Abstract Title Page
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Title: A Randomized Control Trial Evaluating the Effectiveness of Computer Assisted Instruction in Numeracy on Math Outcomes for Monolingual English Speaking Kindergartners from Title 1 Schools

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Abstract Body
Limit 4 pages single-spaced.

Background / Context:
Description of prior research and its intellectual context.

Children from low-income and ethnic minority backgrounds have demonstrated substantially lower levels of math achievement than their middle class majority peers for decades (National Assessment of Educational Progress, 2013). It is therefore important to identify interventions that improve early math outcomes in these children. Despite the importance of kindergarten math achievement (e.g., Duncan et al., 2007), there are few math interventions vetted by the What Works Clearinghouse (WWC, 2015) for this age group.

Purpose / Objective / Research Question / Focus of Study:
Description of the focus of the research.

The present study addressed two research questions. First, when used as a supplement to typical classroom instruction and in isolation from the larger curriculum, does *Building Blocks Software* lead to improvements in math achievement as measured by proximal and distal measures of mathematics? Second, are the impacts of supplemental use of *Building Blocks Software* specific to math achievement?

Setting:
Description of the research location.

Nine Title 1 schools drawn from a large urban school district in Texas that primarily served students from low-income and ethnic minority backgrounds participated in this study. Forty kindergarten classrooms, all with full-day programming, participated.

Population / Participants / Subjects:
Description of the participants in the study: who, how many, key features, or characteristics.

The sample consisted of 243 monolingual English speaking children (52% female). Most of these children represented ethnic minorities: 63% were African American, 30% Hispanic/Latino, 4% mixed ethnicity, 2% Caucasian, and 1% other. At the study's onset, the sample's scores on norm-referenced standardized tests of verbal ability ($M = 84$; $SD = 14$) and nonverbal ability ($M = 77$, $SD = 11$) were low average and below average, respectively, indicating risk for poor academic outcomes.

Intervention / Program / Practice:
Description of the intervention, program, or practice, including details of administration and duration.

Participants were randomized to receive computer assisted instruction (CAI; 90 minutes a week for 21 weeks) with *Building Blocks Software* (Clements & Sarama, 2007/2014) or *Earobics Step 1* (Cognitive Concepts, Inc., 2002), a literacy software program. Participants in the *Building Blocks Software* condition were given access to all of the games that targeted numeracy skills, while participants in the *Earobics Step 1* condition were given access to games targeting phonological awareness. During their ancillary instructional block designated for computer time,

children worked individually with these adaptive software programs (i.e., instruction adjusted to match the level of ability demonstrated by the child). Research assistants were present during ancillary computer time to provide behavioral supervision and technical assistance as needed.

Research Design:
Description of the research design.

Randomized control trial; participants were randomized with equal probability from within classroom to one of the two experimental conditions.

Data Collection and Analysis:
Description of the methods for collecting and analyzing data.

Children's numeracy skills were assessed with the *Research Based Early Math Assessment* (REMA; Clements, Sarama, & Liu, 2008), a measure proximal to the *Building Blocks Software* at the beginning (i.e., pretest) and at the end (i.e., posttest) of children's kindergarten year. At posttest, the *Applied Problems* subtest from the *Woodcock-Johnson III Tests of Achievement* (*WJ-III*; Woodcock, McGrew, & Mather, 2001), a distal measure of broad math achievement, was administered. To examine treatment specificity, vocabulary was assessed with the *Expressive One Word Picture Vocabulary Test* (Brownell, 2000) at pretest and posttest.

Multilevel ANCOVA models, accounting for classroom nesting, were run using restricted maximum likelihood estimation. For proximal math achievement, numeracy scores at pretest and group were included as predictors of posttest numeracy scores. For distal math achievement, numeracy scores from pretest were included with group as the baseline covariate because the Applied Problems subtest was not administered at pretest. Multilevel effect size estimates were computed using calculation procedures derived from Feingold (2009).

Findings / Results:
Description of the main findings with specific details.

Significant benefits for posttest math scores, but not vocabulary scores, were seen for children in the *Building Blocks Software* condition. For numeracy scores at posttest, there was a main effect for group, $F(1, 178) = 8.08$, $p < .01$, after accounting for numeracy scores from pretest and classroom nesting. The *Building Blocks Software* group outperformed the comparison group, with a difference in least squared means of 1.85 raw score units. The resulting effect size was 0.43, which exceeds the WWC threshold of a substantively important positive effect. With regard to Applied Problems scores at posttest, there was a main effect for group, $F(1, 176) = 5.90$, $p = .02$, after accounting for pretest numeracy scores and classroom nesting. Results favored the *Building Blocks Software* group over the control group, with a difference in least squared means of 0.96 raw score units. This equates to a substantively important effect size of 0.37 and a difference in least squared means of the norm-referenced standard scores of approximately 3.61 standard score units. Thus, the use of *Building Blocks Software* led to reliable improvements in children's mathematics outcomes. Finally, results concerned with treatment specificity indicated that experimental condition was not reliably associated with vocabulary scores at posttest, after accounting for pretest vocabulary scores and classroom nesting, $F(1,198) = 0.25$, $p = .62$. The *Building Blocks* group performed similarly to the comparison group with a difference in least squared means of 2.06 raw score units in favor of the

comparison group. The resulting effect size was -0.07. It can therefore be concluded *Building Blocks Software* demonstrated treatment specificity, reliably impacting mathematics scores but not vocabulary scores.

Conclusions:
Description of conclusions, recommendations, and limitations based on findings.

This study demonstrated that a relatively low intensity, supplemental implementation of *Building Blocks Software* throughout most of children's kindergarten school year led to reliable improvements in math achievement. These results are commensurate with early research (e.g., Fletcher-Flinn & Gravatt, 1995) and recent meta-analyses concerned with the effectiveness of CAI in mathematics (e.g., Cheung & Slavin, 2013). Results from the present study are also comparable to the work of others (e.g., Dyson, Jordan, Beliakoff, & Hassinger-Das, 2015) who implemented a supplemental kindergarten numeracy intervention with small groups of children. While the study design permits causal statements about the effectiveness of supplemental use of *Building Blocks Software*, the design does not permit statements concerning the merit of *Building Blocks Software* relative to other supplemental mathematics programs. As it may be, supplemental use of *Building Blocks Software* does not require teachers, does not interrupt children's regular mathematics classroom instruction, and does not interfere with other academic programming. Effect sizes reported in this study are therefore significant and provide support for the use of *Building Blocks Software* as a supplemental prevention program in an effort to decrease risk for school failure by increasing mathematical competencies of monolingual English speaking children from low-income and ethnic minority backgrounds.

Appendices
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Appendix A. References
References are to be in APA version 6 format.

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Appendix B. Tables and Figures
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