Identifying Aspects of Pre-Kindergarten Classrooms that Benefit Mathematics Achievement

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Introduction

With calls for "universal pre-k" and arguments that pre-k experiences are essential for children from low-income families[1], it is critical to identify specific, and potentially malleable, aspects of pre-k classrooms that are associated with greater immediate and sustained gains for at-risk children.

Prior evidence suggests associations between pre-k quality and children's concurrent and future achievement[2], including environments with:

- richness in spoken and written language experiences
- contingent and focused attention on the child
- abundant child exploration
- constructive models of adult language, reading, and learning

However, much of the work examining the impacts of pre-k quality has involved global ratings of the classroom rather than counts of specific and observable aspects of the classroom's practices and behaviors of both teachers and their students[3].

Moreover, little is known about how specific pre-k experiences relate to children's early mathematics knowledge, which has been shown to be a potent predictor of later academic achievement[4].

Lastly, to help ensure that pre-k benefits all children, we need to know if aspects of classroom quality are universal to all children or if they differentially impact gains based on children's initial skills and knowledge.

Current Study

The goal of current study was to:

- Identify specific aspects about the pre-k classroom that predict children's gains on a mathematics measures over the pre-k year.
- Explore if the relations between pre-k classroom predictors and mathematics gains are differentiated by children's entering mathematics knowledge.

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Method

Participants

- 26 full-day (7 hour) pre-k classrooms, across 3 schools, taught by licensed teachers
- 407 children
  - 18% Caucasian, 66% African American, 14% Hispanic, and 2% Asian American
  - 51% female, 12% ELL, 75% FRPL and 12% IEP.
  - Average age at pretest was 55.0 months (*SD* = 3.7).

Mathematic Outcomes

- Woodcock-Johnson III Applied Problems (AP) and Quantitative Concepts (QC) Subtests[5]
- Tools for Early Assessment in Math (TEAM)[6]

Classroom Observations

Three pre-k observations using 1) a timestamped record[7] and 2) a snapshot system for capturing teacher's and children's behaviors[8] across a day-long visit.

Overall Classroom Structure:

- Minutes of the day in Instruction (Whole Group, Small Group, and Centers)
- Minutes of the Day in Non-Instructional Transitions

Teacher Behaviors:

- Quality of Instruction: Inferential questioning, sustained topic focus.
- Emotional Climate: Approving/ disapproving, emotional tone

Children's Behaviors:

- Mathematics Focus: Attending to a learning-related mathematics activity
- Social Learning : associative or cooperative learning interactions

Analytic Approach

Main effects on residualized gains (posttest controlling for pretest) were estimated using multilevel regression. Models were first conducted separately for each focal classroom predictors and mathematics outcome:

$$Posttest_{ij} = \gamma_{00} + \gamma_{01}(ClassroomPredictor_i) + \gamma_{10}(Prestet_{ij}) + \gamma_{20}(Covar_{ij}) + \mu_{0j} + \varepsilon_{ij}$$

Moderation by children's entering mathematics skills was estimated by testing the interactions between the classroom predictor and children's pretest scores.

$$Posttest_{ij} = \gamma_{00} + \gamma_{01}(ClassroomPredictor_i) + \gamma_{10}(Prestet_{ij}) + \gamma_{20}(Covar_{ij}) + \gamma_{11}(ClassroomPredictor_i * Prestet_{ij}) + \mu_{0j} + \varepsilon_{ij}$$

Results

Table 1. Standardized regression coefficients (standard errors) for test of main effects (top panel) and moderation of tested effects by children's pretest scores (bottom panel).

Parameter	AP	QC	TEAM
Main Effects			
Time in Instruction	.043 (.043)	.031 (.037)	**.105 (.041)***
Time in Transition	−.013 (.044)	**−.074 (.035)***	−.062 (.045)
Quality of Instruction	**.078 (.040)†**	−.019 (.037)	.057 (.044)
Emotional Climate	**.094 (.041)***	.005 (.038)	**.074 (.044)†**
Mathematics Focus (child)	**.081 (.041)†**	.037 (.038)	−.039 (.046)
Social Learning Interactions	**.086 (.040)***	**.066 (.036)†**	**.087 (.043)***
Moderation Effect by Pretest			
Time in Instruction	.050 (.037)	−.023 (.034)	−.016 (.039)
Time in Transition	**−.063 (.037)†**	−.017 (.033)	.011 (.040)
Quality of Instruction	**−.072 (.033)***	−.040 (.032)	.001 (.035)
Emotional Climate	−.031 (.038)	**−.066 (.032)***	−.041 (.038)
Mathematics Focus (child)	−.010 (.040)	**−.052 (.032)†**	−.039 (.039)
Social Learning Interactions	.001 (.037)	−.001 (.034)	.003 (.039)

Note. Positive interaction coefficients indicate that the main effect is more pronounced for children who began the school year with higher scores, while negative interaction coefficients indicate that the main effect was more pronounced for children who began the school year with lower scores. *$p < .05$. †$p < .10$

As seen in Table 1, children from classrooms with larger amounts of instruction tended to have larger gains on the TEAM, while children from classrooms with smaller amounts of transition tended to have larger gains of the QC subtest. Effect size estimates associated with these main effects are presented in Table 2. Time in transitions was also found to be detrimental to AP scores for children who began the year with lower scores on the test (bottom panel Table 1).

Table 2. Standardized mean difference effect sizes reflecting a 2 *SD* improvement for each predictor.

Parameter	AP	QC	TEAM
Time in Instruction	0.09	0.06	**0.21**
Time in Transition	−0.03	**−0.15**	−0.13
Quality of Instruction	**0.16**	−0.04	0.12
Emotional Climate	**0.19**	0.01	**0.15**
Mathematics Focus	**0.17**	0.08	−0.08
Social Learning Interactions	**0.18**	**0.14**	**0.18**

Note. Estimates indicate impact of being in a classroom with high (+1 SD) verses low (-1 SD) occurrences of each predictor.

Quality of instruction was found to be related to positive gains on the AP subtest, an effect that was particularly important for children who began the year with lower scores.

The emotional climate of the classroom was related to universal gains on both the AP subtest and the TEAM, yet for gains on the QC subtest, emotional climate was particularly important for children who began the year with lower QC scores.

The proportion of sweeps children were engaged in a mathematics focus was positively related to gains on the AP subtest and for children who began the year with lower TEAM scores.

Lastly, the proportion of sweeps children were engaged in social learning interactions was universally related to gains on the AP and QC subtests and the TEAM. The effect sizes for social learning interactions presented in Table 2 corresponds to a 4%, or 2 *SD*, increase in the number of social learning sweeps.

Discussion

Although correlational, these results suggest that specific aspects of pre-k classrooms have an effect on children's mathematics gains in pre-k, especially with regard to the classroom's emotional climate and the occurrence of social learning interactions.

Results also indicate that the impacts of the classroom predictors examined tended to be more pronounced for children who began school with lower mathematics skills, suggesting that the effects of a high quality classroom might be strongest for children who are most at need.

Children's gains on the mathematics were not highly correlated (*r*s < .24) and the relations between gains and classroom predictors were not consistent suggesting that different aspects of the classroom differentially effect the types of mathematic knowledge and skills being learned.

Policy and Practice Implications

If the benefits of pre-k for at risk children are to be realized, it is essential that we not only provide pre-k, but ensure that pre-k is high-quality and effective at optimizing children's outcomes and success.

Identification of specific aspects of the pre-k classroom that are observable, potentially malleable, and related to outcomes is just the first step in an iterative process to help make classrooms more effective learning environments.

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