

Learning Science and Engineering from Videos and Games; A Randomized Trial of PBS KIDS *The Cat in the Hat Knows a Lot About That*

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Background and Context

Digital media—television, video, apps, digital games, etc.—represents a potentially powerful tool to support children’s science and engineering learning at scale, yet little is known about its effects on young children’s understanding of these topics. Research indicates that early science experiences can help young children develop important critical thinking and language skills and a foundational understanding of science and engineering that will help them later in life. However, many young children have limited opportunities to explore science and engineering at home or in preschool settings (Greenfield et al., 2009; Piasta, Pelatti, & Miller, 2014).

Purpose, Objective, and Research Questions

The purpose of this study is to understand whether providing young children and their families living in low-income households with science-related media resources can help children learn. We focused our study on videos and digital games from *The Cat in the Hat Knows a Lot About That!*TM. The Public Broadcasting Service, in partnership with the Corporation for Public Broadcasting, developed these resources under the 2015-2020 Ready To Learn Initiative, which is funded through the U.S. Department of Education.

The study team sought to answer four primary research questions:

What is the impact of providing eight weeks of access to *Cat in the Hat* resources on low-income 4- to 5-year-old children’s understanding of:

1. physical science concepts and science and engineering practices;
2. the role of material properties and forces in structural stability;
3. the role of material properties and forces on movement down an incline;
4. how objects can be sorted based on their material properties and uses.

We also examined the following exploratory questions:

5. In what ways do 4- to 5-year-old children and their parents engage with the *Cat in the Hat* resources?
6. In what ways is usage of the *Cat in the Hat* resources associated with 4- to 5-year-old children’s physical science and engineering knowledge?
7. In what ways does the impact of the *Cat in the Hat* resources on child outcomes differ for subgroups of children, including gender, ethnicity, children from dual language homes, parent education level, high-achieving children, and children in formal preschool settings?

Setting

Families in five locations participated: Boston, Minneapolis, New York, Phoenix, and San Francisco, California. All children lived in low-income house-holds.

Population, Participants, and Subjects

454 four- and five-year old children participated in the study. The sample included slightly more girls (54%) than boys. Approximately one third (35%) of children were identified by their parent as White, 19% as Hispanic, 18% as Black/African American, 3% as Asian, and 23% as multiracial (see Table 1). We did not observe significant differences between treatment- and control-assigned children or families related to these characteristics, and no differences exceeded the What Works Clearinghouse threshold ($ES = 0.25$) for equivalent samples.

Intervention

Treatment. The study took place over 8 weeks. Families in the treatment group received an Internet-enabled tablet computer with a *Cat in the Hat Builds That!* games app, a video player app with *Cat in the Hat* videos, and hands-on activities that focused on physical science and engineering. Materials included 28 digital videos, 5 digital games, and a set of real-world activities for parents and children to do together. The study team asked parents to have their children use the materials for about one hour each week. The control group children received a tablet and the study team asked parents to have their children select and use any educational videos and games on the tablet for one hour per week (see Table 2).

Research Design

The study team randomly assigned children to receive *The Cat in the Hat* resources or an alternative treatment. Researchers used several procedures to mitigate possible biases: Attrition was low and met the What Works Clearinghouse standards. Study team assessors and analysts remained blind to the participants' treatment status. Parents in the control condition were not told they were control families. The team pre-registered the study design in the Registry of Educational Effectiveness Studies (REES).

Data Collection and Analysis

Assessments of learning. We collected information on children's science and engineering knowledge prior to random assignment using Lens on Science, an externally developed, validated science assessment. We also assessed children at the end of the study using:

- (1) a modified version of Lens on Science focusing on physical science and engineering knowledge, and
- (2) Hands-On Preschool Assessments of Science and Engineering—researcher-developed performance-based assessments.

We used multivariate linear regression (ordinary least squares) to examine differences in post-test outcomes between the treatment- and control-assigned participants. All regression models included controls for children's baseline scores on the Lens assessment. Data collection and analysis procedures were consistent with those in the REES documents.

8. Findings and Results

Providing children with 8 weeks of access to *The Cat in the Hat* resources substantively improved children's understanding of:

- » how the properties of objects and materials (strength and length) and natural and applied forces contribute to the stability of structures ($d = 0.40, p < .001$); and
- » how the properties of materials (texture) and force (friction) influence how objects move ($d = 0.38, p < .01$).

We also found suggestive evidence of small impacts on children's understanding of material properties (ability to sort objects by size, color, shape, and use; $d = 0.15, p = .18$) and children's broader physical science and engineering knowledge and practices ($d = 0.11, p = .12$; Figure 1). Parent reports suggest

that the resources increased children's excitement about science but not engineering and increased children's engagement in science activities (Figure 2).

Conclusions

The results provide strong evidence that *The Cat in the Hat Knows a Lot About That!* helps children learn science and engineering concepts and practices. Large impacts on both the friction and incline and the structure and stability performance-based assessments indicate that children's experiences manipulating materials in a digital context can transfer to understanding of those practices and concepts in the physical world. This finding provides a substantial contribution to the overall research literature on how children learn from digital media.

Table 1. Child science knowledge and demographic characteristics, overall and by condition

	Total Sample (N = 454)	Control Group (n = 225)	Treatment Group (n = 229)
Child is female (%)	54.4	52.9	55.9
Child age in months [mean, (SD)]	59.2 (3.8)	59.3 (3.9)	59.1(3.8)
Baseline science knowledge (<i>Lens on Science</i>) [mean, (SD)]	1.37(1.09)	1.34 (1.05)	1.39 (1.13)
Child race or ethnicity (%)			
White	34.6	36.4	32.8
Hispanic	18.7	18.7	18.8
Black or African American	18.1	17.8	18.3
Asian	3.3	2.7	3.9
Other	2.4	1.8	3.1
Multirace	22.9	22.7	23.1
Child attends center care (non-K) for 30+ hours (%)	25.3	22.3	28.4
Child's primary language is English (%)	75.3	76.0	74.7
Child has an IEP or 504 plan (%)	10.1	12.0	8.3
Family income less than \$50,000 (%)	51.1	53.8	48.4
Responding parent has high school education or lower (%)	17.2	15.5	18.8

Table 2. Resources Provided to Treatment and Control Group Participants

	Technology Resources	Parent Guide Information	Text Messages	Other Resources
Treatment-assigned children	<ul style="list-style-type: none"> • New tablet computer • 8 weeks of data • <i>The Cat in the Hat Knows a Lot About That!</i> Season 3 video player app • <i>The Cat in the Hat Builds That</i> games app 	<p>Have their child use the tablet to access the <i>Cat in the Hat</i> resources</p> <p>Study information and basic tips for using the tablet</p> <p>Description of the <i>Cat in the Hat</i> materials and science-focused tips drawn from the <i>Cat in the Hat</i> website</p>	<p>Weekly text message reminders about the <i>Cat in the Hat</i> content of the week, media log link</p> <p>Text message reminders of data collection appointments</p>	Calendar indicating each week's focal theme of <i>The Cat in the Hat</i>
Control-assigned children	<ul style="list-style-type: none"> • New tablet computer • 8 weeks of data • <i>Cat in the Hat</i> videos and games blocked • Similar science apps, <i>PBS KIDS</i> website, video, and game apps blocked • Instructions for use of educational digital media content 	<p>Have their child use the tablet to access educational media of their choosing</p> <p>Study information and basic tips for using the tablet</p>	Text message reminders of data collection appointments	--

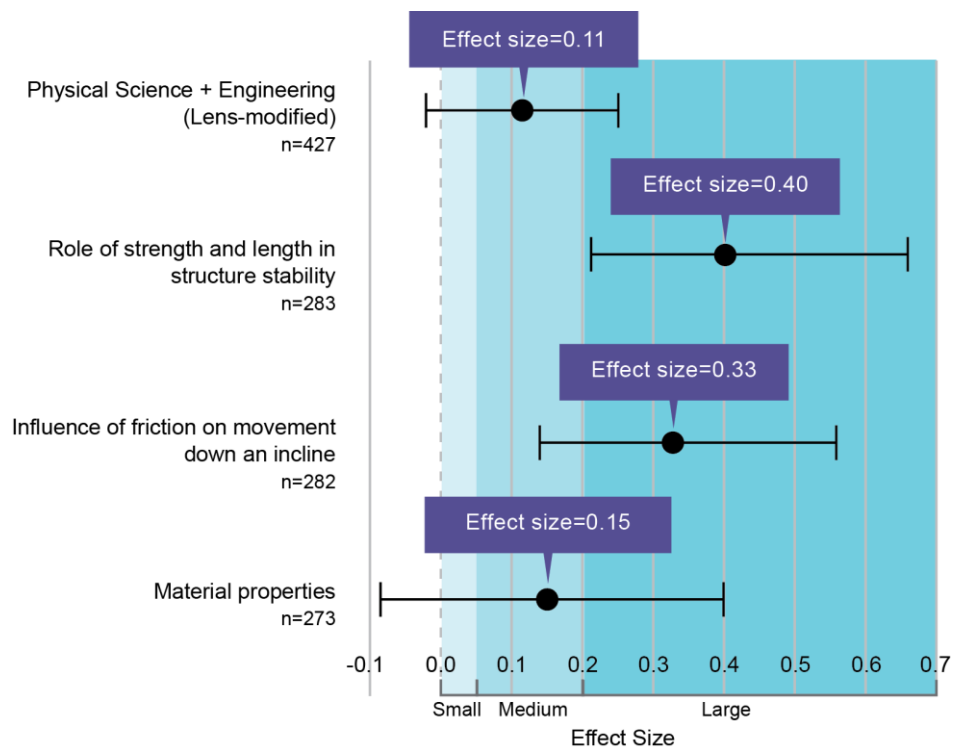
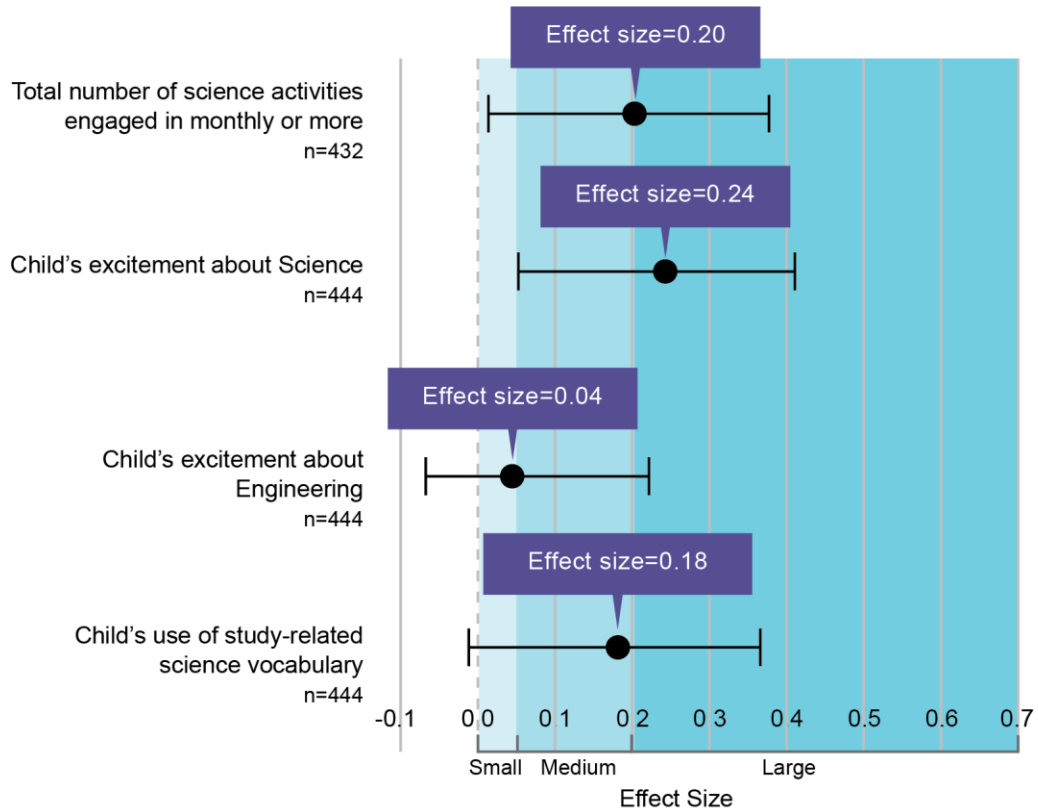


Figure 1. Impacts of *The Cat in the Hat* resources on children's science and engineering knowledge and practices



Note: All models include controls for baseline score on the Lens on Science. Characterizations of effects as small, medium, and large are based on Kraft (2019). Dots represent effect size from the regression models. Bars represent the 95 percent confidence around the effect size.

Figure 2. Impacts of *The Cat in the Hat* on parent-reported outcomes