Effects of a Pre-Kindergarten Mathematics Curriculum on Low-Income Children's Mathematical Knowledge

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The Early Development of Mathematical Cognition in Socioeconomic and Cultural Contexts

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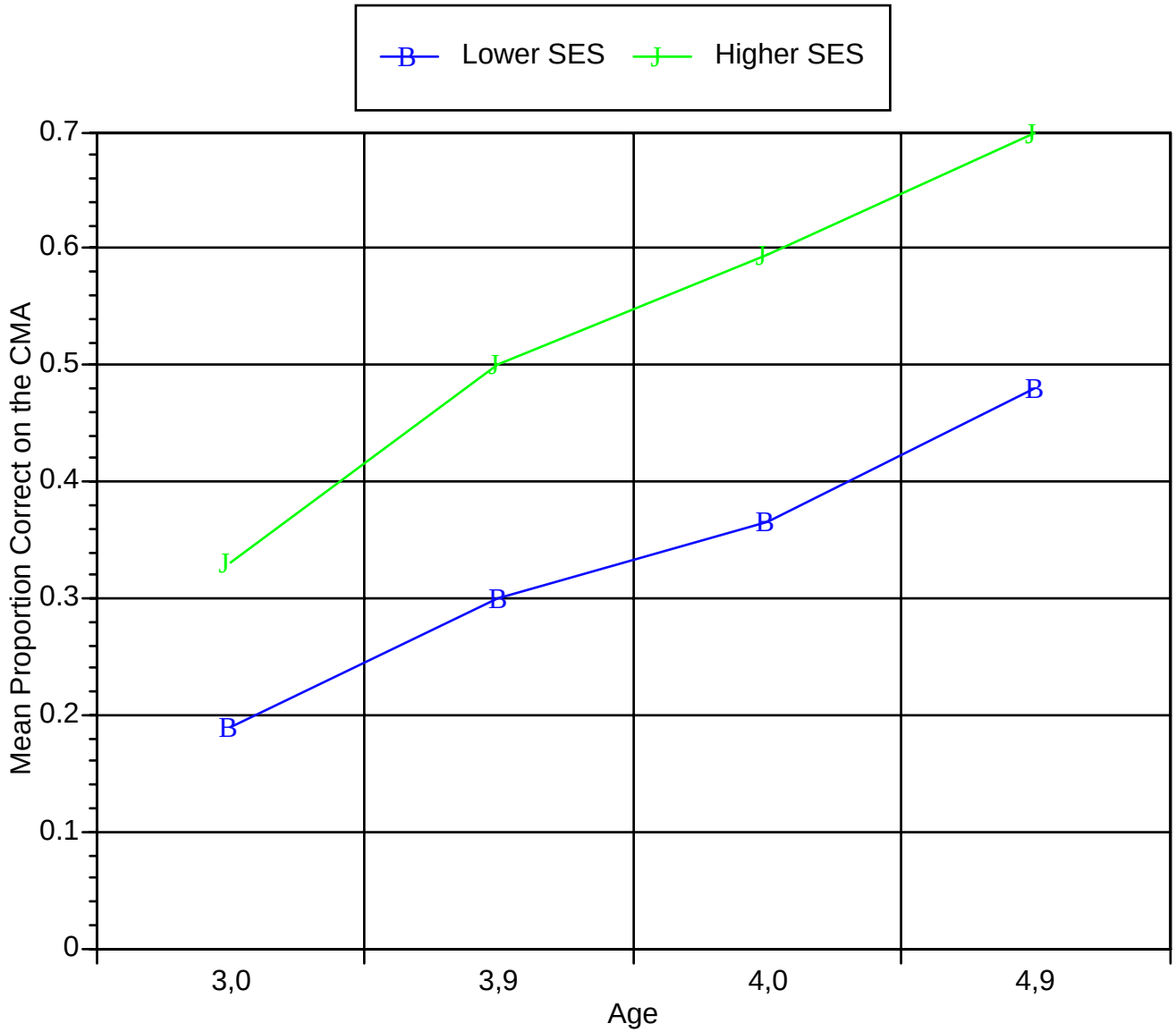
Design

3 Nations (China, Japan, United States)
2 Levels of socioeconomic status (lower SES; higher SES)

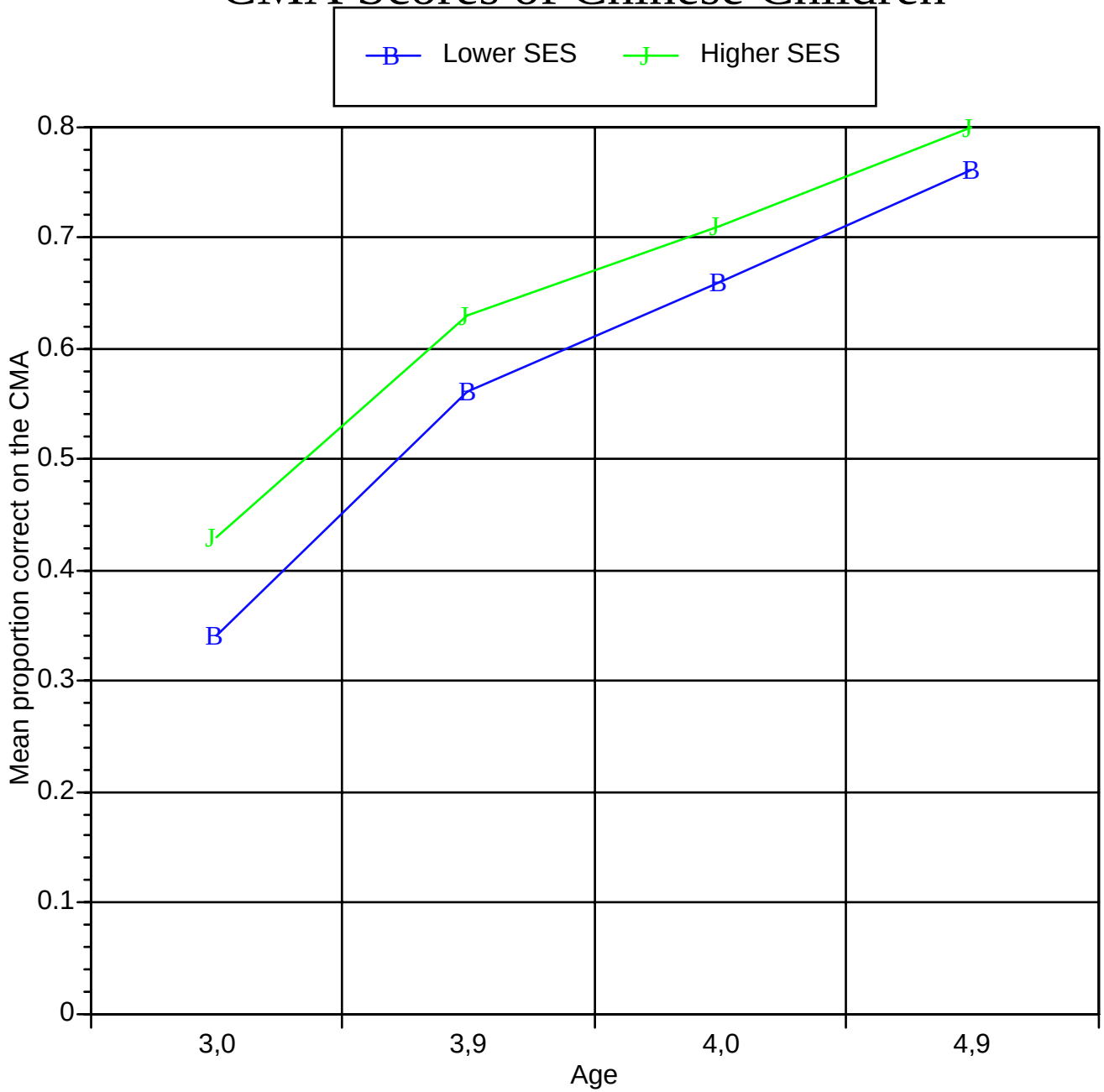
Successive-cohort, longitudinal design
300 children in Cohort 1 (age 3,0 at beginning of study)
300 children in Cohort 2 (age 4,0 at beginning of study)

Children were assessed twice per year for two years

CMA Scores of American Children



CMA Scores of Chinese Children



A Longitudinal Study of the Effects of a Pre-Kindergarten Mathematics Curriculum on Low-Income Children's Mathematical Knowledge

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Rationale

• Research has established that SES differences in mathematics achievement during the elementary school years have roots in early childhood

• The SES-related gap in early mathematical knowledge is present by age 3 years and widens during early childhood (Starkey & Klein, in 2007)

- Children from low-income families, in comparison with their middle-class peers, receive less support for mathematical development in their home and preschool environments (Starkey & Klein, 2007)

- The Head Start Impact Study found that mathematical knowledge at the end of preschool was equivalent in intervention (Head Start) and control children (ACF, 2005)

Project Objectives

- Implement a pre-kindergarten mathematics curriculum in preschools serving low-income children in California and New York

- Study implementation across varied contexts:
  Head Start and state-funded preschools

- Evaluate short-term and long-term effects of the curriculum on children's early mathematical development and learning environments

Components of the Intervention

Pre-K Mathematics Curriculum **by Klein & Starkey**

- 29 developmentally sensitive, small-group, activities with concrete manipulatives for classroom use
- 18 activities for parent-child dyads (in English and Spanish) for home use

Supplementary mathematics software

- 27 computer-based activities, for classroom use, from ***DLM Express*** **by Clements & Sarama**


El alfabeto

Design

- 40 classrooms: 10 Head Start, 10 state-funded preschools per state (California and New York)
- Public random assignment of classrooms to intervention or control conditions within each type of preschool program
- Random selection of 8 children per classroom
- Research sample:

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

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

Research Measures

- **Fidelity of Curriculum Implementation**

- **Early Mathematics Classroom Observation (EMCO)** of teachers' mathematics practices

- **Parent Survey** of mathematics support at home

- **Child Math Assessment (CMA)** of children's mathematical development

Professional Development of Intervention Teachers

Year 1:

- Workshops (4 days Fall and 4 days Winter)
- On-site facilitation (formative evaluation during classroom visits every 2 weeks)

Year 2:

- Refresher workshops (2 days Fall and 2 days Winter)
- On-site facilitation (formative evaluation during classroom visits every month)

Fidelity Measures

- **Fidelity of implementation of small-group activities**

  Dimensions of small-group fidelity:

  1. Adherence to schedule in curriculum plan
  2. Preparation of materials
  3. Delivery of the basic activity
  4. Developmental adjustments of basic activity
  5. Written assessment of children during activity

Fidelity Scores Across 3 Years of Implementation

	California		New York	
Overall Fidelity Score:	Head	State	Head	State
	Start	Pre-K	Start	Pre-K
Implementation Year 1	.91	.92	.89	.83
Implementation Year 2	.93	.95	.97	.97
Implementation Year 3 - Sustainability	.97	.98	.78	.93
Implementation Year 3 - Sustainability				
	Head	State	Head	State
Dimension of Fidelity	Start	Pre-K	Start	Pre-K
The teacher stays on schedule	1.00	.98	.72	.97
Is prepared	.93	1.00	.87	.97
Delivers the basic activity	.99	.98	.89	.97
Makes developmental adjustments	.99	.95	.80	.90
Assesses all children	.97	.99	.63	.84

Table 3

Receipt and Use of Home Mathematics Activities by Parents

		Every 1-2 weeks	Monthly	A few times	Never
How often were activities sent to you (by your childÕs teacher)?	California	.81	.16	.02	.02
	New York	.83	.07	.07	.03
		Almost always	Half of the time	A few times	Never
How often did you use them?	California	.68	.16	.11	.05
	New York	.93	.07	.00	.00

Principal Hypotheses

- More math support will be provided by intervention teachers than by control teachers

- More extensive mathematical knowledge will develop in intervention children than in control children

Effects of the Intervention on Classroom Mathematics Practices

Early Childhood Environment Ratings Scales (ECERS-R)

- Administered in fall and spring

Research Questions: Were intervention and control classrooms initially similar? Did the intervention impact the classroom environment as measured by ECERS-R?

- Comparison of intervention and control classrooms revealed no significant differences at baseline (fall)
- Gain scores on language subscale were higher in intervention classrooms than in control

	Intervention		Control	
Subscale	Fall	Spring	Fall	Spring
Program Structure	3.7	4.1	4.0	3.9
Activities	3.2	3.4	3.6	3.5
Personal Care	2.8	2.7	2.7	2.9
Interaction	3.9	4.6	4.1	4.2
Language	4.0	4.5	4.5	3.9
Space/Furnishings	3.4	3.7	3.6	3.4
Overall score	3.4	3.7	3.7	3.6

Research Question: Was ECERS-R able to detect the intervention?

- Math/Number item: No difference was found between intervention and control classrooms
- Use of TV, Video and/or Computers item: A significant difference was found between intervention and control classrooms, $p<.02$

Effects of the Intervention on Classroom Mathematics Practices

- **EMCO** instrument distinguishes between two types of classroom math activities: Focal and Embedded

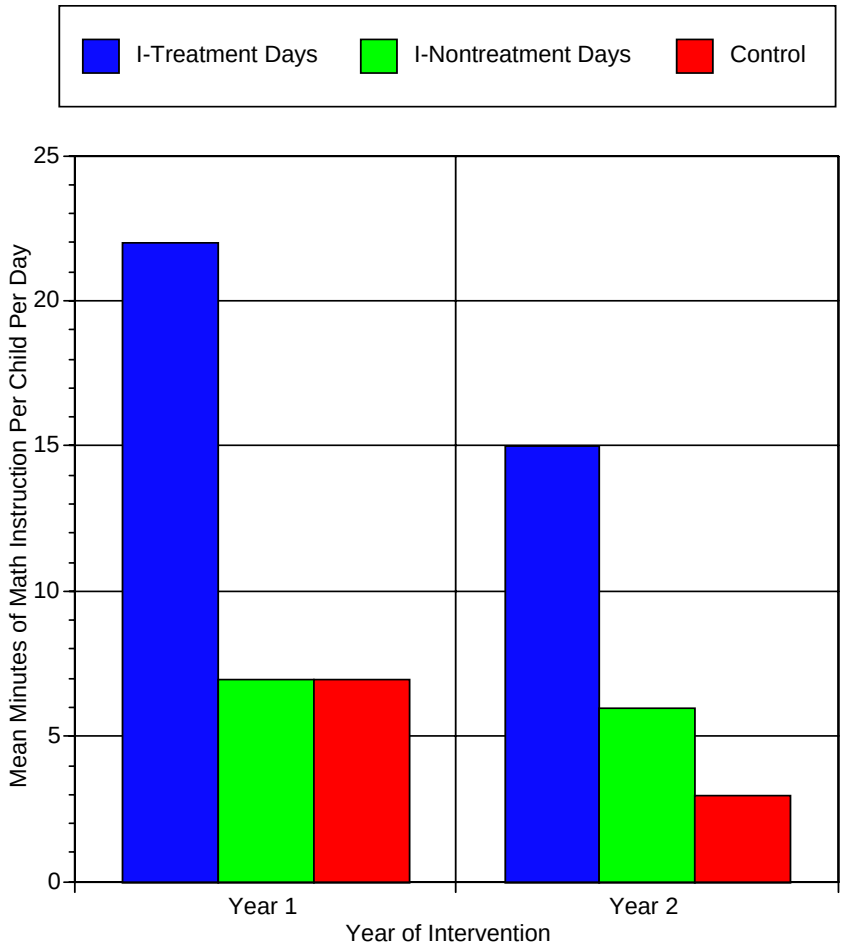
Hypothesis: The curricular intervention will increase the amount of **focal** math provided by intervention teachers

Focal Math Findings:

•Significantly more minutes of focal math per child were provided by intervention teachers than by control teachers, $p<.0001$ (Cohort 1) and $p<.0001$ (Cohort 2)

•Significantly more minutes of focal math per child were provided by intervention teachers on small-group treatment days than on no-small-group treatment days, $p<.02$ (Cohort 1) and $p<.001$ (Cohort 2)

Amount of focal math provided by intervention and control teachers



Conclusion:

- The findings from both cohorts supported the hypothesis that the curricular intervention would increase the amount of focal math provided by intervention teachers as compared to control teachers.

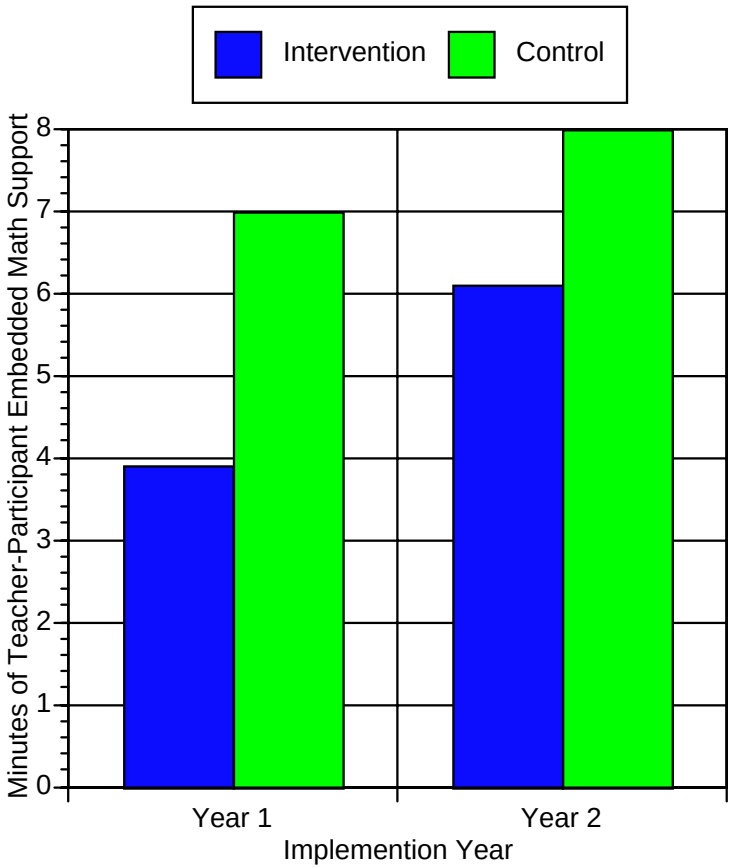
Research Question:
Does the curricular intervention have an impact on the amount of **embedded** math provided by intervention teachers?

Findings:

- Significantly fewer minutes of embedded math per child were provided by intervention teachers than by control teachers in year 1, $p<.05$

- Similar amounts of embedded math per child were provided by intervention and control teachers in year 2, *ns*

Amount of embedded math provided by intervention and control teachers



Research Question: Does the number of minutes of focal or embedded math that teachers provide predict change in children's mathematical knowledge?

Findings:

- Amount of **focal** math significantly predicted change in intervention children's CMA scores, $F(1,17)=15.32$, $p<.0001$ (Cohort 1); $F(1, 17)=6.36$, $p<.025$ (Cohort 2)

- Amount of embedded math did not significantly predict change in intervention or control children's CMA scores, *ns*.

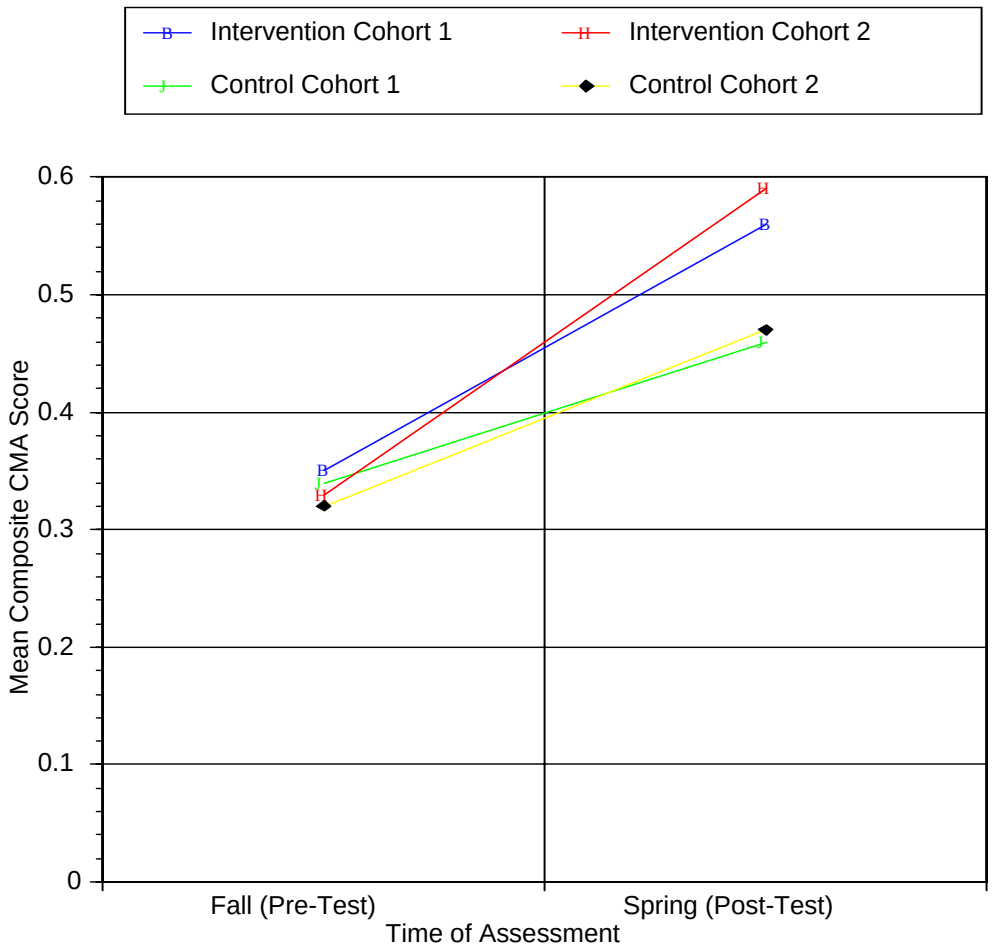
Effects of the Intervention on Children's Mathematical Development

Hypothesis: The curricular intervention will have a positive impact on children's mathematical development

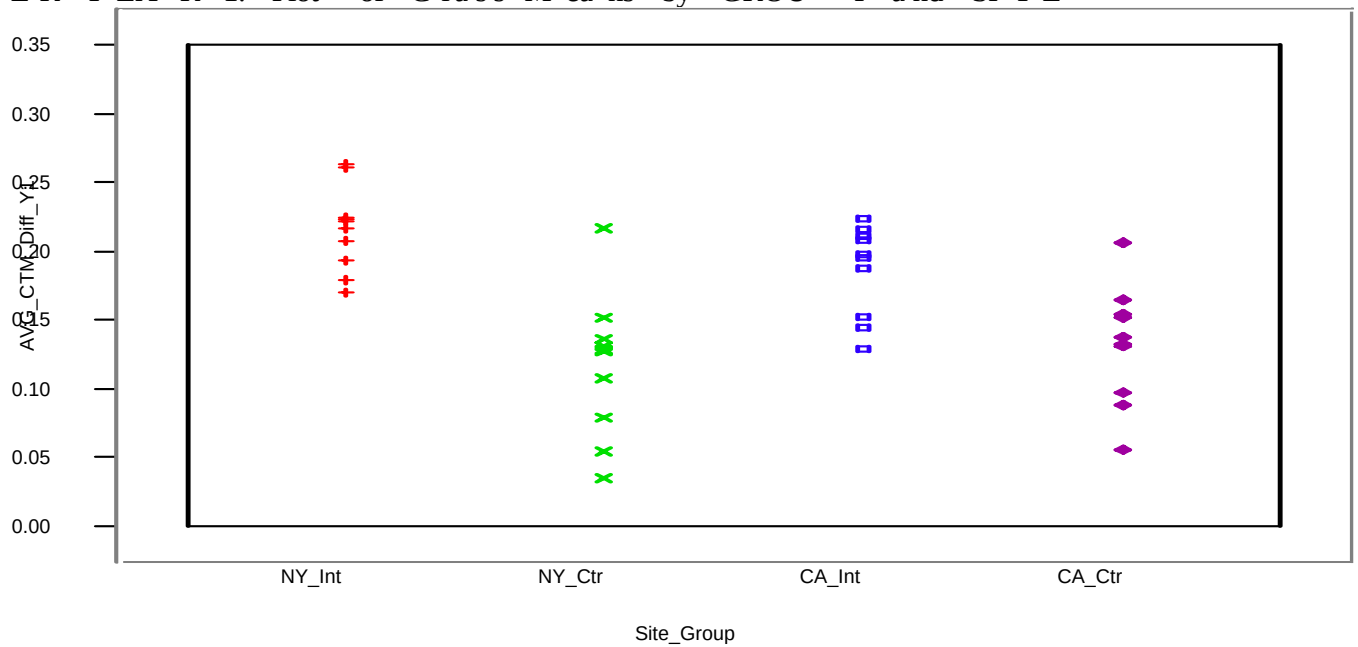
Findings:

- Intervention and control groups did not differ on their CMA scores at pre-test, but they did differ significantly at post- test, $p<.0001$ (Cohort 1) and $p<.0001$(Cohort 2)

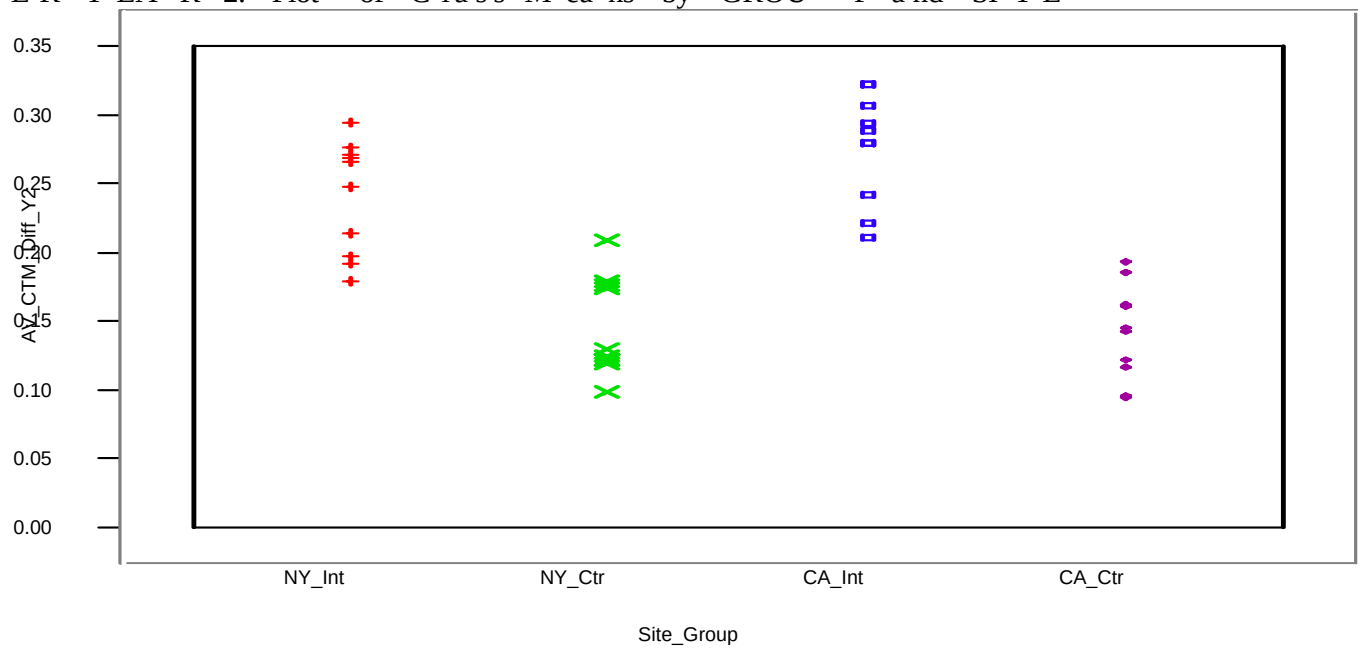
CMA scores in the fall and spring for intervention and control groups



PCER YEAR 1: Plot of Class Means by GROUP and SITE



PCER YEAR 2: Plot of Class Means by GROUP and SITE



•**Cohort 1 effect size** (Cohen's *d*)=**.58**(What Works Clearinghouse's calculation), indicating that the math curriculum produced a 62% increase in math knowledge of intervention children relative to that of control children
•**Cohort 2 effect size=.70**(What Works Clearinghouse's calculation), a 79% increase for intervention children relative to control children

Conclusion:
•The findings from both cohorts support the principal hypothesis of a causal relationship between the curricular intervention and children's mathematical development.

General Conclusions:

- Preschool programs cannot rely on ECERS-R as a measure of the quality of classroom support for mathematical development. Instead, instruments such as EMCO that directly measure teachers' mathematics instructional practices will provide more useful information.

- Our curricular intervention, when implemented with fidelity, can enhance low-income children's mathematical knowledge and promote readiness for school mathematics