Ready To Learn **Research**   November 2019

Early Science & Engineering

The Impact of *The Cat in the Hat Knows a Lot About That!* on Learning

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About the Ready To Learn Initiative

The Ready To Learn Initiative is a cooperative agreement funded and managed by the U.S. Department of Education's Office of Elementary and Secondary Education. It supports the development of innovative educational television and digital media targeted to preschool and early elementary school children and their families. Its general goal is to promote early learning and school readiness, with a particular interest in reaching children from low-income households. In addition to creating television and other media products, the program supports activities intended to promote national distribution of the programming, effective educational uses of the programming, community-based outreach, and research on educational effectiveness.

Contents

Objectives

Digital media—such as television, videos, apps, and digital games—represent a potentially powerful tool to support children's science and engineering learning at scale. In this study, we test whether providing young children and their families with science and engineering-focused digital media leads to improvements in children's science- and engineering knowledge and practices.

Resources Tested

This report examines *The Cat in the Hat Knows a Lot About That!*™, a PBS KIDS multi-platform media property based on "The Cat in the Hat's Learning Library" book series by Random House and Dr. Seuss Enterprises. The television series is produced by Portfolio Entertainment, and the digital games and offline activities are produced by Random House. The Public Broadcasting Service (PBS), in partnership with the Corporation for Public Broadcasting (CPB), developed the media resources researched in this report as part of the 2015–2020 Ready To Learn Initiative, funded through the U.S. Department of Education. *The Cat in the Hat Knows a Lot About That!* resources tested were 28 digital videos, five digital games, and hands-on activities for parents and children.

28 **videos** (3 hours and 43 minutes of content) in a video app

5 **digital games** in *The Cat in the Hat Builds That* app

20 **game-aligned guides** for hands-on activities embedded in the game app

3 **printed descriptions** of science and engineering activities from the website

Methods

The study team randomly assigned 454 children from low-income families to receive either *The Cat in the Hat Knows a Lot About That!* resources or an alternative treatment. The team collected information on children's science and engineering knowledge and practices prior to randomization and then again eight weeks later.

Who participated in the study?

A diverse sample of families,
all living in low-income households.

454

Children:
Ages 4 and 5 years

Key Findings

Exposure to *The Cat in the Hat Knows a Lot About That!* resources had meaningful impacts on 4- to 5-year-old children's physical science knowledge and their ability to engage with science and engineering practices.

Exposure to *The Cat in the Hat Knows a Lot About That!* media resources had a clear positive impact on children's

1 understanding of physical science concepts related to the two physical science core ideas of matter and forces:[1] **(a)** the role of material properties (strength and length) and forces in structural stability and **(b)** the role of material properties (texture) and forces (friction) on movement down an incline; and

2 interest and engagement in science.

We also found suggestive evidence that exposure to *The Cat in the Hat Knows a Lot About That!* had a positive impact on **(a)** children's wider understanding of physical science concepts and science and engineering practices; **(b)** their ability to sort objects by size, color, shape, and use; and **(c)** their use of science-related vocabulary. These impacts were small and approached—but did not reach—the conventional threshold for statistical significance.

Implications

The results of this study indicate that educational media designed to focus on critical science and engineering concepts and skills can help young children understand science and engineering concepts and practices. Second, large impacts on two of the three 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 overall research literature on how children learn from digital media. These findings are especially important given the relative scalability and low per-child cost of media-based interventions in the context of other typically resource-heavy science interventions.

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[1] These concepts are related to two core ideas derived from the PBS KIDS Science Framework, which is aligned with the Next Generation Science Standards: (1) matter and Its interactions and (2) motion and stability: forces and interactions.

Introduction

Young children are **naturally curious**. They delight in asking questions about the world and how things work, generating explanations, using models, and making and revising predictions.

(Fusaro & Smith, 2018; Gerde, Schachter, & Wasik, 2013; National Research Council, 2012)

These behaviors are the first steps in developing important science and engineering knowledge and practices as well as in developing critical thinking, language, mathematical reasoning, executive function, and persistence (Bustamante, White, & Greenfield, 2017; French, 2004; Kuhn, 2011; Nayfeld, Fuccillo, & Greenfield, 2013; Peterson & French, 2008; Wright & Neumann, 2014). Children who engage in science are more likely to be interested in science as adolescents and are more likely to participate in science-related careers later in life (Alexander, Johnson, & Kelley, 2012; Patrick, Mantzicopoulos, & Samarapungavan, 2009).

However, many young children have limited opportunities to explore science and engineering at home or in preschool settings. Four- and 5-year-old children in preschool spend far less time learning science content than they do other subjects, such as language and literacy (Greenfield et al., 2009;

Piasta, Pelatti, & Miller, 2014). Many preschool educators are not trained to support children's science and engineering explorations (Greenfield et al., 2009). And at home, parents[2] often struggle to answer their child's questions about the world around them, and many lack the confidence and resources to seize everyday opportunities that could deepen their child's learning and curiosity about how things work (Silander et al., 2018).

Digital media—television, video, apps, digital games, and so on—represent a potentially powerful tool to support children's science learning (Mares & Pan, 2013; Schroeder & Kirkorian, 2016). Media can model ways of talking about and doing science and can engage families who might otherwise perceive science as too complex or not interesting (Lu, Buday, Thompson, & Baranowski, 2016; Travis, 2017; Troseth, Saylor, & Archer, 2006; Young et al., 2012). Digital media can allow

[2] We use the term "parent" in a broad sense, as our sample includes guardians as well as parents.

→ **Prior research suggests a need to provide young children and their families with more high-quality science- and engineering-focused media resources.**

children to explore and manipulate scientific phenomena and simulations that might be time consuming, difficult, or unsafe to explore in the physical world (Rutten, Van Joolingen, & Van der Veen, 2012). Media is most likely to support learning and development if it features relatable characters and stories (Bandura, 1965; Lauricella, Gola, & Calvert, 2011; Linebarger, Brey, Fenstermacher, & Barr, 2017), is cognitively activating and engaging, supports meaningful and socially interactive learning experiences, and is guided by specific learning goals (Hirsch-Pasek et al., 2015). However, even with well-designed media, transferring knowledge from videos and games to the real world[3] is challenging, particularly for the youngest media users (Bonus & Mares, 2019; Troseth, 2010). Related to this challenge, media's potential to educate is strengthened when children and parents watch and play together, and joint media engagement can be a particularly powerful tool for learning (Rasmussen et al., 2016; Strouse, O'Doherty, & Troseth, 2013).

Educational media's ability to deliver consistent messaging to a wide and varied audience across large geographical areas makes educational media interventions highly scalable at an extremely low cost relative to other person-to-person early childhood interventions (Kearney & Levine, 2019). Children under the age of 8 years spend an average of two hours a day using or watching onscreen media, including television, movies, and apps (Rideout, 2017). Although the potential exists for media to change perceptions and influence outcomes related to science and engineering, a recent national survey of parents found that just over half of parents were satisfied with the science learning media resources available to their children, and even fewer reported that their child "learned a lot" from science media (Silander et al., 2018). These findings suggest a need to provide young children and their families with more high-quality science- and engineering-focused media resources.

To meet this need, the Public Broadcasting Service (PBS), in partnership with the Corporation for Public Broadcasting (CPB), developed the

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[3] We use the term "real world" to refer to activities that are not mediated by the tablet computer.

The Cat in the Hat Knows a Lot About That! (Cat in the Hat) media resources for young children and their parents and caregivers through the 2015–2020 Ready To Learn Initiative, which is funded through the U.S. Department of Education. The Ready To Learn Initiative brings free educational television and digital media resources to children ages 2–8, promoting early learning and school readiness, with an emphasis on supporting children from low-income, underserved communities. Developing a deeper understanding of how national media and the network of local public media stations can support children and family learning at scale drives the CPB-PBS Ready To Learn Initiative. As the research and evaluation team for Ready To Learn, Education Development Center (EDC) and SRI Education (SRI) measure the impact of PBS KIDS digital and hands-on resources on young children's learning.

No large-scale rigorous experimental studies have examined the effectiveness of the existing science- and engineering-focused educational media on children's learning. This study examines how exposure to the *Cat in the Hat* videos, digital games, and hands-on activities affects children's understanding of science and engineering concepts and practices.

The Cat in the Hat Knows a Lot About That! Resources

The Cat in the Hat Knows a Lot About That! is a PBS KIDS multi-platform media property based on "The Cat in the Hat's Learning Library" book series by Random House and Dr. Seuss Enterprises. This study focused specifically on resources developed for the third season of *The Cat in the Hat Knows a Lot About That!*, which PBS developed in partnership with CPB under the 2015–2020 Ready To Learn Initiative. The content for this season is aligned with the K–12 Next Generation Science Standards (NGSS) (National Research Council, 2013) and the Head Start Early Learning Outcomes Framework (U.S. Department of Health and Human Services, 2015). This third season of the television series, produced by Portfolio Entertainment, along with the digital games, apps, interstitials, and real-world activities produced by Random House, support science and engineering learning by modeling science and engineering practices and language and exploring science and engineering content through narrative stories and interactive experiences. The third season specifically focuses on physical science and engineering content, practices, and vocabulary, which are topics that work well for visual storytelling (Sweetman, Mirkin, Lund, & Bishop, 2018). The *Cat in the Hat* content developers selected one or two focal concepts to integrate with science and engineering practices in each episode or game.

At the beginning of each *Cat in the Hat* video adventure, two young characters, Sally and Nick, pose a question or define a problem about the natural and human-designed world they have encountered in their own backyard. The characters then join the lead character, *Cat in the Hat*, on a science-related adventure, such as visiting *Spansylvania* to build bridges, going to Gongolia to find the right size gong to make different sounds, or going to the Frictionarium to investigate why Sally has lost her "slidey-ness" and is stuck on the slide. Guided by the Cat, the children engage in science inquiry and engineering design. They ask questions and define problems, make observations, make predictions, plan and conduct investigations, collect data, make discoveries, design solutions to problems, and generate and discuss ideas about how the world works.[4]

In addition to the videos, the content developers created five digital games and guidance for five sets of real-world activities within the PBS *The Cat in the Hat Builds That* app. The digital games are designed to support science and engineering learning by providing opportunities for children to explore and manipulate scientific phenomena and simulations. The real-world activities are each aligned with one of the five games and provide an opportunity for children (ideally with older family members) to engage in related real-world science and engineering activities. Printable PDFs with guidance for additional real-world activities also are available on the *Cat in the Hat* website. Additional details about the *Cat in the Hat* resources, including individual media assets, are listed below in the Study Materials section.

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[4] Partially adapted from PBS KIDS, https://www.pbs.org/parents/shows/cat-in-the-hat/about/

Study Design and Methods

Research Questions

The study team sought to answer four primary research questions:[5]

What is the impact of providing eight weeks of access to the *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 (strength and length) and forces in structural stability;

3 the role of material properties (texture) and forces (friction) on movement down an incline: and

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 (that is, discuss, practice, try out in the world, show siblings, and so on) the *Cat in the Hat* resources?

6 In what ways, if at all, 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, if at all, does the impact of the *Cat in the Hat* resources on child outcomes differ for relevant subgroups of children, including gender, ethnicity, children from dual language homes, parent education level, high-achieving children (as measured by the pre-test), and children in formal preschool settings?

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[5] The study team published the study design and analysis plans in the Registry of Efficacy and Effectiveness Studies (REES) prior to beginning data collection. Preregistration of study analysis is done to reduce the possibility of study team members manipulating the analyses to produce positive results. The design and analysis practices described in this report are consistent with the information in the preregistry document. Note that the wording of research questions was changed slightly to improve accessibility to a broader audience. REES 1627.1v2; https://sreereg.icpsr.umich.edu/framework/pdf/index.php?id=2294

Recruitment

The study took place over an eight-week period during winter and spring 2019.

8 weeks

Minneapolis, Minnesota

Boston, Massachusetts

San Francisco, California

New York, New York
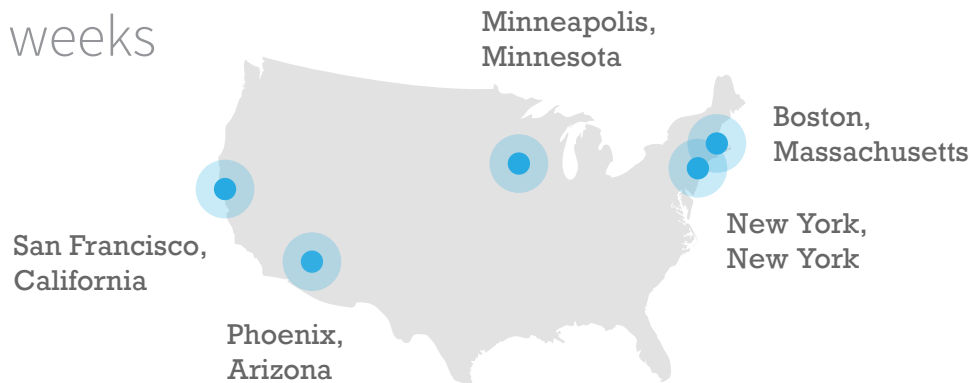
Phoenix, Arizona

The study team recruited families in five locations across the United States: Boston, Massachusetts; Minneapolis, Minnesota; New York, New York; Phoenix, Arizona; and San Francisco, California. Working in collaboration with Drive Research, a qualitative research and recruiting firm, the study team contacted parents through existing email lists and advertisements on social media. Drive Research contacted interested families by phone to provide additional information about the study and to confirm that potential participants met the following criteria:

» Child was born between September 2013 and October 2014 (age 4 years and 3 months to 5 years and 6 months at baseline).

» Child is fluent in English.

» Family is low income.[6]

» At least one parent is proficient in English or Spanish.

» Parent indicated that child could participate in game-like activities for up to 35 minutes (the duration of the pre-test).

Recruiters made these screening phone calls in English and in Spanish. Families that met these criteria and remained interested were scheduled to participate in two meetings with the study team. During the first meeting, members of the study team informed parents that the purpose of the study was to

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[6] For this study, a family qualified as low income if they had an annual household income at or below the U.S. Department of Housing and Urban Development threshold to receive a Section 8 housing voucher for a family of four. This was $81,100 in Boston, $71,900 in Minneapolis, $83,450 in New York, $55,300 in Phoenix, and $117,400 in San Francisco.

understand how young children learn from digital media, that they would receive a tablet computer and $125 in incentives ($25 at the first meeting and $100 at the final meeting), and that they would be asked to complete parent surveys and permit their children to participate in assessments of their early learning knowledge and skills. A study team member then obtained the parents' consent to participate in the study.[7] Table 1, below, displays the number of participants who successfully completed the first meeting at each site. The second meeting occurred eight weeks later and included post-test data collection. These procedures are described in detail in Appendix A.

Table 1. Study Participants by Site

	N	% of total sample
Boston	29	6.4%
Minneapolis	121	26.7%
New York	106	23.3%
Phoenix	116	25.6%
San Francisco	82	18.1%

[7] At the time of consent, parents also were given the option to participate in a second study. Activities associated with the second study took place after the completion of this study. Families could participate in the first study whether or not they chose to participate in the second. The second study will be described in a separate report.

Random Assignment

The study team randomly assigned participants to the treatment or control group by provisioning all study tablet computers in a random sequence with control or treatment materials before the first data collection visit. Once parents completed the study enrollment process, they received either a treatment- or control-provisioned tablet. A member of the study team distributed tablets sequentially, and the study team members who determined the order of the participants were not aware of the tablet sequence. This process ensured that assignment to condition was entirely random and could not be influenced by the participants or the study team. To mitigate possible biases in data collection and analyses, the study procedures throughout the study ensured that assessors and data analysts were not aware of the study participants' assignment to condition.

Sample

The children who participated in the study were an average of 4 years, 11 months old. The sample included slightly more girls (54%) than boys. Approximately one third (35%) of participating children were identified by their parent as White, 19% as Hispanic, 18% as Black or African American, 3% as Asian, and 23% as multiracial. All families met the local criteria for qualifying as low-income, and approximately half (51%) lived in households with annual incomes of less than $50,000. Three quarters (75%) of the children spoke English as a primary language, and 10% of parents indicated that their child received disability services (via an individualized education program or a 504 plan). Table 2, below, displays the demographic characteristics of the families in the overall sample and by condition. We did not observe any statistically significant ($p < .10$) differences between treatment- and control-assigned children or families on any of these demographic characteristics, and in no case did differences exceed the What Works Clearinghouse threshold (ES = 0.25) for equivalent samples.

Table 2. 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 is male (%)[8]	45.6	47.1	44.1
Child age in months [mean (SD)]	59.2 (3.8)	59.3 (3.9)	59.1 (3.8)
Baseline science knowledge (*Lens on Science*) [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
» Multiracial	22.9	22.7	23.1
Child attends center care (non-K) for 30+ hours weekly (%)	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 annual income is less than $50,000 (%)	51.1	53.8	48.4
Responding parent has high school education or lower (%)	17.2	15.5	18.8

[8] Parents reported child gender on the parent pre-survey. Response options were male, female, and other (please specify). All parents selected either male or female.

Attrition from the study was low. Among the 229 children assigned to the treatment group, 223 (97.4%) completed one or more of the post-test assessments. Rates of attrition were similar among control-assigned children, with 220 of the 225 (97.8%) control-assigned children completing at least one post-test assessment.[9] The overall attrition rate of 2.4% and differential attrition rate of 0.4% fall within the What Works Clearinghouse standards for acceptable rates of attrition for experimental studies.

Study Materials

The study team designed the study experience to be an optimized version of what young children experience in their everyday lives. We provided the participating 4- and 5-year-old children and their parents with access to the *Cat in the Hat* videos, *The Cat in the Hat Builds That* app, and printed real-world activities. Families received a tablet computer with a video player app to view the *Cat in the Hat* videos and to play games in *The Cat in the Hat Builds That*. Both apps were accessible to the children via icons on the tablet home screen. Each tablet had a data plan to enable access to the Internet, although use of the *Cat in the Hat* videos and games did not require Internet connection. *Cat in the Hat* producers organized the videos and games into six themes (Table 3, below). Resources included 28 *Cat in the*

Hat videos that together totaled 3 hours and 43 minutes of content. Nine of these videos are interstitials—90-second programs designed to bridge two full-length (11-minute) video segments to fill a 30-minute television slot. Two of the five digital games in *The Cat in the Hat Builds That*, "Bridge-a-rama" and "Slidea-ma-zoo," were designed to be adaptive and build additional levels based on past (saved) gameplay by continuously estimating player ability and choosing appropriate next levels based on factors such as demonstration of mastery and the difficulty of the levels available. In addition to the game-aligned hands-on activities embedded in the app, the study team provided families with three printed science and engineering activities from the *Cat in the Hat* website (see Appendix C for activities).

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[9] Table 2 describes the full sample; a table describing the analytic sample (i.e., those who have at least one post-test assessment) is in Appendix B.

Table 3. *Cat in the Hat* Content Themes

Theme	Content Area	No. of Full-Length Videos	No. of Inter-stitials	No. of Games	No. of App-Based Hands-on Activities	Printed Real-World Parent/Child Activity
Bridge-a-rama	Bridges	4	1	1	4	Daring Design Challenge; Measuring This and That
Slidea-ma-zoo	Slides & friction	3	2	1	4	—
Sorta-ma-gogo	Sorting objects	4	2	1	4	What Floats Your Boat?
Sound-a-palooza	Sounds & soundwaves	3	—	1	4	—
Build-a-maloo	Building & engineering	3	2	1	4	—
Be curious!	Five senses & making observations	2	2	—	—	—

The study team and the written family guide both encouraged treatment group participants to engage with the *Cat in the Hat* digital media content for about one hour per week for eight weeks, but also suggested parents could use their own judgment to determine how much time their child spent with the resources, based on their typical media use and the child's interest. In addition to the *Cat in the Hat* materials described above, the treatment group received the following resources:

A **parent guide** with information about the study, a description of the *Cat in the Hat* materials, troubleshooting tips for using the tablet, and science-focused tips for parents that were drawn from the PBS KIDS Parents website.

A **calendar** with one of three randomized sequences of the *Cat in the Hat* content to focus on each week, including six weeks on a content theme and two weeks of free choice. The order in which families were asked to engage with the *Cat in the Hat* resources was randomized so that performance on assessments would not be influenced by how recently a child engaged with a specific set of videos, games, or activities.

Parents also received weekly text messages reminding them to engage with the target theme for the week and providing them with a link to complete a weekly media log. Participants who did not fill out their weekly media log within three days of the weekly message also received a reminder text.

Control Group. Control group participants received tablets with a data plan to enable access to the Internet. The study team members explained that they were interested in learning about how families use educational media and encouraged the control group participants to engage with educational digital media content on the tablet for one hour per week for eight weeks, or in keeping with their typical approach in guiding how much media the child uses. Third-party software blocked access to the PBS website and PBS games and video apps on the tablet, as well as to a few science-related apps that targeted content similar to *Cat in the Hat*.[10] The control group also received a parent guide with general information about the study along with troubleshooting tips for using the tablet. Control group participants received text messages reminding them about their scheduled second meeting but did not complete media logs. At the end of the eight-week study period, the study team provided control-assigned families with access to the *Cat in the Hat* resources.[11]

Table 4, below, summarizes the resources provided to families in the treatment and control groups.

[10] These apps included *Dino Train Jurassic JR., Measure Up!, PBS Parents Play and Learn Science, PEEP Trash Stash, PEEP Chirp Shapes Up, PEEP Quack's Apples, PEEP Family Science Ramps, PEEP Ciensias: Rampas, PBS KIDS Games, PBS KIDS Video and The Cat in the Hat Builds That.* Despite blocking access to the publicly available *Cat in the Hat* materials, it is possible families may have been able to access PBS KIDS shows through third-party websites such as YouTube or by using other devices.

[11] Control group families were invited to enroll in a subsequent study of the impact of a mobile messaging intervention on parent's beliefs and practices about early science learning. For more information see Registry of Efficacy and Effectiveness Studies #1627.2v1 https://sreereg.icpsr.umich.edu/framework/pdf/index.php?id=2133.

Table 4. Resources Provided to Treatment and Control Group Participants

	Treatment-assigned children	Control-assigned children
Technology Resources	• New tablet computer • 8 weeks of data • *The Cat in the Hat Knows a Lot About That!* Season 3 video player app • *The Cat in the Hat Builds That* games app	• New tablet computer • 8 weeks of data • *Cat in the Hat* videos and games blocked • Similar science apps, PBS KIDS website, video, and game apps blocked • Instructions for use of educational digital media content
Parent Guide Information	• Have their child use the tablet to access the *Cat in the Hat* resources • Study information and basic tips for using the tablet • Description of the *Cat in the Hat* materials and science-focused tips drawn from the *Cat in the Hat* website	• Have their child use the tablet to access educational media of their choosing • Study information and basic tips for using the tablet
Text Messages	• Weekly text message reminders about the *Cat in the Hat* content of the week, media log link • Text message reminders of data collection appointments	• Text message reminders of data collection appointments
Other Resources	• Calendar indicating each week's *Cat in the Hat* focal theme	—

Data

The study team collected three types of data: outcomes measures, parent measures, and tablet usage data.

Outcomes Measures

The study team assessed children's science and engineering knowledge and science practices using two types of assessments:

1 a modified version of Lens on Science, an externally developed measure of young children's physical science and engineering knowledge, and

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2 researcher-developed measures, the Hands-On Preschool Assessments of Physical Science and Engineering.

» **Lens on Science.** The computer-administered, adaptive, item response theory-based Lens on Science (Lens) assessment for preschool children was developed by Daryl Greenfield and colleagues at the University of Miami (Greenfield, 2015). The Lens on Science is aligned with the Framework for K-12 Science Education (National Research Council, 2012) and intended to assess young children's knowledge of core ideas in four science disciplinary areas (life science, earth/space science, physical science, and engineering and technology); science practice skills; and crosscutting concepts. It was designed to detect growth in learning for preschool children from low-income households. It was chosen as an outcome measure

for this study because of the psychometric evidence of its validity and reliability. The assessment takes approximately 20–25 minutes to administer, including a 7- to 8-minute screener that ensures a child understands and knows how to respond to its three different item types. During the assessment itself, children are given a computer adaptive set of items matched to their abilities based on a pool of 498 items.

→ At pre-test, all children completed the full adaptive Lens assessment, which served as a baseline for later analyses to ensure that both groups of children had similar science knowledge at the start of the study.

→ At post-test, all children completed a subset of items from the full Lens (Lens-Modified) that covered topics in the physical science and engineering and technology domains. Details on the post-test are in Appendix D.

» **Hands-On Preschool Assessments of Physical Science and Engineering (Performance-Based Assessments).** The research team developed three performance-based tasks to assess children's understanding of the role of material properties (strength and length) and forces in structural stability, the role of material properties (texture) and forces (friction) on movement down an incline, and how objects can be sorted based on their material properties and uses. The tasks also emphasize the science practices that

are a focus of *Cat in the Hat*, as well as the crosscutting concepts that unite the core ideas of science and engineering related to stability and change, structure and function, cause and effect, and systems. These tasks were developed to complement the Lens and addressed a narrower subset of content covered in *Cat in the Hat*. Children completed these tasks at post-test. In order to limit the total assessment time to no more than 35 minutes, each child was randomly assigned two of the three assessments. Both the specific performance tasks and the order in which the tasks were delivered were determined randomly before the initiation of the study. Additional details about each of these assessments and their scoring is in Appendix D.

→ **Length, Strength, and Stability.** This task assesses a child's understanding of how the properties of objects (such as size and shape) and materials (such as hardness and flexibility) make them suitable for a purpose. Children are provided with a group of objects of different lengths and strengths and asked to choose the most suitable object for building a bridge that can support weight.

→ **Surfaces and Friction.** This task assesses a child's understanding of how the properties of materials and forces—friction in particular—influence the motion of objects. Children are provided with three slides with differently textured (rough/smooth/sticky) surfaces and asked to choose the slide that will enable a toy figure to slide down the fastest.

→ **Colors, Shapes, and Uses.** This task assesses a child's understanding that different objects can be described and categorized based on their observable properties and on how they are used. Children are provided with different sets of objects and are asked to sort them based on color, shape, and standard use (for eating, making art, and playing).

Parent Measures

» **Parent Survey.** Parents completed pre- and post-surveys via the survey platform Qualtrics. All surveys were written at approximately a fifth-grade reading level and were available in both English and Spanish.

→ **Parent Pre-survey.** This included demographic questions regarding parent and child backgrounds. The survey also asked about parent confidence related to science and technology, the child's use of technology and media, and the child's prior exposure to PBS children's media properties, including *Cat in the Hat*. Parents completed the pre-survey before assignment to condition.

→ **Parent Post-survey.** This included questions regarding parent report of child's engagement in science activities and use of the *Cat in the Hat* science vocabulary over the last month, such as "cause," "effect," "measure," "build," and "vibration," as well as science vocabulary not related to the *Cat in the Hat* resources, such as "plant," "gravity," and "chemical." The survey also asked treatment-assigned

families questions about parent perceptions of the impact of *Cat in the Hat* on their child's learning and development. Treatment- and control-assigned families completed the survey at the conclusion of this study (Week 8).

» **Media Log.** The media log was a brief (5-minute) survey with several questions about the child's engagement in the study materials over the prior week. Parents in the treatment group received one text message per week that reminded them of the content of focus for the week and included a link to complete the weekly media log. Participants who did not complete the weekly media log within a few days received an additional text reminder to do so.

» **Parent Interviews.** Four parents at each of the five sites (20 total, approximately 5% of the overall sample) were sampled to participate in a brief (10- to 15-minute) phone interview during the week after their post-test data collection. Parents were sorted within sites into one of four groups based on their child's use of the *Cat in the Hat* resources as measured by the tablet usage data (low, medium low, medium high, or high). The study team randomly selected one parent from each usage group within each site. Interviewers asked parents to describe their child's overall experience using the *Cat in the Hat* videos, games, and hands-on experiences during the study. Parents were compensated $25 for their time. Interviews were conducted in either English or Spanish.

Tablet Usage Data

The study team worked with a third-party app developer to develop the *Cat in the Hat* video player app, which was how children watched the *Cat in the Hat* videos. The app logged which the *Cat in the Hat* videos each treatment-assigned child watched and for how many minutes. In addition, PBS developed a research version of *The Cat in the Hat Builds That*, identical to the publicly available app except that it logged the games each treatment-assigned child played and their use time. Finally, the study team installed

third-party data tracking software, InterGuard, on both treatment and control tablet computers. The software collected usage data in two ways: **(1)** the name of each online web page that was accessed using the device, along with the date, and **(2)** the name of any apps that were opened and the time of use. The primary purpose of the third-party software was to monitor the control group for possible use of the *Cat in the Hat* resources. This software also blocked control families from accessing the *Cat in the Hat*-related resources. Data were collected using participant and tablet identification numbers to protect

children's identities. We created summaries of the tablet usage data using frequencies, means, and standard deviations to understand the breadth and depth of children's engagement with the videos and games and their engagement across the weeks of the study among children in the *Cat in the Hat* group.[12]

For more information on data collection instruments and analysis procedures, see Appendices A and B.

Data Analysis

We used multivariate linear regression (ordinary least squares) to examine differences in post-test outcomes between the treatment- and control-assigned participants.[13] For the outcome models—child assessments and parent-reported measures— all regression models included controls for children's baseline scores on the Lens on Science assessment. This approach permitted us to identify the impact of *Cat in the Hat* on children's understanding of science and engineering concepts and practices while controlling for any differences in their initial skills. Children who were missing records or had incomplete records of either their initial skills (Lens pre-test) or post-test data were not included in the analyses. We tested the sensitivity of the regression analyses by including relevant child and family demographic characteristics.[14] The results of

the analyses for research questions 1–4 can be interpreted as supporting causal inferences about the impact of *Cat in the Hat* on children's science and engineering knowledge and practices. For these analyses, we characterize the magnitude of the effect size using benchmarks drawn from Kraft's (2019) research on the distribution of effect sizes from a large sample of randomized studies using standardized assessments as educational outcomes. This research characterizes impacts of less than 0.05 SD as small, effects of 0.05 SD to less than 0.20 SD as medium, and 0.20 SD or greater as large.[15]

We also conducted exploratory analyses on differences in the impact of the *Cat in the Hat* resources for subgroups of children and families (research question 7). We conducted these analyses by adding interactions of the subgroup and treatment indicators to the multivariate regression analyses used to answer research questions 1–4.

We explored how the amount of time that a treatment-assigned child used the *Cat in the Hat* resources was associated with the child's learning during the study. We did this by conducting regression analyses of the relationship between usage metrics and the residual value produced by the impact regressions on the four primary outcome variables (described above). These residual values represent the difference between a child's observed value for the outcome variable

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[12] Families were instructed that only the child selected to participate in the study should use the tablet during the study. However, it is possible that other members of a household, such as siblings, may have used the *Cat in the Hat* materials during the study.

[13] Appendix B provides additional detail on our data analyses.

[14] We included the relevant family and child demographic characteristics in our analyses We selected these child and family characteristics for inclusion in the analyses if they were statistically significant predictors of the outcomes in bivariate analyses. See Appendix B for model-specific covariates.

[15] Note that these classifications of effect size magnitude differ from those suggested by Cohen (1969): <0.2 Small, 02.- 0.5 Medium, >0.8 Large).

and the value that was predicted from the impact regression analyses on the respective outcome. For each outcome variable, we conducted separate regression analyses of the relationship between the residual and the number of minutes of video usage, the number of minutes of game usage, and the percentage of the available games or videos the child accessed at least once over the course of the study.[16] For analyses with the Lens data, we used usage metrics that included use of all the *Cat in the Hat* resources. For the analyses using the performance-based assessments, we used information on the usage of content related to those learning goals. For example, in examining the relationship between the residual score on the Length, Strength, and Stability task and usage, we examined the amount of time children spent watching videos that were part of the "Bridge-a-rama" content theme only. This approach provided information about whether the amount of usage of the *Cat in the Hat* resources was related to whether a child performed better or worse than expected based on his or her science and engineering skills at preschool entry and demographic characteristics.

These analyses were exploratory and did not support causal inferences about the impact of usage on children's learning.

For the quantitative data regarding family background and engagement with the *Cat in the Hat* resources collected through parent surveys and tablet usage data, the study team conducted descriptive analyses by calculating basic frequencies, percentages, means, and standard deviations.

The study team analyzed parent interview data to identify common themes about how families engaged with the *Cat in the Hat* materials using four categories: use and engagement, challenges experienced, perceived benefits for children, and perceived benefits for parents. After identifying subthemes that emerged in each of the categories, the study team selected key quotes to illustrate each of the themes.

[16] We report associations that are statistically significant at $p < .03$. We arrived at $p < .03$ by using an alpha level of $p < .10$ and accounting for multiple comparisons using a Bonferroni correction.

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Results

The analyses indicate that engagement with *Cat in the Hat* resources had medium to large **positive impacts** on children's learning of specific science and engineering concepts and practices.

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Impacts of the *Cat in the Hat* Resources on Children's Science Knowledge and Practices

The analyses indicate that access to *Cat in the Hat* resources had medium to large positive impacts on children's learning of specific science and engineering concepts and practices. Analyses provide promising evidence that *Cat in the Hat* also supported improvements in broader physical science and engineering knowledge. We describe the magnitude of these impacts using Cohen's *d* effect sizes (represented as "*d*" below).

Specifically, the results indicate that providing children with eight 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

» children's understanding of how the properties of materials (texture) and forces (friction) influence how objects move ($d = 0.33$, $p < .01$).

We also found suggestive evidence of a small positive impact on children's understanding of material properties (ability to sort objects by size, color, shape, and use). However, this impact was not statistically significant ($d = 0.15$, $p = .18$). Similarly, we found suggestive evidence that the *Cat in the Hat* resources improved children's broader physical science and engineering knowledge and practices as

measured by a subset of items from the Lens on Science (*d* = 0.11, *p* = .12). Although this impact is not statistically significant at conventional levels, the relatively low probability that this finding is an error (that is, 12% likelihood versus the 5%-10% convention) provides promising evidence of the *Cat in the Hat's* impacts on children's broader understanding of physical science and engineering knowledge and practices. These results are displayed graphically in Figure 1.

Figure 1. *Cat in the Hat* **resources' impacts on children's science and engineering knowledge and practices**
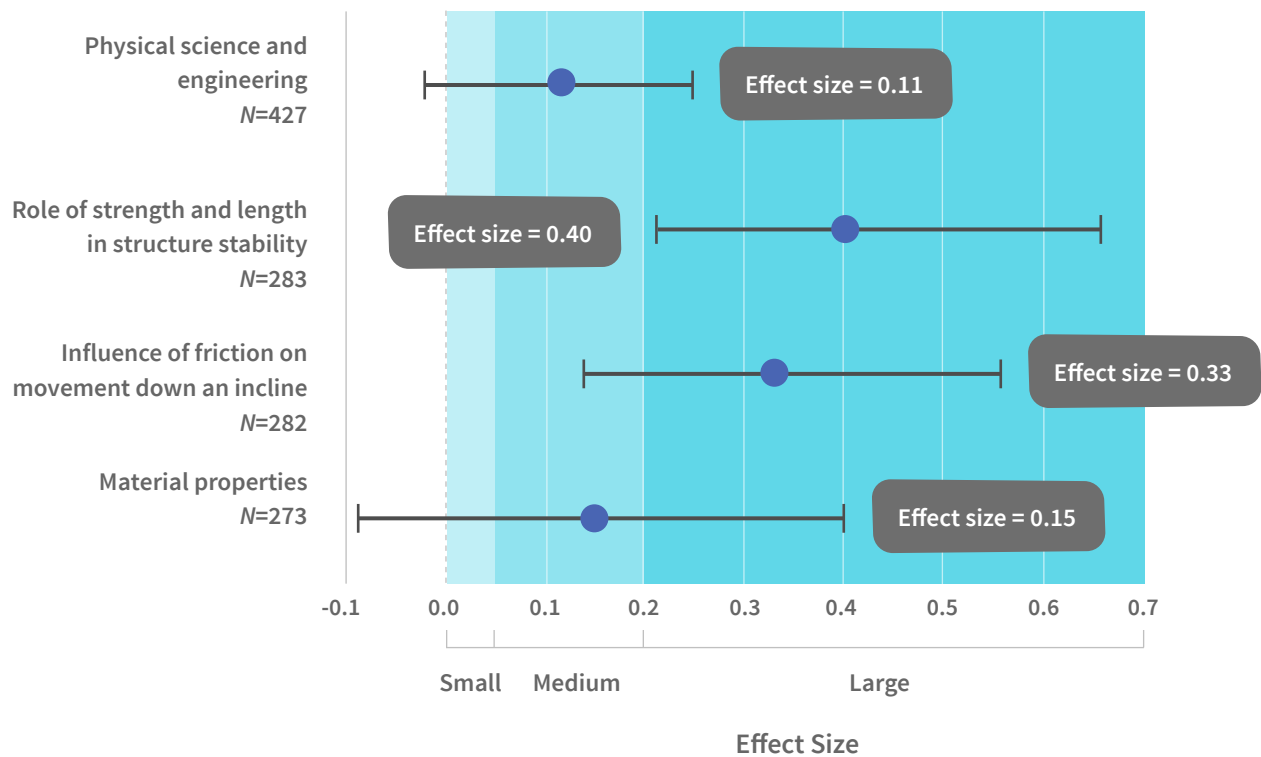
Note: All models include controls for baseline score on the Lens on Science. Effect size refers to the standardized mean difference between two groups in standard deviation units (Cohen's *d*). Characterizations of effects as small, medium, and large are based on Kraft (2019). Dots represent effect size from the regression models. Bars represent the 95 percent confidence intervals around the effect size.

Impacts of *Cat in the Hat* Resources on Parent Reports of Science and Engineering Engagement

We conducted exploratory analyses to better understand impacts of the *Cat in the Hat* resources on children's engagement with science and use of science-related vocabulary. Results from parent reports suggest that providing children with access to the *Cat in the Hat* resources increased their excitement about science (Figure 2, page 29). On average, parents in the treatment group rated their children's excitement about science higher than did parents in the control group ($d = 0.24$, $p < .05$). There were no differences between treatment group parents' reports of children's excitement about engineering. Treatment-assigned parents also reported that children engaged in more science activities over the past month than did control-assigned parents ($d = 0.20$, $p < .05$).

The exploratory analyses suggest that the *Cat in the Hat* resources increased children's use of program-related vocabulary as reported by their parents, such as cause, effect, measure, build, and vibration. Treatment-assigned parents reported that their children used more study-related science vocabulary in the past month than control-assigned families reported ($d = 0.18$, $p < .10$). These results should be interpreted with caution as they are no longer statistically significant when we control for student and family characteristics. We did not find treatment-control differences in parent reports of vocabulary words not related to the *Cat in the Hat* resources.

What Parents Say

"She always likes to build and everything. But now it's more not just building but seeing the differences in the buildings she makes. Is one stronger or not? She's questioning—why one fell and the other one didn't. So she's looking at the structure of the buildings she makes." —*Parent*

"I think there was more of a deliberateness or a consciousness in me to explain the little things that might just have passed by if it weren't for the app. Like, for the simple concept of gravity, I did get to discuss that with him because when we were looking at the slide and how to build it, how inclined it should be, and things like that." —*Parent*

"She was talking about different cause and effects, which I think is one of the videos, and like how one thing causes another thing to happen. She was talking about that later and about building bridges and how different weight is supported by different materials." —*Parent*

**Figure 2.** *Cat in the Hat* impacts on parent-reported outcomes
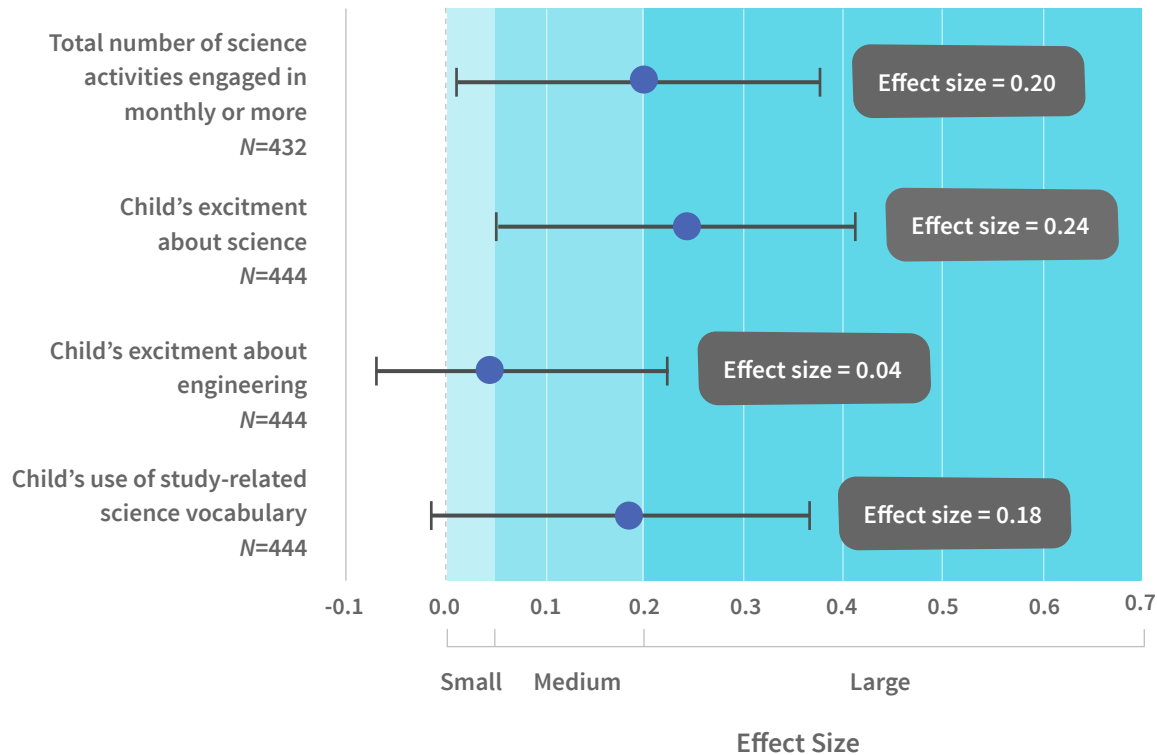
Note: All models include controls for baseline score on the Lens on Science. Effect size refers to the standardized mean difference between two groups in standard deviation units (Cohen's *d*). Characterizations of effects as small, medium, and large are based on Kraft (2019). Dots represent effect size from the regression models. Bars represent the 95 percent confidence intervals around the effect size.

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Use of *Cat in the Hat* Resources

Over the eight-week study period, children in the treatment group on average played the *Cat in the Hat* digital games for a total of 2 hours 48 minutes and watched the *Cat in the Hat* videos for 4 hours 20 minutes. Video and game usage differed substantially across children: While approximately one quarter (24%) of treatment-assigned children engaged with the videos or games for less than 2 hours across the eight weeks, over half (59%) of the children engaged with these materials for more than 20 hours. Video and game usage declined sharply after the first week of the study. During Week 1, children engaged with the study videos and games for an average of 5 hours 14 minutes. Average usage of the *Cat in the Hat* games and videos in the second week of the study dropped to just under 2 hours, and then declined to less than half an hour by Week 8.

Figure 3. Minutes spent using the *Cat in the Hat* videos and games by week

Mean	5 hrs, 14 mins	1 hr, 56 mins	1 hr, 16 mins	1 hr, 2 mins	51 mins	32 mins	34 mins	27 mins
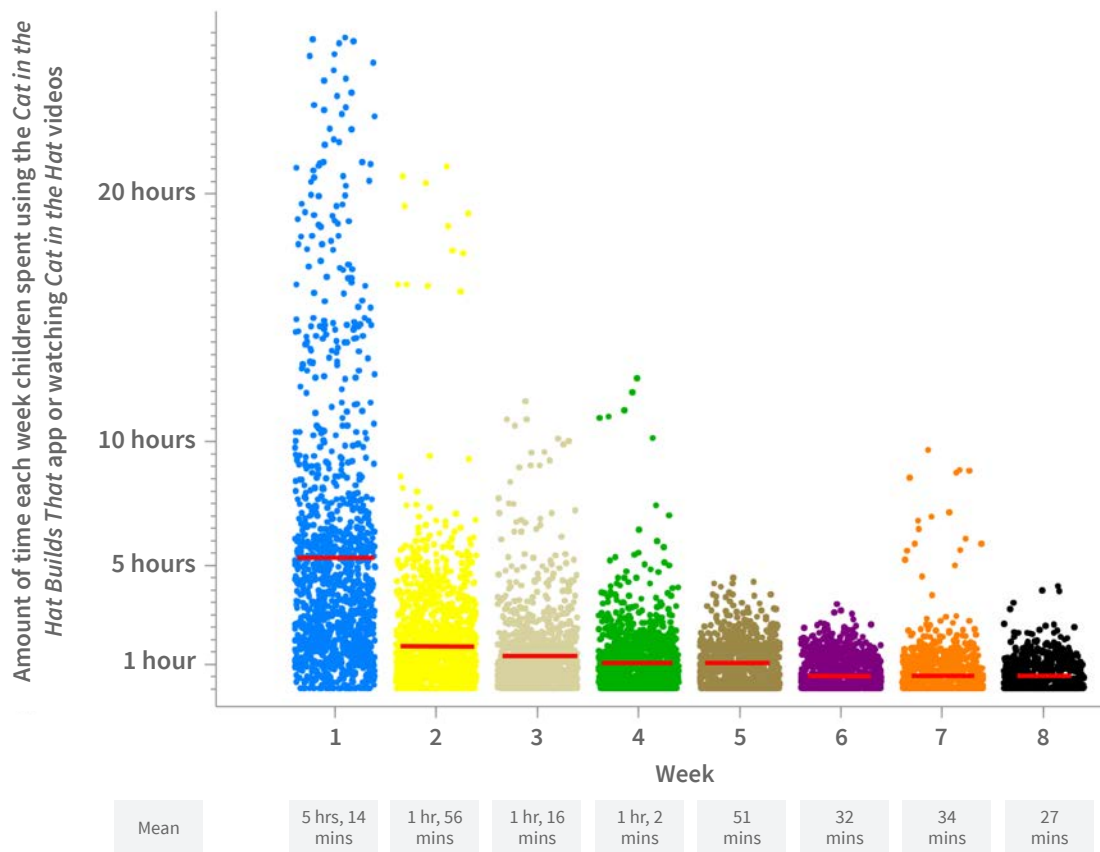
Note. Each dot represents the amount of time a single child spent using the *Cat in the Hat Builds That* app or watching the *Cat in the Hat* videos in a given week. Red horizontal bars represent the average amount of time for all children in that week.

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→ **Three quarters of the children in the treatment group (75%) accessed materials from four of the six *Cat in the Hat* content themes for 20 minutes or more across the eight-week study, and nearly half of the children (47%) accessed material from all six content themes.**

Figure 4. Percentage of all *Cat in the Hat* games and apps used by treatment group children (*N*=229)
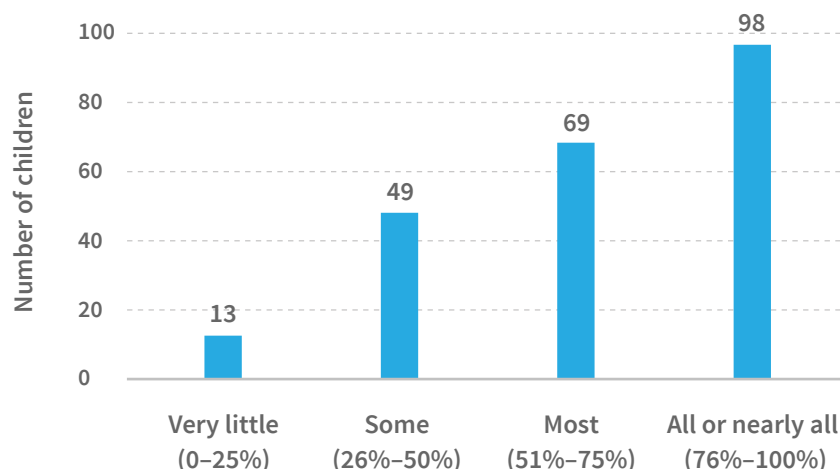
Analyses of tablet usage data suggest that about half (49%) of the children accessed at least one of the real-world activities embedded in *The Cat in the Hat Builds That*. Children accessed the hands-on activities 1.4 times on average, for an average time of under one minute (0.48 minutes).

Among children in the control group, six were able to circumvent the app-blocking software, and one of these children accessed more than 20 minutes of *Cat in the Hat* content over the study period.

Parent responses during interviews indicate that children enjoyed playing the games and watching the videos. Parents reported that the "Bridge-a-rama" and "Slidea-ma-zoo" games were particularly popular with children. In addition to using the *Cat in the Hat* apps, children also watched the *Cat in the Hat* videos on other platforms such as Netflix and YouTube.

Parents also reported that their children enjoyed the real-world activities, although they used these activities less regularly. Interview data suggest that the resources also fostered more informal everyday science and engineering activities. Close to three quarters (73%) of parents reported in their weekly media logs that they used a *Cat in the Hat* hands-on activity with their child at least once during the study period. Interviewed parents indicated that the videos and games were a great source of ideas for everyday activities and that their children mimicked activities they saw in the media with their toys, such as building bridges or making patterns. Some interviewed parents also noted that the resources gave them ideas for science activities to do with their children at home and how to incorporate science into everyday activities in a way that was fun and child-friendly. For example, parents reported becoming more aware of their own language and trying to include more science talk and scientific concepts and ask more questions.

When asked about study challenges, five parents reported that they had trouble getting their child to follow the suggested schedule because their child wanted to choose what to do or repeat an activity rather than do the ones in the suggested calendar, or that their child stopped playing games after a short period because they were not challenging enough or did not have enough levels—perhaps a reason for the decline in usage of the *Cat in the Hat* videos and games over the course of the study (see Figure 3). Some parents referenced their own lack of knowledge about science concepts and about how to engage children in science.

The majority of interviewed parents indicated that the activities helped their child learn about a variety of science concepts and skills. Specifically, parents talked about an increase in skills related to asking questions, predicting, problem solving, trying different methods, and testing, as well as critical thinking and curiosity. Parents also described learning related to concepts such as math and measurement; the properties of different materials; and content related to plants, insects, and sounds. Parents did not use the term "engineering" in describing learning, but many referenced "building." A few parents also noted enhanced social-emotional development, including patience, confidence, and independence. Finally, many parents felt that children's interest in science and engineering increased or was enhanced, although many reported that their children were already interested in science before the study.

Relationship between use of the *Cat in the Hat* resources and performance on science and engineering measures.

In general, we did not identify a consistent relationship between the amount of time children used the *Cat in the Hat* games or watched the *Cat in the Hat* videos and their performance on post-test measures. We did find some evidence to suggest that the more time children watched the "Bridge-a-rama," videos, the more they outperformed our predictions on the Length, Strength, and Stability assessment. Similarly, the more time children spent playing the "Slidea-ma-zoo" game, the more they outperformed predictions on the Surfaces and Friction task. However, the positive relationship between use and outcomes appears to weaken at very high levels of use (approximately 2 hours of "Bridge-a-rama" video use and 3 hours 30 minutes of "Slidea-ma-zoo" gameplay). Future analyses will explore this relationship in more depth. We did not observe

any statistically significant relationships between usage variables and children's performance on the Lens or the Colors, Shapes, and Uses measures.

Impacts of *Cat in the Hat* by Subgroup

We examined whether the impact of *Cat in the Hat* on children's science knowledge and practice differed depending on children's prior science knowledge and demographic characteristics. Specifically, we considered whether the impact of providing access to the *Cat in the Hat* resources differed depending on children's baseline Lens scores, age, gender, ethnicity (White versus non-White); whether the parent had a high school education or higher; and whether the child lived in an English-only household, attended center-based care for 30 hours or more, and was in kindergarten.[17]

We did not find evidence that the impact of *Cat in the Hat* on children's physical science and engineering knowledge, as measured by the Lens on Science assessment, was statistically significantly different for children in any of the subgroups described. Similarly, we did not find evidence that the impact of the *Cat in the Hat* resources on children's understanding of the role of material properties (strength and length) and

forces in structural stability or the role of material properties (texture) and forces (friction) on movement down an incline varied depending on their baseline physical science and engineering knowledge or background characteristics.

However, we did find that the impacts of *Cat in the Hat* on children's understanding of how objects can be sorted based on their material properties and uses were stronger for children whose families spoke English only at home than for children whose families spoke a language other than English at home ($p < .01$). These findings suggest that the *Cat in the Hat* resources differentially affected children's understanding of material properties as measured by the Colors, Shapes, and Uses performance-based assessment: Children who spoke English only at home seemed to benefit more from access to the *Cat in the Hat* resources relative to their understanding of material properties than did children from families who spoke languages in addition to or other than English at home.

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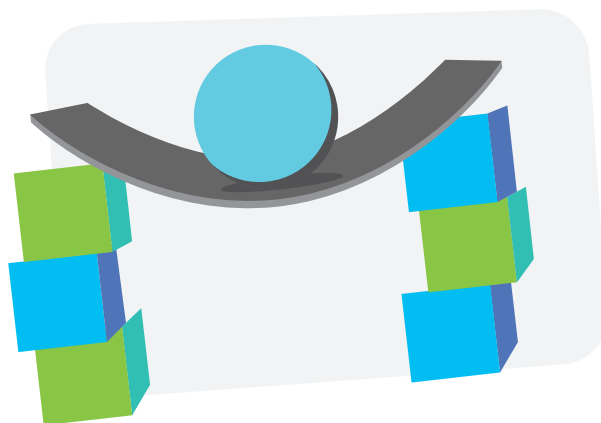
[17] We report associations that are statistically significant at $p < .0125$. We arrived at $p < .0125$ by using an alpha level of $p < .10$ and accounting for multiple comparisons using a Bonferroni correction.

The results of this study indicate that providing young children and their families with **access to science-based media resources** can support their science- and engineering-related learning.

Specifically, our study found that providing families with access to the *Cat in the Hat* videos and digital games improved children's understanding of physical science concepts related to the two physical science core ideas of matter and forces: the role of material properties (strength and length) and forces in structural stability, and the role of texture on friction and movement down an incline. Children who were provided access to the *Cat in the Hat* resources outperformed those who did not have access on measures of how the properties of objects (such as size and shape) and materials (such as hardness and flexibility) make them suitable for different purposes, and how different forces (pushes and pulls) can cause objects to move and influence the stability of a bridge. Children with *Cat in the Hat* access also learned more about how the properties of objects, materials, and forces (including friction) influence the motion of objects. We also found promising evidence that children's understanding of sorting and their understanding that different objects can be described and categorized based on their observable properties or functions improved as a result of using the *Cat in the Hat* resources. Although not statistically significant, and thus less certain, results from the externally developed assessment of children's physical science and engineering knowledge and practices also provided suggestive evidence of the *Cat in the Hat's* impact on broader science and engineering learning.

The treatment-control differences in children's performance on the performance-based assessments also provided evidence of children's ability to transfer learning from a digital environment to a real-world setting. This evidence is notable in the context of a substantial body of research that has documented the challenges young children face in transferring knowledge from videos because of difficulties in separating fantasy from reality (Woolley & Ghossainy, 2013), confusion about how videos and games relate to the real world (Mares & Sivakumar, 2014), and difficulties in transferring two-dimensional

experiences to a three-dimensional world (Anderson & Pempek, 2005). The results of this study offer evidence that fantasy-based story-telling can support young children's accurate scientific understanding if the narrative content focuses on factual science and engineering concepts and practices.

Among the strengths of this study was the attention to minimizing bias wherever possible. Attrition was minimal and met the What Works Clearinghouse standards. Study team assessors and analysts remained blind to the participants' treatment or control status throughout the study. Parents in the control condition were not told they were control families. These processes allow us to feel confident in making casual inferences regarding the impacts of the *Cat in the Hat* resources.

Young children spend substantial time using digital media. A critical question raised by these practices is whether this time spent engaging with videos and digital games can be productive. The increasing ubiquity of media in our daily lives and the opportunity that media offer to scale up an educational intervention at a low cost add urgency to this question. A growing body of research on media resources suggests that certain kinds of media experiences can help children learn literacy, math, and socio-emotional skills (Anderson et al., 2001; Fisch, Truglio, & Cole, 1999; Hirsh-Pasek et al., 2015; Hurwitz, 2018; Kirkorian, Wartella, & Anderson, 2008; Schmidt & Anderson, 2007). However, very little is known about how and whether media can help young children learn science concepts and practices, and few science-based media

resources are available for young children. This study adds new knowledge about the promise of media to support science and engineering learning. Moreover, despite the research evidence about the difficulty children face in transferring knowledge to new contexts, this study provides important findings about the possibilities media resources hold for helping children develop knowledge that can transfer from a digital to a physical environment.

The size of the impacts of *Cat in the Hat* on learning is particularly notable given the relatively low per-child cost to scale up access to the *Cat in the Hat* resources compared to typical effective science interventions such as resource-intensive science kits or professional development (Slavin, Lake, Hanley, & Thurston, 2014). In this context, the size of the *Cat in the Hat* resource impacts on learning (ranging from 0.11 to 0.40 SD) are substantial.

The results of the study also raise new questions. The study focused on a relatively narrow set of physical science and engineering concepts and practices; future research should examine whether media hold promise for other concepts in science that are more abstract. In addition, measures of parent engagement in the media in this study relied almost entirely on self-report; an important question related to children's ability to transfer learning from a digital environment to the physical world is the extent to which parents facilitated this transfer through, for example, real-world activities and talking about the *Cat in the Hat* content.

Limitations

This study used a rigorous experimental design. Assignment and data collection procedures prevented assessors and families from knowing their treatment condition, and attrition from the study was minimal. We nevertheless encourage readers to consider the following limitations when interpreting study findings.

Generalizability of Study Sample. Study sites were selected to include multiple geographic regions (Northeast, Midwest, Southwest, and West), but site selection was not designed to produce a nationally representative sample. Further, participating families were volunteers recruited through social media posts regarding participation in a digital media study. They and their children may thus be different from parents who do not use social media or are not interested in participating in a digital media study.

Generalizability of Study Experiences. The *Cat in the Hat* materials are widely available through the PBS KIDS website and local public media stations, but the ways study children accessed them differed in important ways from how they would be accessed by children outside of the study. First, all digital materials (games and videos) were preloaded onto tablet computers and were accessible to children via icons on the tablet home screen. This kind of accessible display most likely encouraged treatment-assigned children to access the materials more often than they would have otherwise, particularly given that episodes

are not available all at once—rather, several episodes at a time are broadcast over a year. Second, all participating children were given a new tablet computer as part of the study. Providing this resource does not limit the internal validity of the study findings as both treatment- and control-assigned children were given the new tablets. It is nevertheless likely that the novelty of the new device encouraged treatment-assigned children to use the *Cat in the Hat* resources more than they would have without a new device. Third, treatment-assigned parents were encouraged to support their children's use of the *Cat in the Hat* materials through reminders about study material. Again, these reminders most likely led children to use the materials more often than they would have outside the study.

Study Measures. We used a combination of existing measures and measures that we adapted or created for use in this study. The study team designed these measures to reflect children's understanding of the knowledge and practices that are the targets of the *Cat in the Hat* content. We do not have information on the validity and reliability of these measures. A detailed description of our measure development procedures is in Appendix D.

Implications

We see three **key implications** from this study.

1 First, interacting with the Cat in the Hat resources measurably improved some aspects of children's knowledge of science and science and engineering practices.

Although our certainty about the impacts is stronger for a subset of content knowledge and practices in physical science and engineering, the results provide consistent evidence that *Cat in the Hat* helps children learn science and engineering concepts and practices.

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2 Second, the strong results on the friction and incline and the structure and stability performance-based measures indicate that children's experiences manipulating materials in a digital context can transfer to mastery of those practices and knowledge in the physical world.

This finding provides a substantial contribution to overall research literature on how children learn from digital media.

Recent research on effect sizes and educational interventions (Kraft, 2019) calls for considering the magnitude of a program's impact within the broader context of the costs and risks associated with the interventions. Given both the easy scalability and low per-child cost of providing access to the

Cat in the Hat resources, the positive results from this study also appear meaningful in the context of other typically resource-heavy science interventions. In other words, we should interpret these findings differently than we would those for a classroom science intervention over the course of a school year that requires training of a teacher and other expensive resources and that is challenging to scale up. The cost and effort to implement this intervention is less, and so a smaller impact on learning is more meaningful. For example, before the eight-week *Cat in the Hat* experience, children were most likely already engaged in similar activities—using media—but possibly with a less-educational resource, given the general lack of quality of educational apps (Hirsh-Pasek et al., 2015). In other words, even in the face of medium to small effect sizes, simply directing families to high-quality media and to some guidance for parents about how to use the media seems like an important step in improving young children's engagement in science.

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3   **Third, these findings also point to the importance of careful design that aligns with key learning goals relevant for young children.**

The *Cat in the Hat* media were developed with an intensive focus on core science and engineering concepts and practices and with the engagement of content experts and iterative formative development processes, all of which likely contributed to the resulting high-quality media. The positive results of this study demonstrate that well-designed, high-quality, and learning-focused content can support learning outcomes among young children.

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