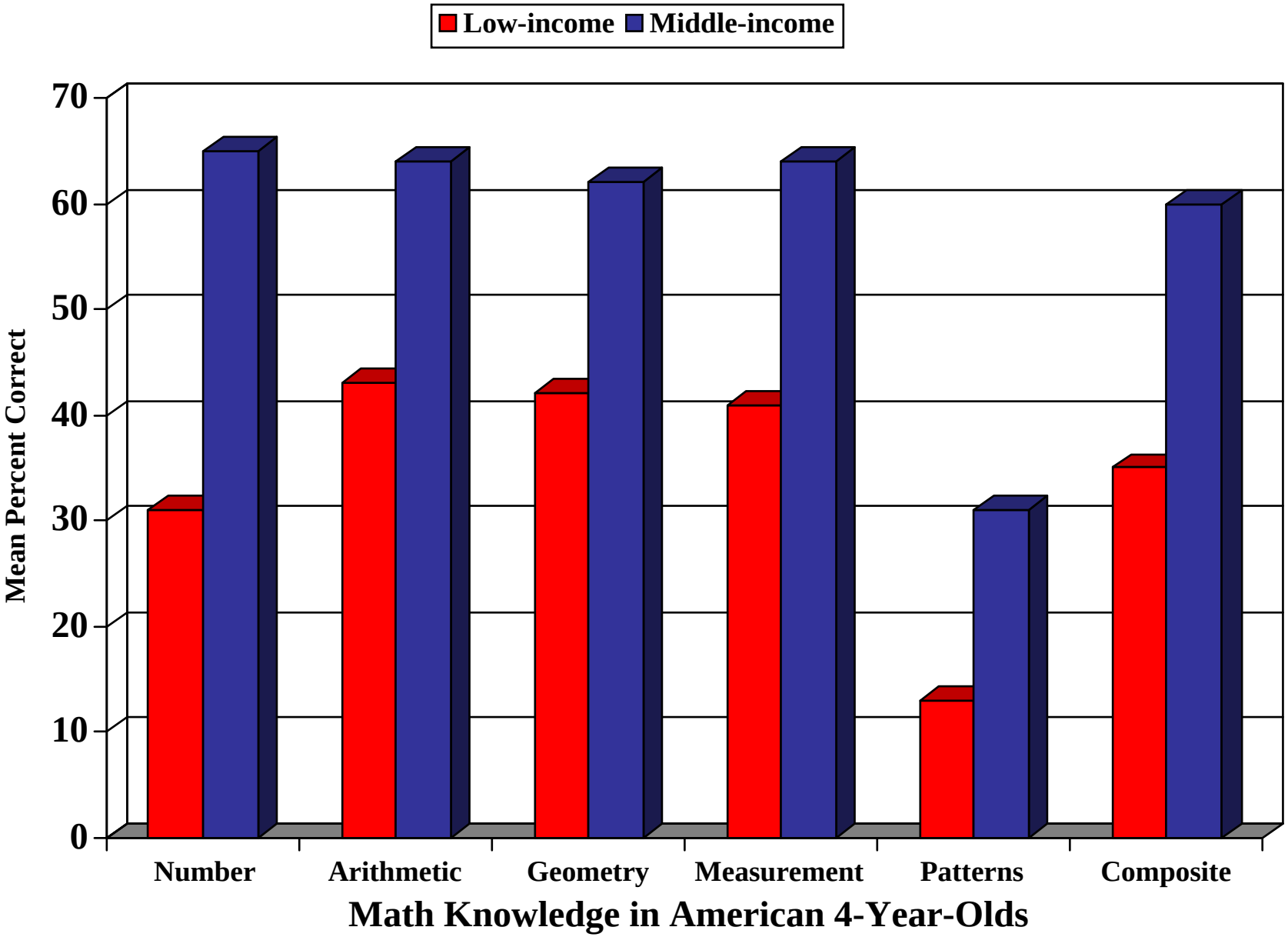
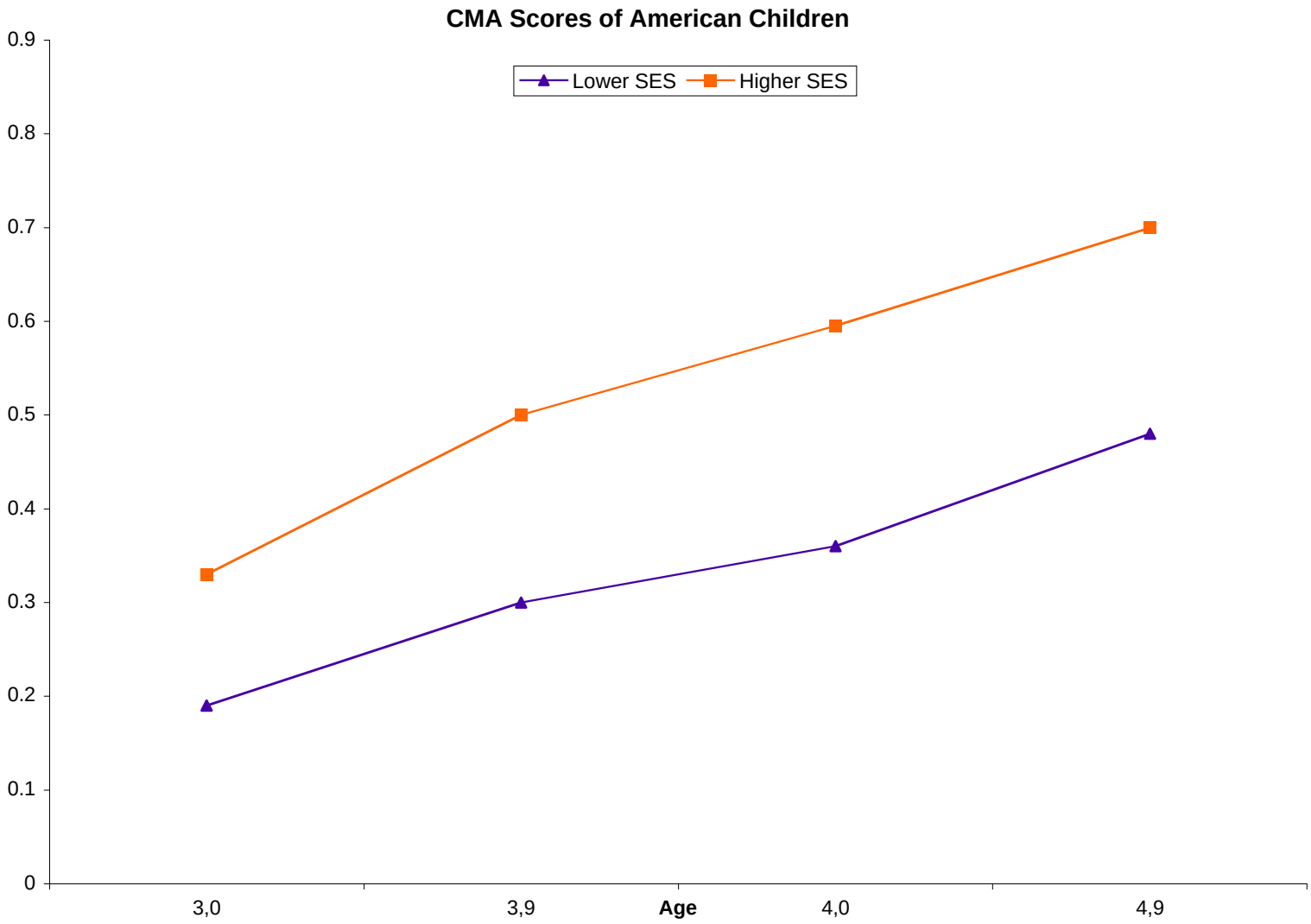
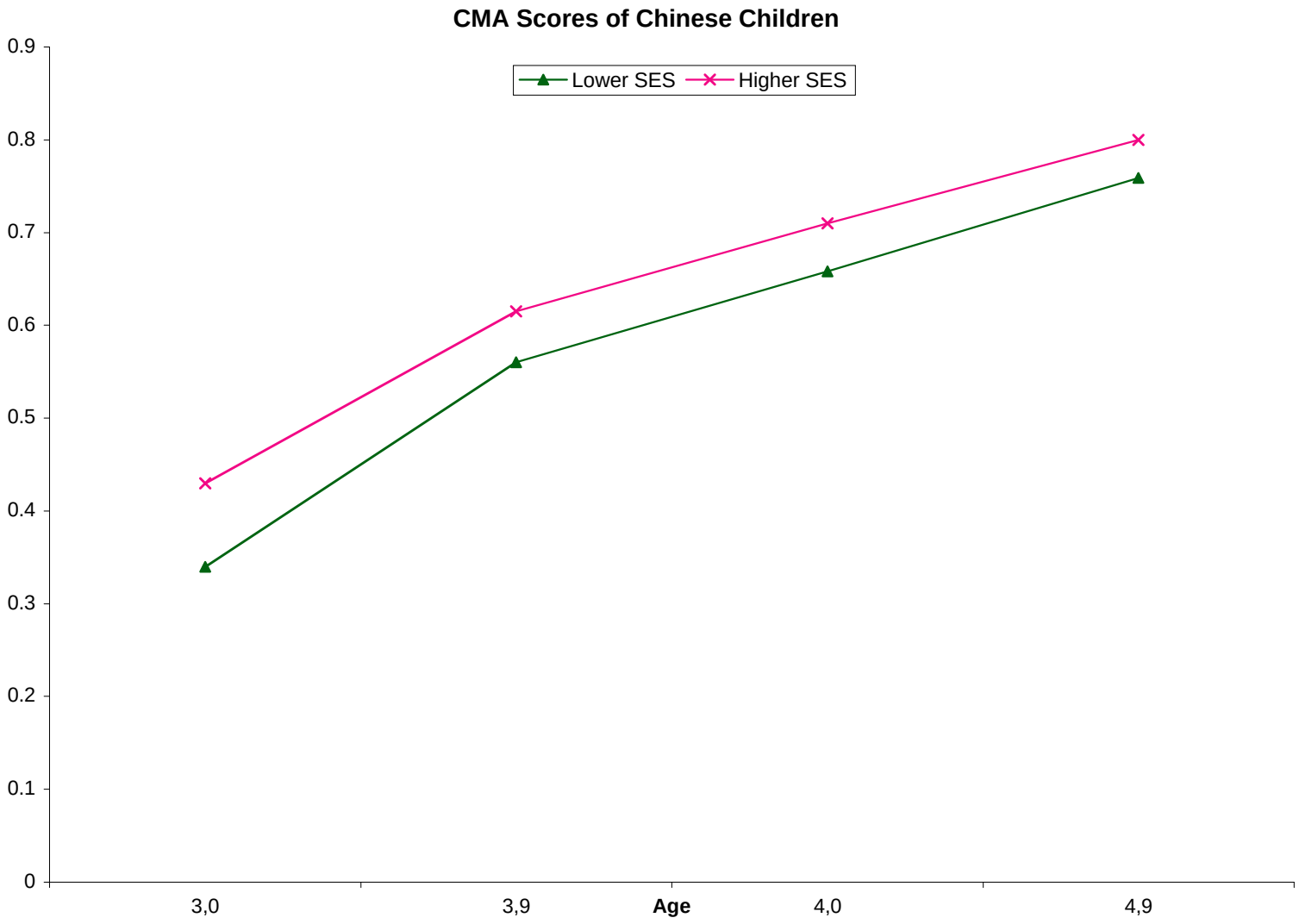

Low-income
Middle-income
70
60
50
40
30
20
10
0
Mean Percent Correct
Number
Arithmetic
Geometry
Measurement
Patterns
Composite
Math Knowledge in American 4-Year-Olds

Socioeconomic Differences in Informal Math Knowledge

A growing body of research has revealed a socioeconomic gap in young children's mathematical knowledge

- This gap is broad
- It first appears before children enter preschool
- It widens during the preschool years in the United States


CMA Scores of American Children
Lower SES
Higher SES
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
3,0
3,9
Age
4,0
4,9


CMA Scores of Chinese Children
Lower SES
Higher SES
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
3,0
3,9
Age
4,0
4,9

Why does the math gap widen in the United States?

American preschool children from low-income families, in comparison with their middle-class peers, receive less support for mathematical development in their home environment

The Home Learning Environment of Young, Economically Disadvantaged Children:

- Fewer math-related materials
- Fewer math activities in which an adult participates
- Lower parental expectations about mathematical development prior to elementary school

The Preschool Classroom Learning Environment of Economically Disadvantaged Children

Curricula in widespread use in public preschool programs have been found to be ineffective, relative to controls, at enhancing early math knowledge:

•The Head Start Impact Study (2005, 2008) found no difference in mathematical knowledge between intervention (Head Start) and control children at the end of the pre-kindergarten year

• The IES Preschool Curriculum Evaluation Research Initiative (2008) found that general curricula (e.g., Creative Curriculum) in widespread use in public preschool programs are not effective in the area of mathematics relative to control curricula (e.g., High Scope). Our math-focused curriculum, however, was found to be effective.

Why does the math gap narrow in China?

Possible explanations:

- National mathematics curriculum for preschools
- High parental and teacher expectations for mathematical development

Implications

- Effective curricula are needed to close the SES gap in early math

- Early math curricula should provide enrichment for both the home learning environment and the preschool classroom

Pre-K Mathematics Curriculum

Alice Klein & Prentice Starkey

Published by Scott Foresman-Addison Wesley
Mathematics series - Pre-K level
Core Program Package: Item #
0328092436978032809243 7

http://www.pearsonschool.com/index.cfm?locator=PSZ153&PMDbSiteId=2781&PMDbSolutionId=6724&PMDbSubSolutionId=6731&PMDbCategoryId=806&PMDbProgramId=28182&level=4

Pre-K Mathematics Curriculum

Units of the Curriculum:

- Unit 1 - Number Sense and Enumeration
- Unit 2 - Arithmetic Reasoning (Fall)
- Unit 3 - Spatial Sense and Geometric Reasoning
- Unit 4 - Pattern Sense and Pattern Construction
- Unit 5 - Arithmetic Reasoning (Spring)
- Unit 6 - Measurement and Data Representation
- Unit 7 - Logical Relations

- Each unit contains multiple small-group activities with concrete materials for teachers to use in their classrooms. (Evaluated with a **U.S. Department of Education grant**)

- Each unit also includes home activities for parents to use with their children. Home activities are explicitly linked to small-group activities in the classroom. (Evaluated with a **Head Start-University Partnership grant** from the Administration for Children and Families)

Small Group Activity:

Watch Me Make a Shape
(3-dimensional shapes)


El alfabeto

Small Group Activity:

How Many Dinosaurs
(addition and subtraction)

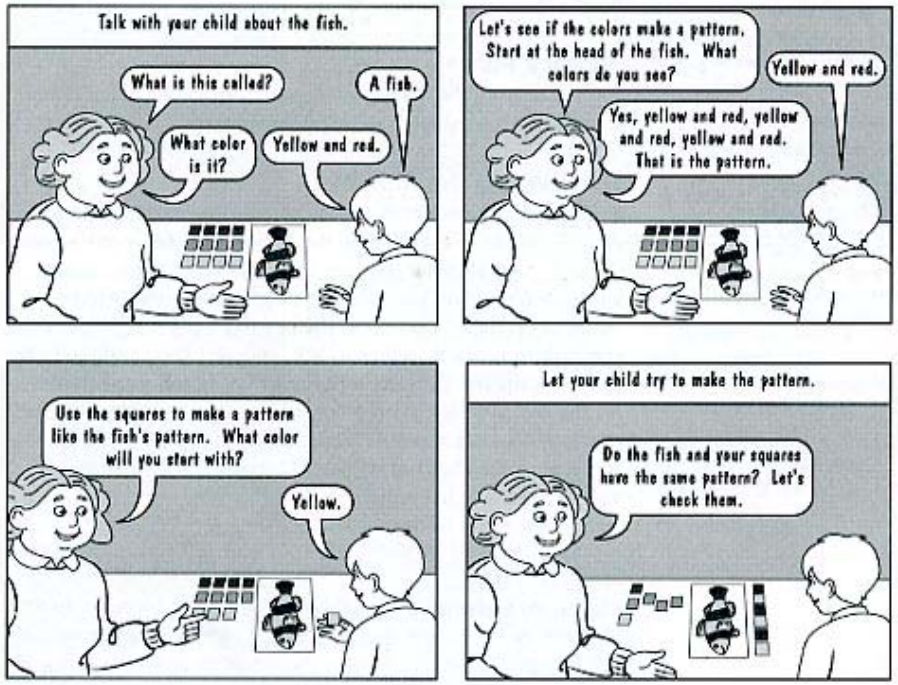
Home Activity:

Color Patterns in Nature
(pattern duplication)

HOME ACTIVITY 1

PROBLEM 1: Fish (yellow, red, yellow, red)

Color the fish and the squares as indicated on Activity Aids 65 and 66. Place the picture of the fish and 4 red, 4 yellow, and 4 blue squares on the table near your child.



Try These
Put a 3-color pattern (red-yellow-blue) on the extra fish.
Put a 4-color pattern (black-red-black-yellow) on the extra snake.

Training and Assistance for Intervention Teachers

- 2 Workshops (beginning and middle of program year)

- On-site facilitation (classroom visit by math trainer every 2 weeks)

Preschool Curriculum Evaluation Research Project: Randomized Trial of a Pre-K Math Intervention

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The research reported here was supported by the Institute of Education Sciences, U.S. Department of Education through Grant R305J020026 to UC, Berkeley.The opinions expressed are those of the authors and do not represent views of the U.S. Department of Education

Design

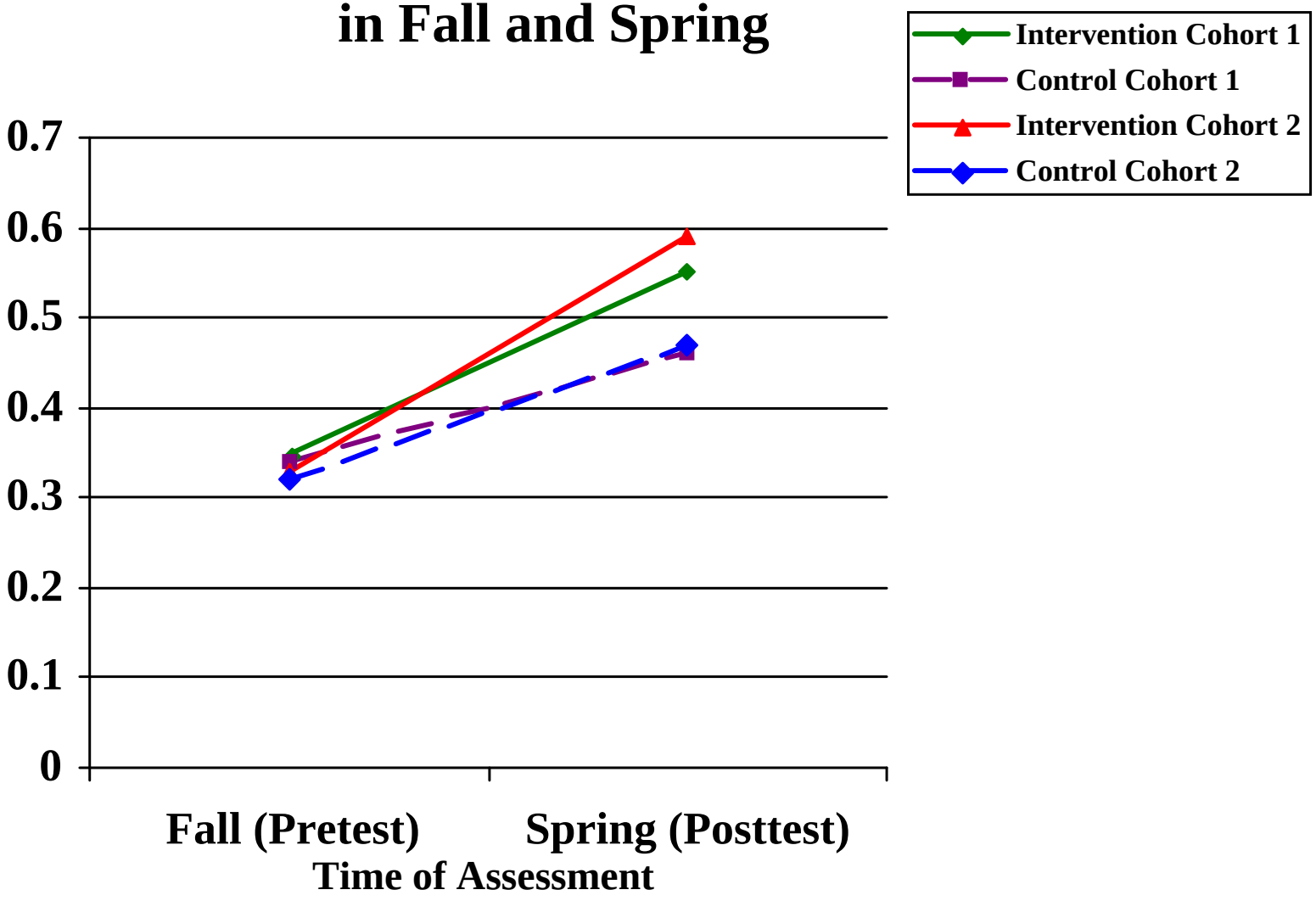
- 40 classrooms: Half were Head Start and half were state-funded preschool classrooms in California and New York
- Random assignment of classrooms to intervention or control conditions, using block randomization at the program level
- Random selection of 8 low-income children per classroom
- Child sample:

  Cohort 1 (Year 1): 316 pre-k children

  Cohort 2 (Year 2): 312 pre-k children

Effects of the Intervention on Children's Mathematical Development

CMA Scores of Intervention and Control Children in Fall and Spring



- **Cohort 1 effect size** (Cohen's *d*)=**.58** (What Works Clearinghouse), a 62% increase in math knowledge for intervention children relative to control children [Klein, et al. (2008). *Journal of Research on Educational Effectiveness*, *1*(3).]

- **Cohort 2 effect size=.70** (What Works Clearinghouse), a 79% increase for intervention children relative to control children

- Significantly more math knowledge was acquired by children in Cohort 2 than in Cohort 1

-

Long-Term Effects

- Kindergarten: Math knowledge at end of kindergarten was significantly greater in intervention children than in control children.

- Grade 1: For Head Start graduates, math knowledge at end of first grade was significantly greater in intervention children than in control children.

Scaling Up the Pre-K Mathematics Intervention: A Randomized Controlled Trial

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The research reported here was supported by the Institute of Education Sciences, U.S. Department of Education through Grant R305K05186 to UC, Berkeley. The opinions expressed are those of the authors and do not represent views of the U.S. Department of Education

Objectives

- To scale up the *Pre-K Mathematics* intervention in programs serving low-income families to determine whether the intervention is effective when implemented at a customary level of scale - - a Head Start program or a school district's pre-kindergarten program -- with mandatory participation by teachers

- To study implementation when teachers receive T/TA from program staff rather than by our research staff

- To determine whether the intervention is effective in varied contexts (e.g., urban vs. rural programs; in Head Start vs. state-funded pre-k programs)

Design

A cluster randomized trial with preschool site as the unit of randomization

Classrooms were randomly selected within sites

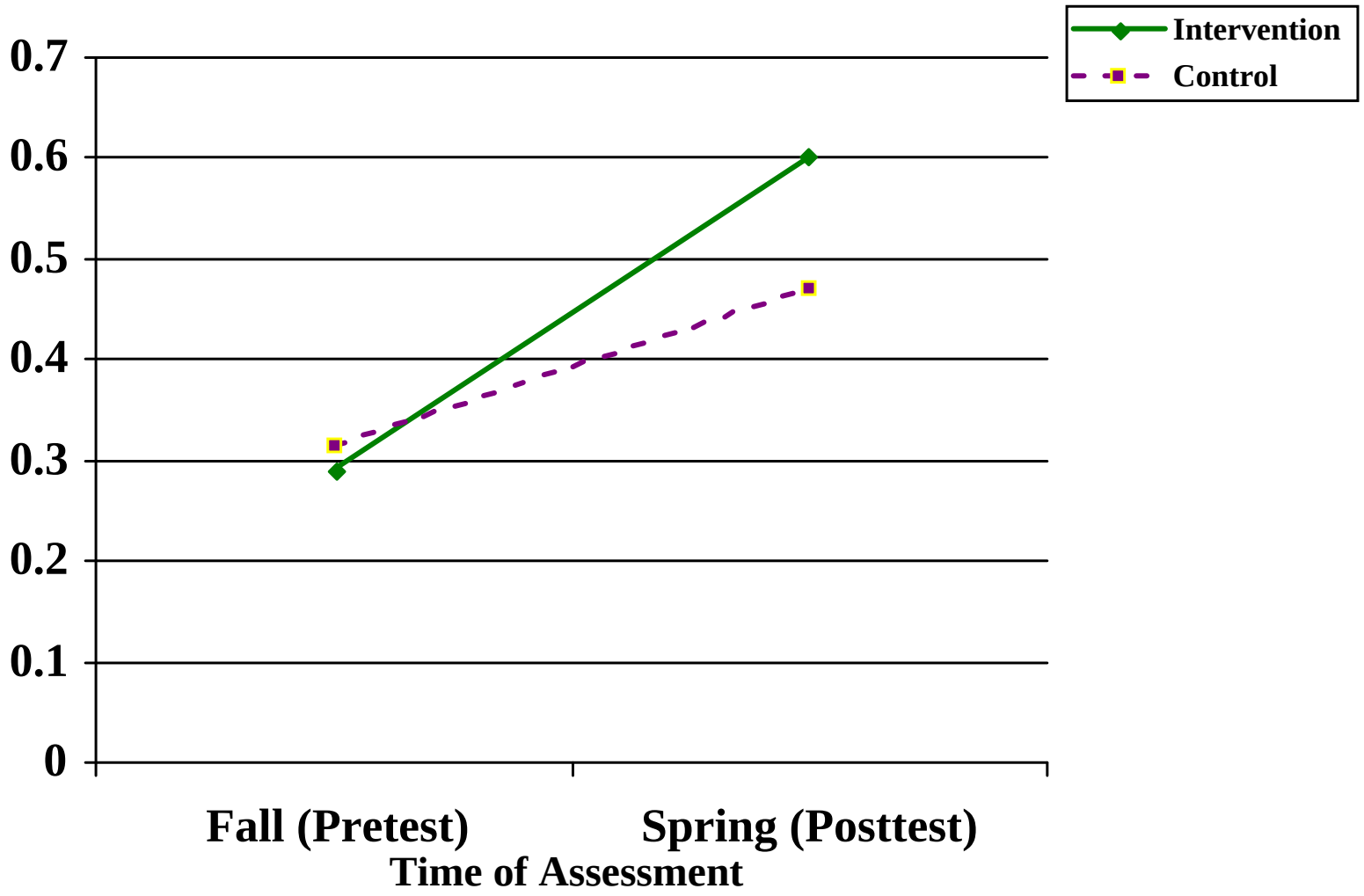
Pre-kindergarten children were randomly selected within classrooms (8-10 per classroom)

States: California and Kentucky/Indiana

Program Type: Head Start and State-Funded Preschool

Treatment Condition: Intervention (Pre-K Mathematics curriculum) vs. Control (Business-as-usual=Creative Curriculum)

CMA Scores of Intervention and Control Children in Fall and Spring



Effects of the Intervention on Children's Mathematical Development

- Intervention children's gains in mathematical knowledge over the pre-k year were approximately twice that of control children

- **Effect Size = .83 (Large)**

- The intervention was effective in Head Start and state preschool programs serving ethnically diverse urban families in California

- It was also effective in Head Start and state preschool programs serving predominantly white rural families in Kentucky and Indiana

Thus, the intervention was effective across a variety of contexts in which it was implemented.

In closing, the socioeconomic gap in young children's mathematical knowledge does not have to widen during the preschool years.

Our intervention research has shown that Head Start and state-funded preschool programs can make significant strides in closing this gap by training teachers to utilize effective math activities and by empowering parents to do so.

When an effective math curriculum is used, children not only enter elementary school better prepared for math, they continue to exhibit better achievement in math in kindergarten and first grade.