Abstract Title Page

Title: **The efficacy of an intervention synthesizing scaffolding designed to promote self-regulation with an early mathematics curriculum: Effects on executive function**

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Abstract Body

Background / Context:

Early childhood education is replete with debates about the role of content-focused, or "academic" curricula and more global goals and approaches. There is little research on the issue of whether such approaches stand in opposition, competing for time in the early childhood classroom, or whether they can be synergistically combined, each to the benefit of their own as well as the other's goals. We conducted an efficacy trial of one approach to such a synthesis, by evaluating the integration of two empirically-tested interventions, identifying mediators and moderators of effects, with children from low-income families.

Purpose and Research Question:

Our goal is twofold. First, we wished to produce a theoretically-based approach to this synthesis. Child-centered programs have a long history. However, concerns about children's achievement, and the pressure of content-specific standards, have set up a perceived conflict, in which educators believe they are being asked to abandon child-centered approaches, or, at least, to compromise and squeeze in, as one teacher put it, "Literacy on Monday-Wednesday-Friday, math on Tuesday-Thursday, and socioemotional during our shortened play periods." We hope that our approach, *if* shown to be efficacious, will serve as a model that others can use to successfully and *synergistically* combine these strategies so the whole is *more* than the sum of its integrated, not conflicting, parts.

Second, and more importantly, we are producing a rigorous evaluation of the efficacy of this approach. The research is also designed to answer *which components* are responsible for its effects, and *why* these components led to the outcomes. Thus, we are empirically testing our hypotheses, which will provide an evidentiary basis for researchers and practitioners. This report is the first (and only partial) description of our findings.

The two interventions we synthesized are both theoretically and empirically grounded. The NSF-supported *Building Blocks* (BB*)* project produced a research-based math curriculum that addresses geometric and spatial ideas and skills and quantitative ideas and skills (mathematical building blocks). The approach of BB is finding the math in, and developing math from, children's activity (including children's building blocks). Funded by the NSF and IES, three RCT evaluations have documented BB's positive effects on young children's math achievement (e.g., Clements & Sarama, 2007, 2008). Increasing math proficiency is significant. The role of mathematics in young children's development is often taken by many as important but secondary to academic areas such as language and literacy. Rigorous studies show mathematics to be of primary importance. Using each of six longitudinal data sets, the strongest predictors of later achievement are early *math* skills, followed by reading skills and then attention (Duncan et al., 2007).

Also documented, albeit not as extensively, are the facilitative effects of scaffolding designed to promote self-regulation (SSR) through make-believe play, an activity at the core of the child-centered approach. Self-regulation is important in facilitating learning and retention, especially for children at risk for later school failure. When explicit content-oriented instruction is mistakenly implemented as (only) teacher-led activities at the expense of engaging children in

activities of their choice, children practice being "teacher-regulated" and are not given an opportunity to develop self-regulated behaviors which affects their ability to later engage in learning behaviors of their own accord. Our belief is that the dichotomy between explicit instruction and child-centered approach is a false one and that it is possible to design a program that would combine an explicit focus on content with equally explicit focus on promoting self-regulatory behaviors. The use of specific pedagogical strategies that optimize make-believe play have been proven successful in improving young children's self-regulation competencies and academic achievement (e.g., Bodrova & Leong, 2005). Used as a part of a comprehensive preschool curriculum as well as a part of an early literacy intervention, these strategies have been proven successful in improving young children's self-regulation and academic achievement (Barnett, Yarosz, Thomas, & Hornbeck, 2006; Bodrova & Leong, 2001; Bodrova, Leong, Norford, & Paynter, 2003; Diamond, Barnett, Thomas, & Munro, 2007).

There is empirical support for the notion that curricula designed to improve self-regulation skills and enhance early academic abilities are most effective in helping children succeed in school (e.g., Blair & Razza, 2007). Further, young children's self-regulation scores correlate with both concurrent and future mathematics achievement scores (even more strongly than IQ). However, the evidence of the relationship between self-regulation and math achievement has been collected primarily on older children and using general measures (e.g., executive function measures against math tests). We need research that investigates the foundation of these abilities and analyzes cause and effect relationships among specific components of these abilities.

The research question we address is: What are the immediate effects of the synthesized intervention, as implemented under diverse conditions, on children's self-regulation?

Thus, we focus on a single outcome domain and then explore factors that may have influenced it, using a three-armed cluster randomized trial and hierarchical linear models (HLM) explained in more detail below. We first analyze whether any of the 3 conditions resulted in a statistically significantly different level of executive function skills and then we will present our empirically-based hypotheses about why such differences might have occurred.

Setting:

The performance site for this study includes 4-year-old classrooms in public preschools and child development centers in three school districts in San Diego County, California.

Population / Participants / Subjects:

Our analytic sample consists of 826 children in 84, 4-year-old classrooms across the three districts. A large proportion of the classrooms are multi-racial/multi-ethnic, with average demographics across the three districts showing Hispanic children being the majority minority at on average 39%, Asian Pacific Islander 18%, African-American 11%, and non-Hispanic White 31%. On average, 27% of the students are English Language Learners (with roughly 20% having Spanish as the primary language).

Intervention / Program / Practice:

The *Scaffolding Self-regulation* approach combines current research on the development of self-regulation and executive function with Lev Vygotsky's cultural-historical theory of child development to design optimal ways to support the development of self-regulation in young children (Bodrova & Leong, 2007a). The defining feature of this approach is its emphasis on promoting mature, intentional dramatic play as the primary social context allowing children to practice self-regulatory behaviors (Bodrova & Leong, 2007b). Scaffolding self-regulation in non-play activities is accomplished by re-designing the social context for these activities as well as by teaching children to use specific "tools" that assist them in taking control over their behaviors (Bodrova & Leong, 2007c).

Several studies indicate that scaffolding that promotes self-regulation improves mathematics learning. Indeed, in one sample of classrooms using strategies for SSR children did better on math tests without changes in the content of math curriculum (curriculum was focused on literacy and self-regulation) compared to High Scope classrooms (Barnett et al., 2006). We implemented a theoretically-grounded synthesis of the Building Blocks preschool mathematics curriculum (BB) and SSR as the main intervention of interest.

Research Design:

The proposed paper utilizes a three-armed cluster randomized control trial in which classrooms in study schools were randomly assigned to the three study conditions. Random assignment was conducted separately for schools/centers with only one participating classroom (group A) and those with two classrooms (group B). Schools/classrooms in group A were placed into five randomization blocks such that each block consisted of all half-day or full-day PreK classrooms in a given study district.[1] Within each block, schools were then sorted with respect to prior math achievement, % free/reduced price lunch eligible, and %ELL. Schools were randomly assigned to the three conditions three at a time starting at a randomly chosen point in the sorted list and then moving to the top of the list. This is an application of the systematic circular sampling scheme (Lahiri, 1951), which was utilized to ensure three experimental groups that are balanced geographically and in terms of the length o f the PreK program and key background characteristics of the schools/centers. For group B schools, random assignment was conducted within each school, where the two conditions classrooms were assigned were determined randomly.

Data Collection and Analysis:

Collection of data in second year of intervention used four measures— the HTKS (Ponitz, McClelland et al., 2009; measures inhibitory control and working memory), Pencil Tap (e.g., Diamond & Taylor, 1996; measures inhibitory control), Forward & Backward Digit Span

[1] The five randomization blocks are: San Diego full-day classrooms, San Diego half- day classrooms, Poway full-day classrooms, Poway half-day classrooms, and South Bay full-day classrooms.

(Wechsler, 1986; Gathercole & Pickering, 2000; measure general attention and verbal working memory, respectively).

For the two fall 2010 (baseline) measures and four spring 2011 (post-test) measures, we conducted three pair-wise comparisons between the three groups (BB vs. Control, BBSR vs. Control, and BB vs. BBSR) as well as a joint test of the statistical difference of the measures across the three groups. The BB vs. Control and BBSR vs. Control differences are referred to as the impact of the BB and BBSR conditions, respectively while the BB vs. BBSR difference is used to assess the effectiveness of the self regulation portion of the synthesized intervention. These pair-wise differences were estimated using a pooled two-level HLM (level1: students and level 2: classrooms or teachers) that takes into account the clustering of students within teachers/classrooms. The HLM specification included two indicator variables for the BB and BBSR groups (control group being the reference group) as the primary predictors and covariates such as age and baseline measure of the outcome when post-test measures are analyzed. The model also included indicator variables (fixed effects) for the randomization blocks. Following Raudenbush, Spybrook, and Martinez (2007) and Schochet (2008), we modeled these blocks as fixed because we will not be seeking to generalize the study results beyond our sample. Finally, the joint significance test across the three groups is conducted using the estimated pair-wise differences and a t-test.

Findings / Results:

Results of the analyses described above are presented in Exhibit 1 for the two baseline measures and in Exhibit 2 for the four post-test measures. These exhibits include the mean scores in each group (regression adjusted for BB and BBSR and unadjusted for Control, representing the true counterfactual); estimated pair-wise differences or impacts in the original unit of the measures as well as in effect sizes that were calculated using the standard deviation of each measure in Control group; and p-values of the pair-wise differences and the joint significance test. Comparing the group means in Exhibits 1 and 2 suggest that the pencil tapping and HTKS scores increased between fall and spring measurements. Exhibit 1 shows that while none of the estimated pair-wise differences between the study conditions on the pencil tapping score were statistically significant at the usual p=0.05 level, the BB vs. Control and BB vs. BBSR differences on the HTKS score were statistically significant and somewhat sizeable (0.24 and 0.34 standard deviations, respectively). Exhibit 2 indicates that all but one of post-program differences analyzed for the four measures were small statistically insignificant. Only the BB vs. Control difference for the backward digit score exceeded 0.2 of a standard deviation, but its p-value was 0.14.

Conclusions:

Adding the SR component to the BB curriculum did not produce the hypothesized impact on children's executive function skills. On the contrary, there is a *very slight* probability that the BB curriculum by itself may have enhanced children's verbal working memory skills. The paper discusses possible explanations for the failure of the synthesized approach to engender development of self-regulation skills.

Appendices

Appendix A. References

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Exhibit 1. Results from analyses of Fall 2010 Measures (Pre-test)

Measure	Group Means			Estimated Differences			Effect Sizes of Differences			P-Values for Differences			
	BB (Adjusted)	BBSR (Adjusted)	Control (Unadjusted)	BB vs. Control	BBSR vs. Control	BB vs. BBRS	BB vs. Control	BBSR vs. Control	BB vs. BBRS	BB vs. Control	BBSR vs. Control	BB vs. BBSR	Joint Test
Pencil Score	7.157	6.080	6.251	0.906	-0.171	1.077	0.144	-0.027	0.171	0.266	0.825	0.184	0.370
HTKS Score	12.472	8.270	9.446	3.026	-1.176	4.202	0.244	-0.095	0.339	0.045	0.406	0.005	0.017

Exhibit 2. Results from analyses of Spring 2011 Measures (Post-test)

Measure	Group Means			Estimated Differences			Effect Sizes of Differences			P-Values for Differences			
	BB (Adjusted)	BBSR (Adjusted)	Control (Unadjusted)	BB vs. Control	BBSR vs. Control	BB vs. BBRS	BB vs. Control	BBSR vs. Control	BB vs. BBRS	BB vs. Control	BBSR vs. Control	BB vs. BBSR	Joint Test
Pencil Score	10.157	10.175	9.966	0.190	0.209	-0.019	0.032	0.035	-0.003	0.738	0.701	0.974	0.915
HTKS Score	15.258	16.043	14.707	0.551	1.336	-0.786	0.039	0.094	-0.055	0.704	0.332	0.583	0.619
Forward Digit Score	3.944	3.792	3.736	0.208	0.056	0.155	0.159	0.043	0.118	0.225	0.733	0.372	0.459
Backward Digit Score	0.656	0.408	0.450	0.206	-0.042	0.164	0.205	-0.042	0.163	0.136	0.750	0.233	0.295