Preschool Children's Math Skills & Executive Functions: Classroom Quality Makes a Difference

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Background

- Executive functions (EF) are referred to as a set of cognitive skills, including short-term and working memory, attention, and behavior shifting (Diamond, 2013)
- EF plays a significant role in promoting children's lifelong learning and better academic outcomes, including math skills (Blair, 2007).
- Studies showed that preschoolers with higher levels of EF skills perform better on math tasks (Willoughby, Kupersmudt & Voegler-Lee, 2012 & Fuhs et al., 2014)
- Current study explored patterns of change in children's EF and math skills, while receiving education for over two semesters at a high-quality early childhood education program–Educare (Educare, 2021).

Research Objectives

1. To identify patterns in children's development of EF and math skills over a year of enrollment in a high-quality early childhood education program.

2. To examine patterns of change in EF and math skills (a) within and (b) between different group profiles over two semesters (Fall 2017 and Spring 2018).

Data Collection & Research Settings

This exploratory cross-sectional study used a secondary dataset collected during Fall 2017 and Spring 2018 from two Educare sites and across four schools.

- It offers center-based services for children ages 0-5-years.
- There are currently 25 Educare schools in the United States.

- Educare is an enhanced Early Head Start (EHS) and Head Start program model.
- It aims to provide high quality care and education for children growing up in poverty.

Acknowledgement

Participants

- N= 156 preschoolers
- **Mean Age.** Fall 2017= 45 months; Spring 2018= 52.1 months;
- **Gender.** 78 boys and 78 girls; **Primary Language.** Spanish 20; English 120.
- **Educare Sites.** Site 1, N=45; Site 2, N=111.

Measures

Variables. Data for children's math skills and EF skills were collected at both time points (Fall 2017 and Spring 2018). Classroom environment was assessed only at Fall 2017.
1. Preschooler's Woodcock-Johnson IV (Applied Problems) was used to measure math skills (Schrank et al., 2014).
2. Minnesota Executive Function Scale (MEFS) was used to to assess children's (above 2-years-old) EF skills (MEFS, 2017).
3. Classroom Assessment Scoring System (CLASS)-PreK was used to measure the quality of the classroom environment (Pianta et al., 2008)

Data Analysis

- Hierarchical agglomerative analysis (following Ward's method) was conducted to understand the appropriate cluster fit of standardized mean for MEFS and WJ scores across Fall and Spring semesters using SPSS v25.
- The intracluster correlation coefficient values for three-level clustering (child< classroom< school) were non-significant for both WJ and MEFS scores; hence, clustering was not incorporated in the analyses.
- Paired sample t-tests were conducted to determine change in WJ and MEFS scores over two semesters within each of the exploratory groups and between Spanish- and English-speaking group of children.
- One-way ANOVA with Bonferroni's correction were conducted to understand between group differences for each variables.

Figure 1. Graphical Representations of Mean Differences for z-score of MEFS and WJ Scores for Each Group over Two Semesters
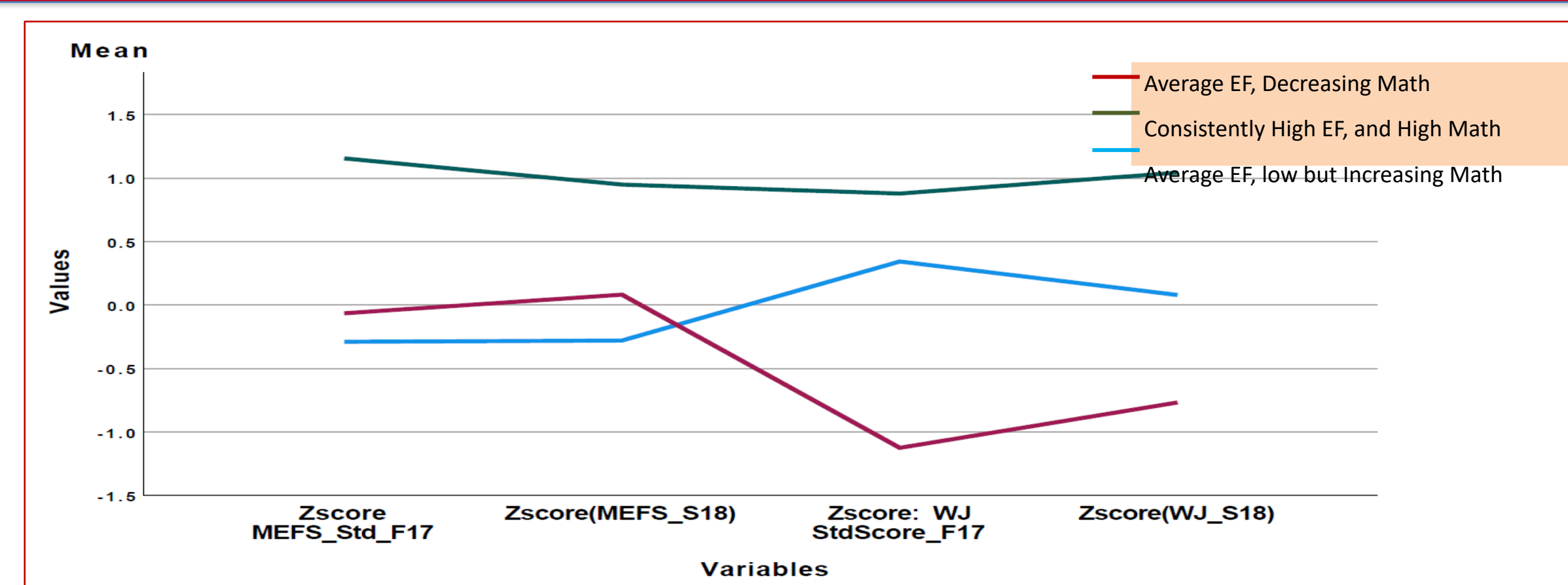

Table 1. Change in Executive Function and Math Scores from Fall to Spring Semesters Between and Within Groups (N=156)

Groups (N)	Woodcock-Johnson IV		Minnesota Executive Function Scale	
Exploratory Groups[a] (N)	**Average change in score from Fall to Spring semesters within each exploratory groups[b]**			
Average EF, Decreasing Math (85)	-4.3(±10.15)*		1.6(±10.26)	
High EF, High Math (27)	1.9(±9.73)		.3(±7.71)	
Average EF, Increasing Math (44)	5.8(±16.08) *		2.8(±8.76) *	
Comparison of average score received each semester between two language groups[b] (N=140)				
Primary Language Groups	**Fall 2017**	**Spring 2018**	**Fall 2017**	**Spring 2018**
English (120)	88.5(±15)**	88.8(±14.3)**	98(±6.3)	100(±8)
Spanish (20)	74.3(±15.4)**	74.4 (±15)**	97.9(±6.3)	96.9(±10.6)

[a]Exploratory groups were identified based on the patterns of children's executive functions and math skills development over Fall and Spring semesters. [b]Significance tests were conducted using paired sample t-tests in IBM SPSS® V 25. *p<.05, ***p<.001; Significant p-values after Benjamini-Hochberg correction (with false-discovery rate of 5%) for multiple tests.

Results

Three exploratory groups were found: (1) Average EF, decreasing math, (2) Consistently high EF, high math; (3) Average EF, low but increasing math **(Figure 1)**.

1. **Classroom environment makes a difference.** Only *Average EF, low but increasing math* group showed significant positive changes in both areas after two semesters. This group also had significantly higher quality rating for their classroom environment scores than *Average EF, decreasing math* group. MEFS scores in the Spring 2018 were significantly positively associated with higher CLASS: Emotional Support (B_{std}.= .23; p =0.03) and higher WJ score in the Fall 2017 (B_{std}= .55; p<.001).

2. **Primary language is important to consider during children's skill assessment.** Current study found that Spanish speaking children had significantly lower WJ scores at both semesters than English speaking children **(Table 1)**. However, MEFS scores were not significantly different. This urges the need to utilize tools available in a child's dominant language to assess his skills by researchers and program evaluators.

Discussion

1. Classroom environment support has substantial contribution towards achieving school readiness and reducing the achievement gap among the children who are at-risk.
2. Primary language is important to consider during children's skill assessment. Children are asked to follow a certain set of directions, complete cognitive tasks, and respond to questions in pre-defined ways during standardized skill assessments. However, if children are from different cultures and are non-English speakers, they may not be familiar with the interactions and investigators' style of asking questions. Consequently, children may not respond in the expected ways, leading to underestimating a child's skills.

Limitations

1. Classroom quality assessments were conducted only at one time point.
2. Current study examines development pattern for only two semesters, which is a short duration for understanding the nature of EF and math skill development.
3. The results may not be generalizable to children outside of Educare program.
4. Parents' demographic characteristics were not included owing to high percentage of missing values.

Implications

1. Programs aspiring to reduce school achievement gaps and ensure equity in early childhood education can track children's skill development more closely to maintain children's growth by offering necessary stimulation in classroom.
2. Assessing children's skills using primary language and with culturally sensitive assessments may provide some leverages to the researchers and programs to measure children's actual development.