Presentation 2

Title: The Effect of Time Spent on Mathematics-Related Computer Activities on Children’s Achievement Outcomes in Pre-Kindergarten

Author(s):
Karen Anthony, Vanderbilt University (PRESENTER) (karen.anthony@vanderbilt.edu)
Amy Holmes, Vanderbilt University (PRESENTER) (amy.b.holmes@vanderbilt.edu)
Dale Farran, PhD, Vanderbilt University (dale.farran@vanderbilt.edu)
Mark Lipsey, PhD, Vanderbilt University (mark.lipsey@vanderbilt.edu)
Douglas H. Clements, PhD, University at Buffalo, The State University of New York (clements@buffalo.edu)
Julie Sarama, PhD, University at Buffalo, The State University of New York (jsarama@buffalo.edu)
Kerry Hofer, PhD, Vanderbilt University (kerry.g.hofer@vanderbilt.edu)
Carol Bilbrey, PhD, Vanderbilt University (carol.bilbrey@vanderbilt.edu)
Elizabeth Vorhaus, Vanderbilt University (elizabeth.vorhaus@vanderbilt.edu)

Background / Context:
Productive participation in an increasingly interconnected and globalized society necessitates technological competence, yet data indicate a persistent digital divide in the home based on family income, parent education level, and race (Becker, 2000; Calvert, Rideout, Woolard, Barr, & Strouse, 2005; Rideout, Foehr, & Roberts, 2010). Unfortunately, this disparity in computer access parallels the well-documented achievement gap between White, middle class students and those from low-income, minority backgrounds. Indeed, several studies have shown that children who have regular access to computers at home have higher achievement than their peers without computers and that preschool-aged children with access to a computer performed better on measures of cognitive development and school readiness than their counterparts without access (Becker, 2000; Fish et al., 2008; Li & Atkins, 2004). To equip students, including those from low-SES backgrounds and culturally marginalized groups, with the academic competencies and the technological expertise to thrive in a wired world, some have argued that schools must take the lead in narrowing the digital divide (Becker, 2000; Fish et al., 2008).

Integrating the use of educational technology in the classroom to foster achievement has indeed emerged as a high priority for schools and the broader educational community, and a growing body of literature documents a positive relationship between computer-based instruction and student achievement (Vogel et al., 2006). However, the majority of this research has focused on technology use among elementary and secondary students (Kulik, 2003), and there is evidence to suggest that access alone is not enough to boost achievement (Becker, 2000). In fact, the effect of computer technology on student learning may depend greatly on the curriculum in which the technology is embedded, as well as the teacher’s ability to engage and monitor students as they participate in these activities (Clements, 2000; Clements, 2002).

Consequently, researchers and teachers alike are interested in ways that computers might be used more effectively within classrooms to foster student learning. Given the expansion of educational technology into early childhood classrooms, there is mounting demand for research investigating the relationship between computer use and young children’s achievement, particularly within diverse and at-risk populations (Kim & Chang, 2010). To this end, the present
study sought to examine the effect of time spent engaged in computer-based learning on at-risk preschoolers’ mathematics achievement.

**Purpose / Objective / Research Question / Focus of Study:**

The current study is part of a randomized trial investigating the effects of a prekindergarten mathematics curriculum, *Building Blocks for Mathematics* (Clements & Sarama, 2007). The purpose of the *Building Blocks* scale-up study was to determine the effectiveness of the *Building Blocks* math curriculum in enhancing prekindergarten children’s mathematics performance. The developers’ TRIAD (Technology-enhanced, Research-based, Instruction, Assessment, and professional Development) model incorporates high-quality curriculum materials, professional development/training opportunities for teachers, and technology resources for both teachers and students.

While the overall treatment effects of the curriculum have been explored and reported elsewhere (Clements, Sarama, Farran, Lipsey, Hofer, & Bilbrey, 2011), the focus of the current study was to examine the effects of the specific student-related technology component of the *Building Blocks* intervention on children’s math learning. This student-related component consisted of a year-long sequence of computer activities/games. The primary research goal of this study was to examine the relationship between the amount of time children in treatment classrooms spent on the *Building Blocks* computer games and their achievement at the end of prekindergarten.

**Setting:**

The scale-up study of the *Building Blocks* curriculum included three urban school districts: the Buffalo Public School system in Buffalo, NY, the Boston Public School system in Boston, MA, and a combination of the Metropolitan Nashville Public School system and the Metropolitan Action Council Head Start system in Nashville, TN. Schools within each of the three sites were randomly assigned to participate in the intervention and business-as-usual conditions. The current study analyzed data from the Nashville site only, which included 16 public schools and 4 Head Start centers. A total of 57 prekindergarten classrooms participated in the study, 31 of which were assigned to the treatment condition.

The current study sample consists of the 31 Nashville treatment classrooms that were assigned to implement *Building Blocks*. Within those 31 classrooms, 392 children had pretest and posttest assessment data from the prekindergarten year.

**Population / Participants / Subjects:**

The study sample consisted of at-risk preschoolers between the ages of 4 and 6, with an average age of 53.6 months (roughly 4.5 years). Of the 392 children who were enrolled in treatment classrooms and had pre- and post-test data, just over 80 percent were African American, 56 percent were female. Virtually all children were from low-income families.

**Intervention / Program / Practice:**

Prekindergarten teachers in the treatment condition were provided with 15 days of professional development and training over the course of two years, as well as coaching and mentoring that was focused on providing high-quality mathematics instruction in the prekindergarten classroom. During the first year, teachers participated in the training activities in order to learn the curriculum, but full data collection took place during the second year (the
2007-08 school year). Teachers also had extensive access to a software application, *Building Blocks Learning Trajectories (BBLT)*, which provides teachers with extensive explanations of the mathematical learning trajectories on which the curriculum is based, as well as activity ideas and sample teaching videos.

The curriculum incorporates mathematics throughout the day – through both whole group and small group activities – in order to help children build their formal mathematics knowledge. As one part of the curriculum, children completed a series of computer activities linked to the current week’s mathematics focus. These activities were designed to progress as the class moved through each different mathematics focus, but teachers could also specify certain activities for certain children. Thus, the computer activities could be tailored to focus on each child’s strengths and weaknesses. Children’s computer log-ins were tracked individually to determine how much time each child spent on the computer over the entire school year.

**Research Design:**

The *Building Blocks* scale-up study was a cluster randomized field trial in which schools/centers were randomly assigned to experimental conditions. The current study focuses on data from treatment classrooms only, as those classrooms are the only ones that implemented the specific computer activity component.

**Data Collection and Analysis:**

Direct assessments of children’s academic achievement were administered individually to children in the fall and spring of the prekindergarten school year over the course of two separate testing sessions. Standardized achievement measures included the Letter-Word Identification, Applied Problems, and Quantitative Concepts subtests of the Woodcock-Johnson III Tests of Achievement. The Number and Geometry Assessments of the Research-based Early Maths Assessment (REMA), measures created by the curriculum developers, were also administered. The REMA has established content validity and concurrent validity (Klein, Starkey, & Wakeley, 2000).

Linear mixed models were used to predict children’s spring achievement based on the amount of time they spent on the *Building Blocks* computer activities. Independent models were run for each outcome measure. Children were nested within classrooms and schools. These models also controlled for child demographics (gender, race/ethnicity, disability status, and age), as well as pre-test score and the interval between assessment sessions.

**Findings / Results:**

The results showed that time spent on the computer activities significantly predicted spring achievement on Applied Problems ($b = .010, p = .001$), as well as Quantitative Concepts ($b = .011, p = .000$). Computer time predicted achievement on the REMA Number ($b = .004, p = .010$) and Geometry ($b = .002, p = .004$) assessments as well. The results for Letter-Word Identification, however, were not significant. Thus, the time children spent on the computer activities positively predicted their math outcomes at the end of prekindergarten, over and above what was predicted by their initial pre-test scores, and controlling for a variety of other child-level factors.

Prior research has suggested that students in classrooms with greater curriculum fidelity made greater mathematics gains than children in lower fidelity classrooms (Farran, Lipsey, Clements, Sarama, Hofer, Bilbrey, & Vorhaus, 2011). Thus, additional analyses were conducted...
to examine if the effects of computer time on children’s math outcomes might just be a proxy for the effect of overall fidelity. These analyses used an index of observed curriculum fidelity as a classroom-level predictor to test if, after accounting for the quality of the mathematics environment, time on the computer significantly predicted children’s mathematics performance at the end of prekindergarten. After accounting for the overall quality of the mathematics environment, preliminary results showed time on the computer still significantly predicted children’s outcomes on all four math measures.

Conclusions:

Children who have regular access to computers in the home have higher achievement than those without computers, but children from low-SES backgrounds are less likely to have access to computers at home (Becker, 2000). In recent years, computer access within schools has become quite similar among low- and high-poverty schools (Espinosa, Laffey, Whittaker, & Sheng, 2006; Judge, Puckett, & Bell, 2006), but access alone may not be enough to improve achievement outcomes.

In the current study, computer activities were part of an integrated early childhood mathematics curriculum, rather than the stand-alone activities which might be provided in typical classrooms. While previous work has suggested that the Building Blocks curriculum has positive effects on children’s mathematics learning, this study specifically focused on the effects of the student-related technology component. The findings suggest that this type of integrated computer activity had positive effects on children’s mathematics performance at the end of prekindergarten. This finding is particularly important because the children in the study were all from at-risk backgrounds. Future analyses will further explore characteristics of classrooms with greater amounts of computer usage. For instance, the relationship between computer usage, overall classroom quality, and curriculum fidelity will be examined in more detail.
References


