PBS KIDS Play & Learn Science

Evaluation Report

July 2019

Ready To Learn **Research**

EDC Education Development Center

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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 Innovation and Early Learning. 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 low-income children. 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.

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Executive Summary

The PBS KIDS *Play & Learn Science* app was developed as part of the Corporation for Public Broadcasting (CPB) and Public Broadcasting Service (PBS) Ready To Learn Initiative, funded by the U.S. Department of Education. This study explored the impact of the PBS KIDS *Play & Learn Science* app, when used in a supportive context, on

- children's understanding of science concepts and use of science and engineering practices;
- children's use of science vocabulary;
- child and parent-child engagement in science and engineering; and
- parent confidence supporting their child's science learning.

PBS KIDS *Play & Learn Science* App and Supports

The *Play & Learn Science* app introduces foundational science concepts and science and engineering practices through five distinct sets of activities: *Water Games*, *Ramp and Roll*, *Shadow Play*, *Weather Control*, and *Gear Up*. Each activity set includes three digital games and a designated parent page that incorporates suggestions for supporting their children's game play (*Tips*) and their related real-world explorations (*Activities*).

For this study, the research team developed a four-week structured experience to support exploration of the *Play & Learn Science* app. Families were encouraged to focus on one set of in-app and hands-on activities each week. Two family science nights allowed families to preview these activities and receive take-home supplies.

Methods

Participants were recruited from two child-care centers: a private child-care center in the South that accepted child-care fee waivers, and a Head Start center in the Northeast. Sample sizes ranged from 31 to 33 participants by outcome measure. Children's ages ranged from 37 to 67 months.

This study had a single-group design with pre- and post-experience parent surveys and child assessments. The research team developed non-standardized child assessments for this study, which were tailored to *Play & Learn Science* content. Children participated in pre- and post-experience vocabulary and performance-based assessments. The multiple-choice vocabulary assessment measured children's receptive English language vocabulary for key words from the *Play*

& Learn Science app. The performance-based assessment consisted of five researcher-developed hands-on tasks, each designed to assess focal concepts and skills from one or more *Play & Learn Science* activity sets.

Findings

Findings suggest that when used in a supported context, the PBS KIDS *Play & Learn Science* app can benefit both children and their parents.

Child outcomes include

- gains in understanding of science content and in use of science and engineering practices;
- increases in use and understanding of science vocabulary; and
- increased excitement about science, technology, engineering, and mathematics.

Parent outcomes include

- increased parent-child engagement in science- and engineering-related activities; and
- increases in confidence for supporting their child's science learning.

Limitations

This study's single-group design limits our ability to make claims about causation and does not meet What Works Clearinghouse evidence standards (What Works Clearinghouse, 2017). In addition, we cannot claim that these findings would extend to average users of the *Play & Learn Science* app, because this study included additional supports based on the app. Further, the study used researcher-designed assessments aligned to the *Play & Learn Science* app content because no existing assessments were appropriate for this study's content and design. We cannot say whether gains found in this study would translate to standard academic assessments.

Conclusions

As part of the CPB-PBS Ready To Learn Initiative, the PBS KIDS *Play & Learn Science* app is intended to support families in exploring science together. The findings suggest that a high-quality digital app can be a catalyst for real-world science exploration, especially when it incorporates tips for parents about how to mediate children's use of science-focused digital games, explicit guidance for related real-world science activities they can do at home with their children, and specific suggestions for interacting with their children in ways that stimulate science exploration, thinking, and conversation. Findings also suggest that parents benefit from direct guidance that helps them navigate the app, modeling of the hands-on activities and interaction suggestions in the app, and supports and encouragement for using the app in a structured and sequential manner. These results add to a body of research that demonstrates the potential of educational media to support children's learning, particularly when adults support their children's media use. These findings underscore the value of current CPB-PBS Ready To Learn family-focused science outreach programs and suggest that schools, child-care centers, and other organizations aimed at increasing family engagement in science learning should consider using the app as part of their own family science events.

Background

Objective

This report presents findings on the impact of the PBS KIDS *Play & Learn Science* app, when used in a supportive context, on children's science learning—their early understanding of science concepts, their use of science and engineering practices, their use and understanding of science vocabulary, and their interest in doing and talking about science. The PBS KIDS *Play & Learn Science* app was developed as part of the CPB-PBS Ready To Learn Initiative, funded by the U.S. Department of Education.

The importance of science education in the 21st Century

Science literacy has become essential for navigating the demands of our increasingly science- and technology-oriented world and for pursuing training and careers across the workforce. Furthermore, our democracy depends on the ability of all citizens to make evidence-based decisions on a range of science-related topics and to access, understand, analyze, and evaluate information from a vast number of sources. It is critical that a 21st-century science education introduces students to core science ideas and concepts, engages them in using the science and engineering practices, cultivates their critical thinking, and fosters their scientific habits of mind. Furthermore, the science education community must commit itself to promoting equity for all students (National Research Council [NRC], 2012). The Next Generation Science Standards (NGSS; NGSS Lead States, 2013) exemplify this vision. The NGSS incorporate core ideas, practices, cross-cutting concepts, and a learning progressions approach that recognizes the capacity of all K–12 students to do and learn science. However, children's science learning begins long before they reach the kindergarten door (McClure et al., 2017). Additionally, increasing attention is being paid to the science that children learn outside of school, as well as to the roles that families, informal experiences, and digital media can play in supporting and fueling children's science learning, inquiry, and interests (NRC, 2009).

Science education should start before kindergarten

Research clearly indicates that young children are primed to engage with the concepts and practices of science long before they begin formal schooling (Duschl, Schweingruber, & Shouse, 2007; Gelman, Brenneman, Macdonald, & Román, 2009; NRC, 2012; National Science Teachers Association, 2014), and that high-quality inquiry-based science experiences in the early years lay a foundation for later academic learning and achievement across the developmental domains (Allen & Kelly, 2015; Saçkes, Trundle, Bell, & O'Connell, 2011). Doing and learning science promote children's conceptual learning, their ability to grasp more abstract ideas, and their development of executive function and self-regulation (Kirschner, Sweller, & Clark, 2006; Weisberg, Hirsh-Pasek, &

Golinkoff, 2013). Cognitively challenging, personally meaningful science experiences also boost children's motivation, persistence, and interest in doing and learning science, and influence their later school achievement and career choices (Heckman, Stixrud, & Urzua, 2006; Institute of Medicine, 2000; Lindahl, 2007).

Challenges to science in the early years

Many young children do not have access to high-quality science experiences and, similar to the "literacy opportunity gap," the "science opportunity gap" already exists by the time children enter kindergarten (American Educational Research Association, 2016). Many teachers and families of children ages 3 to 6 report that they lack the knowledge and confidence to support children's early science learning (Gerde, Pierce, Lee, & Van Egeren, 2018; Silander et al., 2018), and that an emphasis on literacy in early childhood classrooms means that little time is devoted to science in preschool and kindergarten (Gelman et.al., 2009). Implicit biases about science, misconceptions about its relevance and appropriateness for young children, and a lack of understanding of its increasing significance at all levels of the workforce may even cause some adults to steer children away from science and other STEM (science, technology, engineering, and mathematics) opportunities (Bian, Leslie, & Cimpian, 2017; Kadlec, Friedman, & Ott, 2007; Newitz, 2014).

The critical role of parents and families

The 21st-century demand for a more science-literate population and workforce has provoked a national dialogue about science education in schools, including for our youngest students. However, current research indicates that young children's informal science experiences may be even more influential than school science experiences in sparking their motivation to do and learn science (Crowley et al., 2001; Turkle, 2008) and that families are powerful mediators of their children's science activities, interests, and learning (Silander et al., 2018; Turkle, 2008; Weiss, Little, Bouffard, Deschenes, & Malone, 2009). Informal experiences are compelling because they enable children to pursue their individual science interests, address children's need to figure things out and solve problems, and forge connections between the science children are learning and real-world applications (Crowley et al., 2001). Specific behaviors of parents that are associated with sustaining children's interests in science activities are having fun themselves, getting actively involved, initiating and sustaining science talk, and making connections to their children's daily lives (Fender & Crowley, 2007; Liebham, Alexander, & Johnson, 2013; Rigney & Callanan, 2011). A growing body of research points to the importance of parent–child conversations for igniting children's science dispositions and supporting their causal and conceptual reasoning (Callanan, Castañeda, Luce, & Martin, 2017; Haden, 2010). However, science can be a challenging domain for parents to define and support, and many parents lack the confidence, information, and resources they need to nurture their children's natural scientific impulses (Silander et al., 2018).

The potential of digital media to support children and families

The Public Broadcasting Service (PBS), in partnership with the Corporation for Public Broadcasting (CPB), has developed a range of digital resources to support children's and families' science learning. These resources were developed as part of the CPB-PBS Ready To Learn Initiative, funded by the U.S. Department of Education, to promote school readiness, particularly for low-income children. Studies of Ready To Learn resources have shown that digital media can further children's learning, particularly when knowledgeable and nurturing adults mediate their use by coviewing, engaging, and interacting with children as they view and play (Anderson, Huston, Schmitt, Linebarger, & Wright, 2001; Fisch, Truglio, & Cole, 1999; Hurwitz, 2018; Moorthy et al., 2013; Pasnik, 2018; Rideout, 2017; Schmidt & Anderson, 2006). The National Association for the Education of Young Children (NAEYC) and the Fred Rogers Center (2012) agree that technology and media can support positive family/child relationships, as well as learning, when adults mediate their use. CPB and PBS, as leaders in educational media, are likewise committed to creating and disseminating digital resources that support 2- to 8-year-old children's foundational science learning in relation to the NGSS and that enable parents to more fully realize their potential in promoting their children's science learning. However, families in a previous study (Silander et al., 2018) reported that their children were less likely to learn science or math from educational media—in comparison to literacy, for example—and that they, as parents, were less likely to help their children make connections between science concepts introduced in media and their daily family activities. Parents also said that they would do more science with their children if they had access to engaging, high-quality science content, ideas for activities they could do at home with readily accessible and inexpensive materials, information about what their children should be learning, and tips about how they can best support science learning (Silander et al., 2018).

PBS KIDS *Play & Learn Science* App

To address this need, the CPB-PBS Ready To Learn Initiative developed the PBS KIDS *Play & Learn Science* app. This app (described below) is intended to support family science exploration both within the app and through direct hands-on explorations for children ages 3 to 5 and their parents. High-quality media can help adults broaden their understanding of the nature of science, enabling them to view it as an active, collaborative, and creative process of questioning, investigating, sharing observations and findings, and figuring out how the world works (Goldstein, Christensen, Gerard, & Silander, 2018). Media resources also can provide parents with ideas for at-home science explorations that are engaging to their children, accessible and affordable, and incorporate explicit guidance for asking questions that fuel children's science inquiry, thinking, and motivation (Silander et al., 2018; Troseth, Saylor, & Archer, 2006). The independent research organizations Education Development Center (EDC) and SRI International (SRI) explored how well the PBS KIDS *Play & Learn Science* app and associated supports engage children and families in science practices and concepts. We implemented this experience in child-care centers in two U.S. sites, one in a small city in the South, and the other in a small city in the Northeast.

PBS KIDS *Play & Learn Science* App and Supports

Theory of change

The objective of this study was to evaluate the impact of the *Play & Learn Science* app, when used in a supportive context, on children's science learning—their early understanding of science concepts, their use of science and engineering practices, their science vocabulary, and their interest in exploring and talking about science topics. The research team developed a structured study experience intended to support family engagement and joint parent/child media use. To optimally and intentionally promote their children's science learning, parents need guidance about appropriate content, activity ideas for supporting their children's inquiry and exploration during their families' daily lives, and explicit tips for interacting with their children in ways that promote science exploration and that help them think and talk about their experiences, observations, and ideas (Silander et al., 2018). Such guidance is provided in the *Play & Learn Science* app itself, and this study further focused on support for parents by emphasizing a limited number of games and related activities, creating a specific structure and sequence for what topics and activities families would explore, providing materials and books that elaborate on target concepts and practices, and modeling the activities, tips, and conversational prompts during face-to-face family science nights. An additional support for families was a guide that provided information about the study and the app and reinforced the suggested activities and tips available in the app. Other resources were a tablet, two face-to-face family science nights, a variety of simple, everyday exploration materials to take home, and reminder texts to use the app.

PBS KIDS *Play & Learn Science* app

The *Play & Learn Science* app introduces basic science concepts and science and engineering practices by way of five distinct sets of in-app and hands-on activities: *Water Games*, *Ramp and Roll*, *Shadow Play*, *Weather Control*, and *Gear Up*. Each set of activities includes three digital games and a designated parent page that incorporates the following:

- **Tips.** Information for parents about the concepts and skills the game introduces, as well as suggestions for how they can interact with children in ways that support their science inquiry and learning and help them make connections to everyday life experiences.

- **Activities.** Three or four "real-world" hands-on activities that promote further exploration of the concepts introduced in the games; integrate use of the science and engineering practices; and include specific implementation/facilitation suggestions for parents. One activity in each set incorporates a list of suggested children's books that center on the relevant target concepts.
- **Journal.** Images from the target games with explicit suggestions for comments and questions parents can use to support their children's reflection on their game experiences.

Water Games and *Ramp and Roll* introduce physical science concepts related to the NGSS core ideas (1) Matter and Its Interactions and (2) Motion and Stability: Forces and Interactions. *Shadow Play* introduces concepts related to the core idea Waves and Their Applications in Technologies for Information Transfer. *Weather Control* and *Gear Up* introduce Earth and Space Science concepts related to the core idea Earth's Systems. The PBS KIDS Science Learning Framework[1] describes what 2- to 8-year-old children might be expected to do and learn in relation to these core ideas, concepts, and practices. All the activity sets, in the combined context of the games and the real-world explorations, engage children in using science and engineering practices with a focus on planning and carrying out investigations, analyzing and interpreting data, using mathematics and computational thinking, constructing explanations, and obtaining, evaluating, and communicating information.

Each week the study focused on one activity set. The research team suggested games and activities within that set for parents to play with their children (Exhibit 1). We selected games and activities based on the opportunities they provided for children's active engagement, how well the activities related to the target games, how easily parents could implement and facilitate the activities at home, and our own capacity to implement and model the activities at the face-to-face family science nights. The components of the intervention in this study are detailed in Exhibit 1.

[1] Development of the PBS KIDS Science Learning Framework has been informed by the Next Generation Science Standards and other learning standards, and guided by early science advisors as part of the CPB-PBS Ready To Learn Initiative

Exhibit 1. Study schedule of PBS KIDS *Play & Learn Science* app activities and supports

Activity set	Target game	Related parent activity	Take-home family science materials
Week 1: *Ramp and Roll*	Explore the Roll Supplement: Hit the Target	Roll, Slide, or ... Not! Supplement: How Far Will It Go?	Cove molding ramp Bag of objects for rolling/sliding Target Book about motion
Week 2: *Water Games*	Sink or Float	Does It Sink or Float?	Sink/float prediction chart Bag of objects for sinking/floating Book about sinking/floating
Week 3: *Shadow Play*	Guess the Shadow Supplement: Exploring Shadows	Flashlight Shadows Supplements: Changing Shadows Animal Shadow Puppets	Flashlight Materials to make shadow puppets Sidewalk chalk for tracing shadows Book about shadows
Week 4: *Gear Up and Weather Control*	Gear Up Supplements: The Amazing Umbrella Thermometer Picking	Gear Up Let's Go Outside Supplements: The Amazing Umbrella Testing materials with water Thermometer activity	Weather chart Plastic pipettes Four different materials Child-safe thermometer Book about weather

Family science nights

The study included two family science nights, one at the beginning and one midway through the study. Attendance at the first science night was mandatory for families to be part of the study. At that session, parents completed a pre-experience survey and received a tablet computer they could keep. Attending the second science night was optional; however, attendance at both family nights was monetarily incentivized.

The research team drafted plans for both family science nights, incorporating feedback from staff at the centers participating in the study and educators at WCTE[2]. The activities presented at each night modeled the games and activities that families would be asked to do at home during the subsequent two weeks.

The research team and local center staff facilitated the family science nights, which lasted 1.5 to 2 hours. The science nights began with a shared meal and a brief discussion of the evening's focal science content, including tips for engaging young children in science and an introduction to the evening's activities. Families were provided with "passports" to support their navigation through three to four facilitated stations and were invited to rotate among the stations for the rest of the night. At the first family night, the station topics were *Ramp and Roll* and *Water Games*. At the second family night, the stations focused on *Shadow Play* and *Gear Up*/*Weather Control*. Each station had materials and tools for two to four investigations that mirrored the parent activities in the app and signage with recommended conversation prompts to stimulate parent-child conversation about each activity. Each station also offered an opportunity to record predictions or findings for at least one of the activities.

At both family nights, children and their parents had an opportunity to become familiar with the app and to play the target games. At the first family night, the app was introduced at a separate station. At the second family night, use of the app was integrated into each station so that families could make closer connections between the games, tips, and activities in each activity set and the related hands-on investigations. Facilitators supported families' use of the app and all hands-on investigations, encouraging parent-child exploration and conversation. Facilitation of the app included familiarizing children and their parents with the games, how to navigate through them, and how to locate the family activities and tips within the app.

[2]WCTE is a PBS member station that works closely with the CPB-PBS Ready To Learn Initiative and supports local outreach programming.

Additional intervention supports

In addition to the family science nights, this study supported families' use of the *Play & Learn Science* app at home by providing the following:

- family guide with instructions for using the tablet, the *Play & Learn Science* app, and each focal parent activity;
- calendar of study events and weekly topics;
- take-home materials for family activities to do at home and demonstrated during the family science nights (see Exhibit 1); and
- eight text messages reminding parents of study activities, as well as of weekly topic areas and associated games and parent activities.

Because all these resources and materials were used at home, we could not support families' use of them directly. However, facilitators kicked off the second family science night with a reflection, inviting children and families to describe what activities they had done together at home and asking parents to share what they thought about the activities and how their children responded to them or extended them.

Study Design and Methods

Research questions and study design

This study pursued five research questions.

- What is the change in children's understanding of science concepts and use of science and engineering practices after four weeks of exposure to the PBS KIDS *Play & Learn Science* app and supports?
- What is the change in children's use of target vocabulary after four weeks of exposure to the PBS KIDS *Play & Learn Science* app and supports?
- To what extent do parents report that four weeks of exposure to the PBS KIDS *Play & Learn Science* app and supports improved their children's science and/or engineering concepts, skills, and vocabulary?
- To what extent do parents report that four weeks of exposure to the PBS KIDS *Play & Learn Science* app and supports promoted children and their parents doing and talking about science/engineering?

- To what extent do parents report that four weeks of exposure to the PBS KIDS *Play & Learn Science* app and supports improved their confidence in or ability to support their child's science/engineering learning?

To answer these questions, this study had a single-group design with pre- and post-experience child assessments and parent surveys.

Recruitment and incentives

This study targeted child-care centers serving low-income families who had not participated in PBS KIDS science outreach in the past. Site 1 was a private child-care center in the South that accepted child-care fee waivers. Site 2 was a Head Start center in the Northeast.

Centers distributed recruitment flyers and registration and consent forms to families. Each site was encouraged to recruit 15 to 20 families who were likely to meet the eligibility criteria. To be eligible, families had to

- agree to attend the first family science night so they could learn about the study and receive their tablet;
- have at least one child aged 3- to 5-years old; and
- be fluent in English (both parent[3] and child).

Recruitment did not target low-income families specifically. Upon receipt of the registration forms, researchers called families to screen for eligibility.

Participants received $50 for participating in the first family science night; $50 for participating in the second family science night; and $50 for completing the parent post-experience survey.

Child assessments

The research team developed non-standardized child assessments for this study, which were tailored to the *Play & Learn Science* content. The children participated in pre- and post-experience vocabulary and performance-based assessments that the research team administered during the school day. Each assessment lasted 20–25 minutes. Pre-experience child assessments were administered on the day of or the day before the first family science night; all these assessments were completed before

[3] For simplicity, we refer to adult participants in this sample as parents, although the sample may have included a range of caregivers such as grandparents and legal guardians.

the start of the first family science night. Post-experience child assessments were administered after the four-week intervention period.

The multiple-choice vocabulary assessment measured children's receptive English language vocabulary for key words from the *Play & Learn Science* app. It consisted of two training items and 19 assessment items. Children were asked to identify which of four pictures represented the word spoken by the examiner. Items were arranged in ascending order of difficulty based on age-standardized vocabulary lists (Dale & Chall, 1948; Francis & Kučera, 1964; Marvin, Beukelman, & Bilyeu, 1994). To reduce frustration, the assessor discontinued the assessment after a child answered five consecutive items incorrectly, scoring all subsequent items as zero.

The performance-based assessment consisted of the following five researcher-developed hands-on tasks, each designed to assess focal concepts and skills from one or more *Play & Learn Science* games and their associated family materials.

- **Activity set: *Ramp and Roll*; focal game: *Explore the Roll*.** Participating children were asked to observe and describe six objects—two rollers, two sliders, and two objects that can either roll or slide depending on how they are positioned—and to test how each object moves on a ramp. They were given a chart to sort the objects into one of three categories (rolls, slides, can roll and slide). For objects the children identified as rolling or sliding, they were asked to explain their thinking about why these objects move the way they do. For objects the children identified as both rolling and sliding, they were asked to describe or demonstrate how they could make the object roll or slide.
- **Activity set: *Water Games*; focal game: *Sink or Float*.** Participating children were asked to observe and describe six objects—three sinkers and three floaters. They were asked to define the terms *sink* and *float* and to record their predictions about whether each object sinks in or floats on water. For two correctly sorted objects—one sinker and one floater—the children were asked to explain their thinking about why that object would sink or float, and to describe or demonstrate how they would test the objects if a container of water were present.
- **Activity set: *Shadow Play*; focal game: *Guess the Shadow*.** Participating children were asked to identify which one of four objects created a shadow depicted in a photograph and to provide evidence for their claim. The children were then provided with a flashlight and asked to use the object to replicate the shadow in the photograph, demonstrating how they would make the shadow larger and smaller. In the second part of the task, children were shown four different shadows and asked to match an object to its shadow. If they chose correctly, they were asked to describe how the object's shadow is similar to and different from the object itself.

- **Activity set: *Gear Up*; focal game: *Gear Up*.** Participating children were asked to view an image of a child dressed in rain gear, a clear sunny day visible through a window, and an outdoor thermometer indicating hot weather. Children were asked if they noticed anything silly about the image, and a follow-up question about the weather was asked if needed. Children were then asked to name the thermometer, describe what it tells us about the weather, and identify more weather-appropriate clothing for the child, giving a reason for their choices.
- **Activity set: *Gear Up*: focal game: *The Amazing Umbrella*.** Participating children were asked to observe and describe five objects made of different materials. They were then asked to choose which object a toy character should use to stay dry in the rain and to give reasons for choosing or not choosing each object.

Appendix A maps each task to PBS KIDS science content standards.

Parent surveys

Parents completed pre- and post-experience surveys. Pre-experience surveys were completed at the start of the first family science night. Four weeks later, parents received a text message link to complete the post-experience survey on their own devices. To allow for pre-post comparisons, both surveys asked parents about their child's past-month science activities, excitement, and vocabulary usage, and about parents' confidence in supporting science learning and joint science activities with their child. In addition, the pre-experience survey collected demographic information, and the post-experience survey collected information about perceived learning gains resulting from the *Play & Learn Science* app and supports.

Qualitative evidence

The second family science night began with small-group discussions of families' science experiences since the first family night. We use parent quotes, taken from facilitator notes, to illustrate quantitative findings. These discussions were not recorded or transcribed; parent quotes may not be verbatim.

Analysis

We report descriptive statistics for the parent surveys. To compare pre- and post-experience scores on the vocabulary and performance-based tasks, we used repeated measures general linear models. Appendix B details how the child assessments and parent surveys were scored.

Sample Description

Sample size and attrition

Exhibit 2 displays the sample size for each component of the study. Attrition was minimal. The remainder of this section describes the sample (*N* = 32) based on pre-experience survey data.

Exhibit 2. Study sample size

Study component	Site 1	Site 2	Total
Attended first family science night and took parent pre-experience survey	17[a]	15[b]	32
Attended midpoint family science night	16	15	31
Took parent post-experience survey	17	16	33
Child participated in pre- and post-experience assessment[d]	15[c]	16	31

[a] One parent is represented twice in the parent survey sample. This parent enrolled two eligible children in the study and took each survey once for each child. We included both surveys when describing child participants and only one survey for this family when describing parent participants.

[b] For one of 16 consented parents in Site 2, the pre-experience survey was lost due to a technical glitch. That parent was excluded from the parent pre- and post-experience survey sample but retained in the post-experience-only survey sample.

[c] This excludes two children in Site 2 who took the baseline assessment but were ineligible because they did not attend the first family science night. Two eligible children in Site 1 refused the baseline assessment. These two children were excluded from the child assessment sample and not assessed post-experience. They participated in the study intervention. Their parents were retained in the survey sample.

[d] The number of children with usable data varied by child assessment. For the performance-based tasks, *N* = 26. For the vocabulary assessment, *N* = 31.

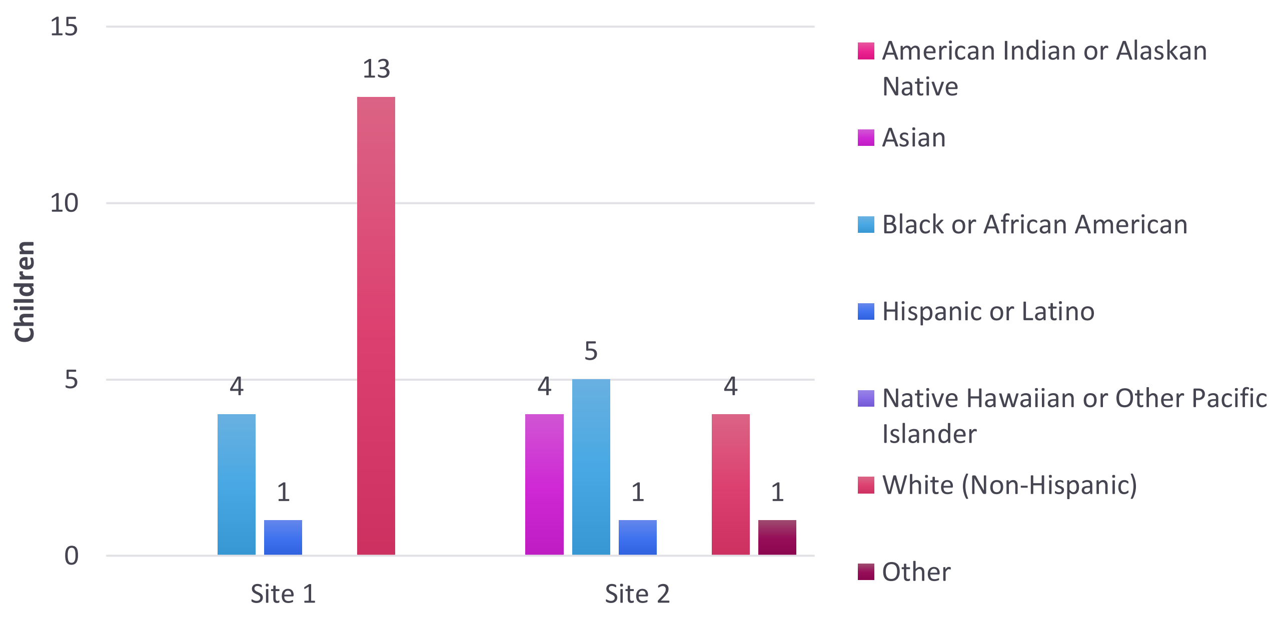
Child gender, IEP status, and age

The sample comprised 13 male and 18 female children. Two children were identified as having an individualized education plan or receiving special education services, one at each site. Children’s ages ranged from 37 to 67 months, with a mean of 51 months (*SD* = 10). Site 1 participants were 47 to 66 months old. Site 2 participants were 37 to 67 months old.

Race/ethnicity and language

Race/ethnicity and language differed by site. Children in the Site 1 sample were predominantly identified as White (non-Hispanic) with some Black/African American children, whereas the Site 2 sample included a mix of children identified as Asian, Black or African American, and White (non-Hispanic), among other ethnicities (Exhibit 3).

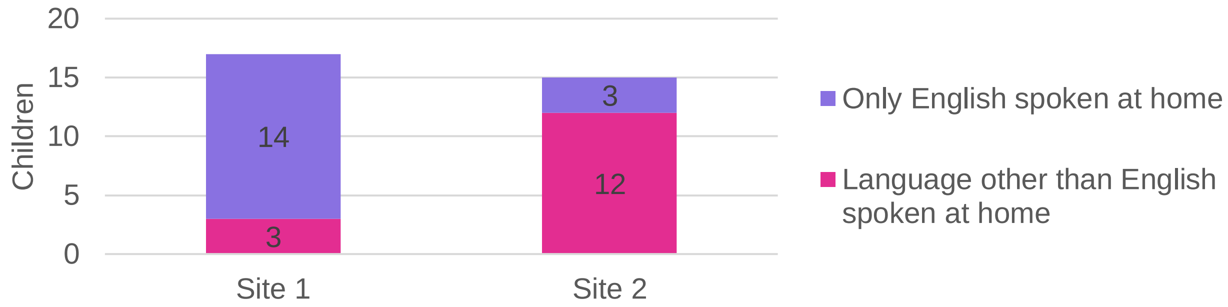
Exhibit 3. Child race/ethnicity



Note: *N* = 32 children. Respondents were asked to select all that apply.

English was the only language spoken at home for most children in the Site 1 sample, whereas a language other than English was spoken at home for most children in the Site 2 sample (Exhbiit 4). Parent-reported languages spoken at home in Site 2 were Arabic, Berber, Chinese (Mandarin, Cantonese, or other), Creole, Esan, Pakhtu, and Portuguese. For the three Site 1 children whose households spoke a language other than English, parents did not identify the languages.

Exhibit 4. Language spoken at home

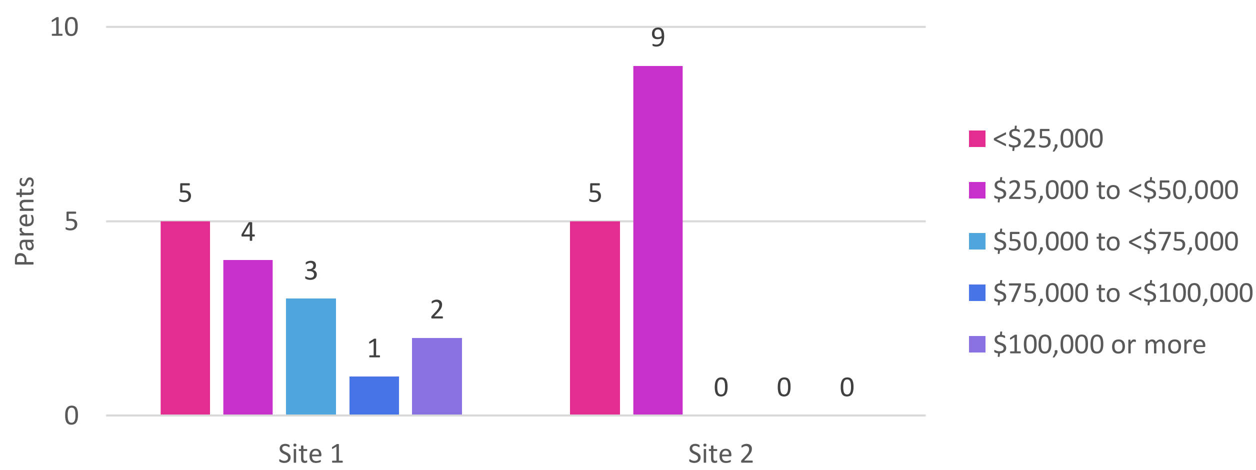


Note: *N* = 32 children.

Parent characteristics

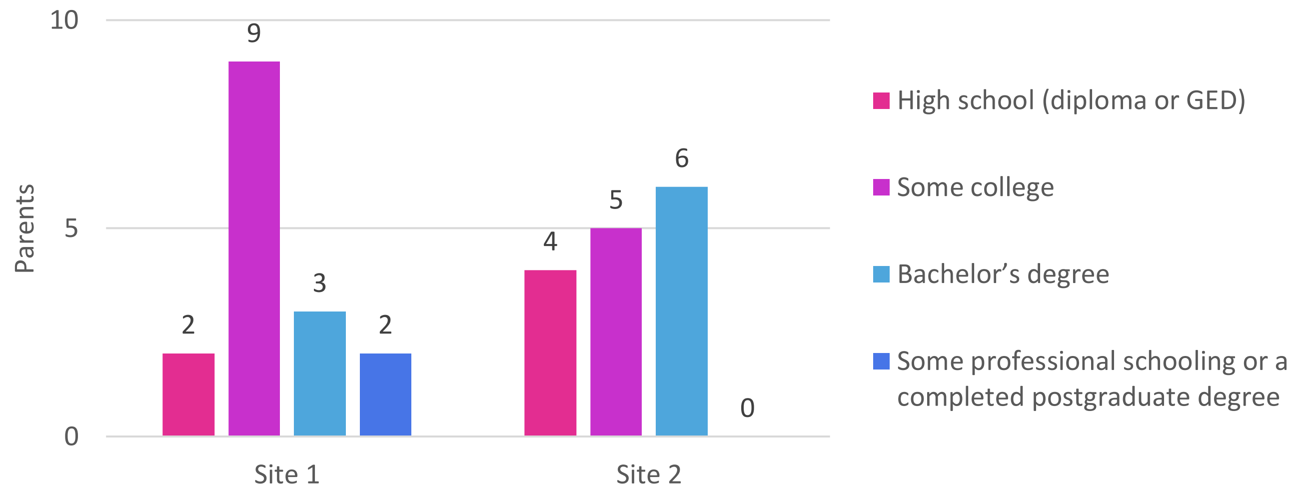
Among the participants who completed the pre-experience survey, 29 were female and two were male. The sample included two grandparents, one at each site. Whereas parent survey respondents at Site 2, the Head Start center, all reported annual household incomes of less than $50,000, those at Site 1, the private child-care center, reported a broader range of incomes (Exhibit 5). Parent survey respondents at both sites reported a range of education levels (Exhibit 6).

Exhibit 5. Annual household income



Note: *N* = 31 parents.

Exhibit 6. Parental education



Note: *N* = 31 parents.

Results

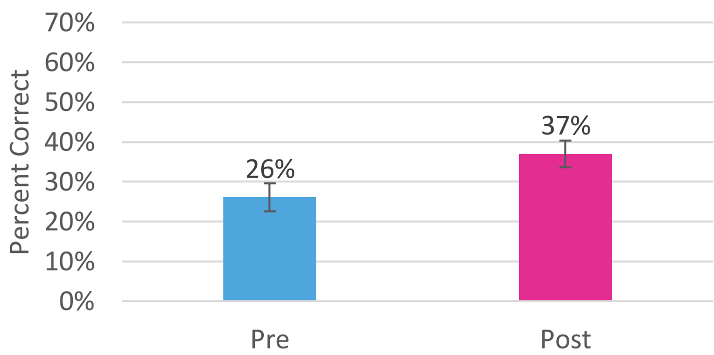
This section presents findings from child assessment and parent survey data. For child assessment data, we report the results of statistical significance tests and associated effect sizes. For parent survey data, we report descriptive statistics and describe apparent numerical differences.

What is the change in children's understanding of science concepts and use of science and engineering practices after four weeks of exposure to the PBS KIDS *Play & Learn Science* app and supports?

CHILDREN DEMONSTRATED GAINS ON A MEASURE OF SCIENCE CONCEPTS AND SCIENCE AND ENGINEERING PRACTICES.

Total scores on the performance-based tasks designed to measure concepts and practices related to *Play & Learn Science* content showed a statistically significant increase from pre-experience assessment to post-experience assessment (Exhibit 7).[4] The size of this effect was medium.[5]

Exhibit 7. Performance-based task scores at pre- and post-experience assessment



Note: N = 26 children. Five children were removed from this analysis because they were unresponsive for most of the assessment. Error bars represent standard error.

[4] A repeated-measures general linear model was used to analyze the effects of time point (pre- or post-experience) on children's performance-based task scores. Performance-based task scores increased significantly from pre-experience assessment to post-experience assessment, $F(1, 25) = 29.91$, $p < .001$. This analysis did not control for child demographic characteristics because children served as their own controls in this design.

[5] Cohen's $d = .62$.

Exhibit 8 presents excerpts from children's responses to selected performance-based assessment items. The table presents the same child's responses at pre- and post-experience assessments to illustrate within-child growth in science understanding.

Exhibit 8. Selected responses to performance-based assessment items

Performance-based assessment item	Pre-experience response excerpt	Post-experience response excerpt
What do you notice about [this car]?	"Racing car is for playing."	"Can roll because it have wheels, wheels can roll."
Why do you think [the marble] would sink?	"Because it does."	"It's heavy and big and made of steel. It would sink."
Why didn't you choose [felt] to keep Woody dry?	"Because it's soft."	"Because it's soft, the rain will make it wet; the rain will get past it."

Note: This table displays responses from three children. For each performance-based assessment item, the table displays the same child's pre- and post-experience responses to show within-child growth over time.

What is the change in children's use of target vocabulary after four weeks of exposure to the PBS KIDS *Play & Learn Science* app and supports?

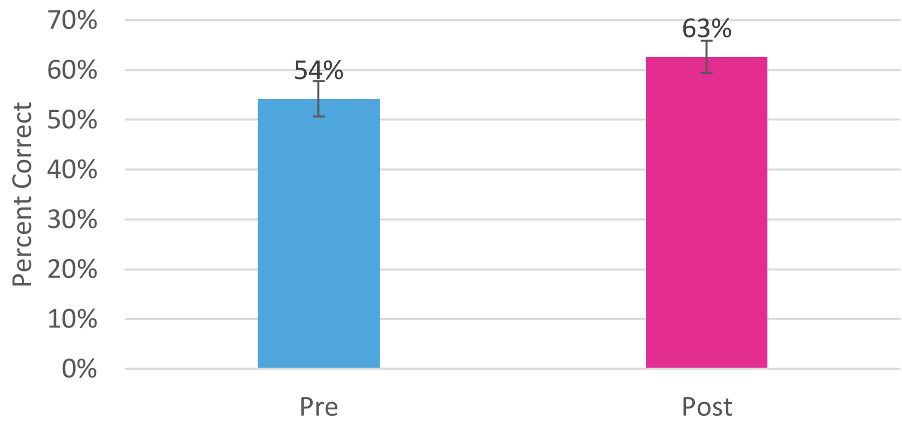
CHILDREN SHOWED GAINS ON TWO CONTENT-SPECIFIC MEASURES OF VOCABULARY.

Children's scores on the multiple-choice vocabulary assessment were statistically significantly higher post-experience than pre-experience (Exhibit 9).[6] The size of this effect was small.[7] Appendix C presents descriptive statistics for all words included on the multiple-choice, performance-based, and parent-reported vocabulary measures, and Exhibit 8, above, presents examples of children's vocabulary use.

[6] A repeated-measures general linear model was used to analyze the effects of time point (pre- or post-experience) on children's multiple-choice vocabulary assessment scores. Scores at post-experience assessment were significantly higher than scores pre-experience assessment, $F(1, 30) = 16.39$, $p < .001$.

[7] Cohen's $d = .45$.

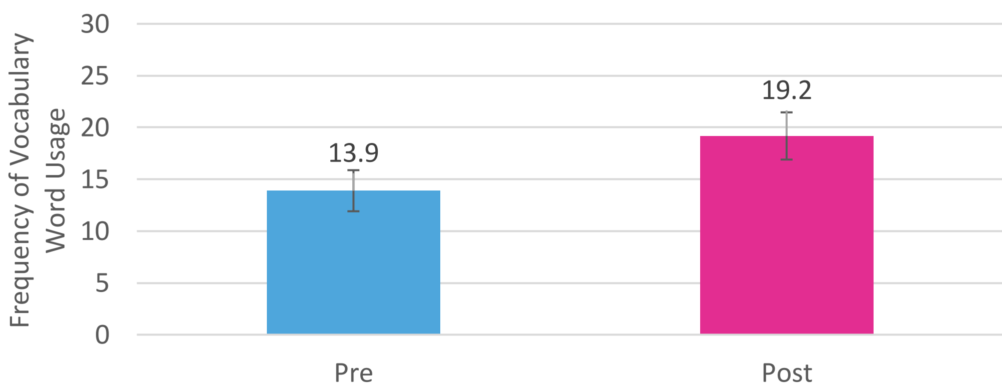
Exhibit 9. Vocabulary assessment scores at pre- and post-experience assessment



Note: N = 31 children. Error bars represent standard error.

There was a statistically significant increase in children's use of vocabulary words during the performance-based task administered at the end of the study, compared to the same task at the beginning of the study (Exhibit 10).[8] This effect size was small to medium.[9]

Exhibit 10. Vocabulary word usage at pre- and post-experience assessment



Note: N = 28. Three children were excluded from this analysis because no utterances were recorded during the performance-based tasks at pre-experience assessment, post-experience assessment, or both. Error bars represent standard error.

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[8] A repeated-measures general linear model was used to analyze the effects of time point (pre- or post-experience) on children's vocabulary usage counts. Vocabulary usage was significantly greater at post-experience assessment than at pre-experience assessment, $F(1, 27) = 13.121$, $p < .05$.

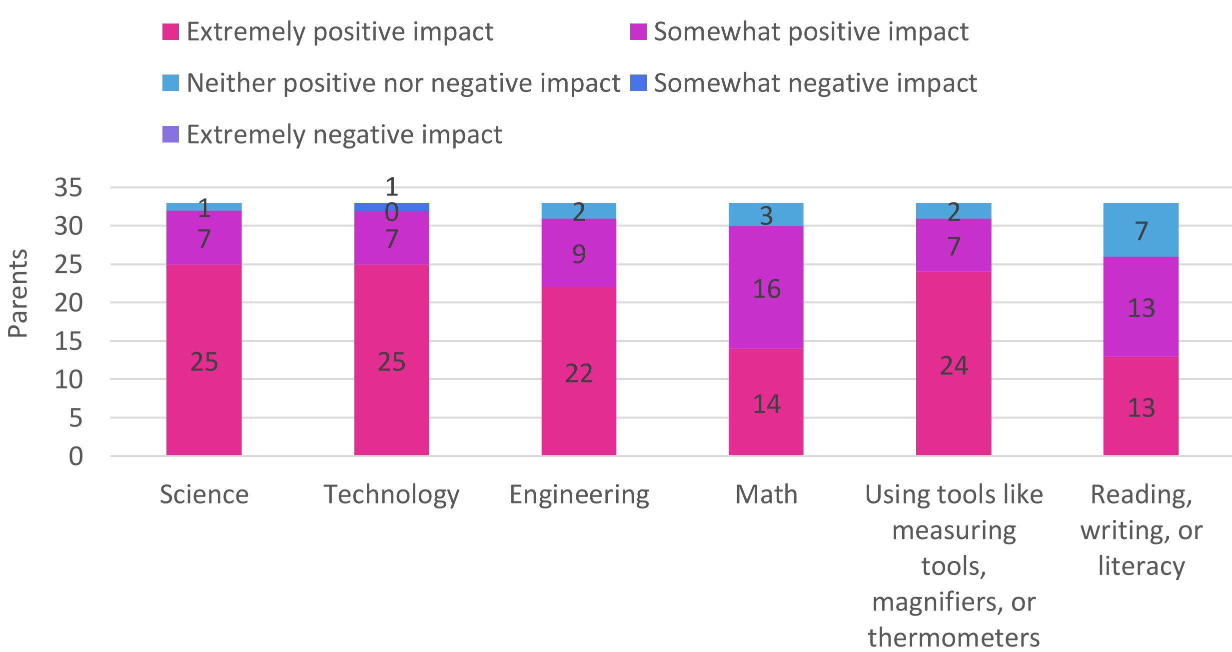
[9] Cohen's d = .47.

To what extent do parents report that four weeks of exposure to the PBS KIDS *Play & Learn Science* app and supports improved their children's science and/or engineering concepts, skills, and vocabulary?

PARENTS REPORTED THAT THE PBS KIDS *PLAY & LEARN SCIENCE* APP AND SUPPORTS HAD A POSITIVE IMPACT ON THEIR CHILD'S SKILLS IN AND EXCITEMENT ABOUT STEM AND ON THEIR USE OF TARGET VOCABULARY.

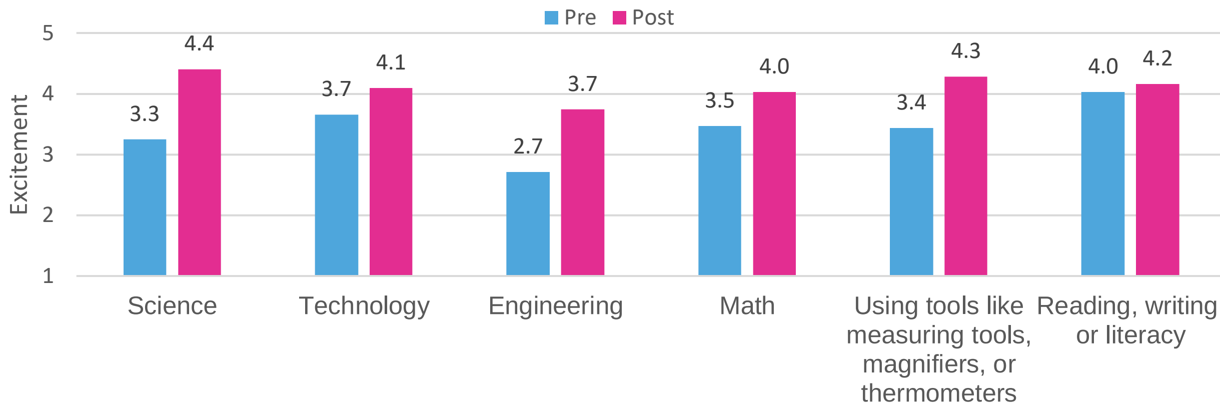
Nearly all—32 of 33—parents reported that their child learned something new from *Play & Learn Science* games or hands-on activities. Of those 32 parents, 30 indicated that their child learned something new about ramps, rolling, or sliding; sinking and floating; and shadows. Twenty-six reported that their child learned something new about weather. Almost all parents reported that the *Play & Learn Science* games and activities had a somewhat positive or extremely positive impact on their child's STEM and literacy skills and interests (Exhibit 11) and their excitement about STEM subjects (Exhibit 12). Parents reported the smallest pre- to post-experience survey gains for their child's excitement about literacy, most likely because literacy was not a focus of the *Play & Learn Science* app and supports.

Exhibit 11. Parent-reported impact on child's skill/knowledge domains



Note: *N* = 33 children.

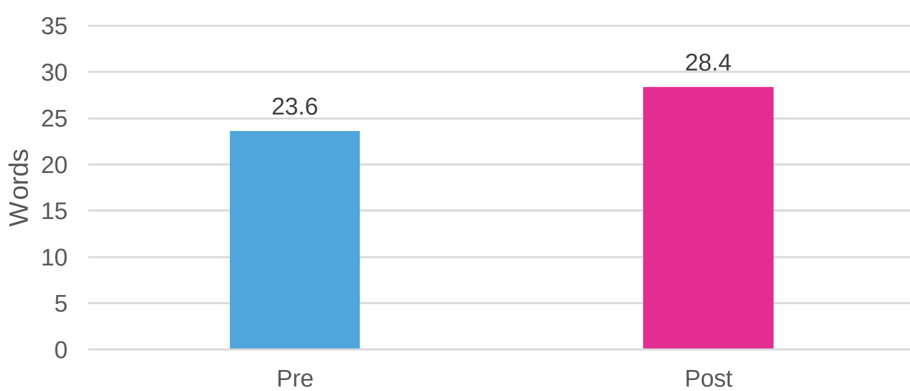
Exhibit 12. Parent-reported child excitement over the past month



Note: *N* = 32 children for all items except reading, writing, or literacy (*N* = 31); and engineering (*N* = 31). One parent did not respond to these items on the pre-experience survey. For comparability, this parent's post-experience survey responses for these items are omitted.

The survey asked parents to select any words they heard their child say or try to say in the last month from a list of 36 target vocabulary words from the *Play & Learn Science* app (see Appendix C). The number of selected words increased from the pre-experience survey to the post-experience survey (Exhibit 13)[10].

Exhibit 13. Parent-reported child past-month vocabulary word usage



Note: *N* = 32 children.

[10] We did not test whether this increase is statistically significant.

In a discussion during the second family science night, one parent described the change in a child's vocabulary: "She is playing with her toys in the tub like she always does, but now she is using words like 'sink' and 'float' that I haven't heard her use before."

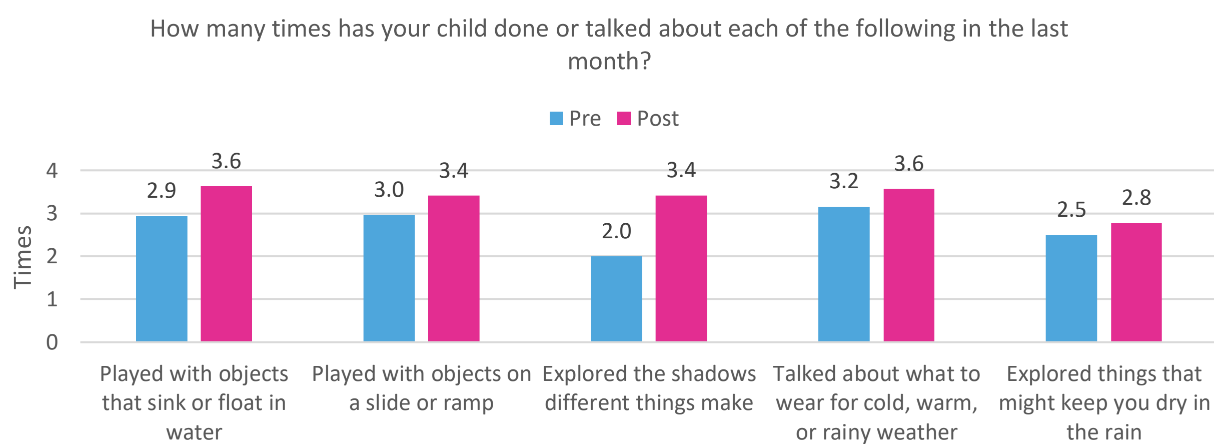
To what extent do parents report that four weeks of exposure to the PBS KIDS *Play & Learn Science* app and supports promoted children and their parents doing and talking about science/engineering?

PARENTS REPORTED AN INCREASE IN ENGAGING IN CHILD AND PARENT-CHILD SCIENCE ACTIVITIES.

Children doing science

The pre- and post-experience surveys asked parents how many times their child did or talked about activities related to the *Play & Learn Science* content. Parent-reported frequency of these activities was higher on the post-experience survey than on the pre-experience survey (Exhibit 14).[11] Parent survey responses also indicated a pre- to post-experience survey increase in how frequently children engaged in more general science-related activities not specific to the *Play & Learn Science* app and supports (Exhibit 15).[12]

Exhibit 14. Parent-reported frequency of *Play & Learn Science*-related activities



Note: *N* = 32, except for "Explored the shadows different things make" (*N* = 31). One parent did not respond to this item on the pre-experience survey; that parent's post-experience survey response was omitted for consistency.

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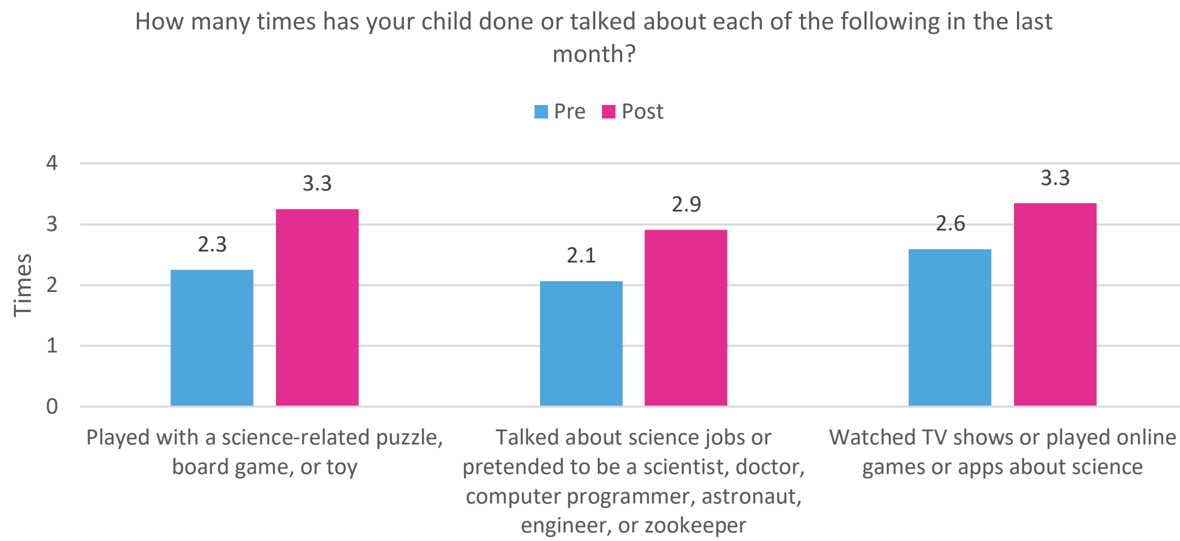
[11] We did not test whether this increase is statistically significant.

[12] We did not test whether this increase is statistically significant.

Exhibit 15. Parent-reported frequency of general science-related activities



Note: *N* = 32 children.

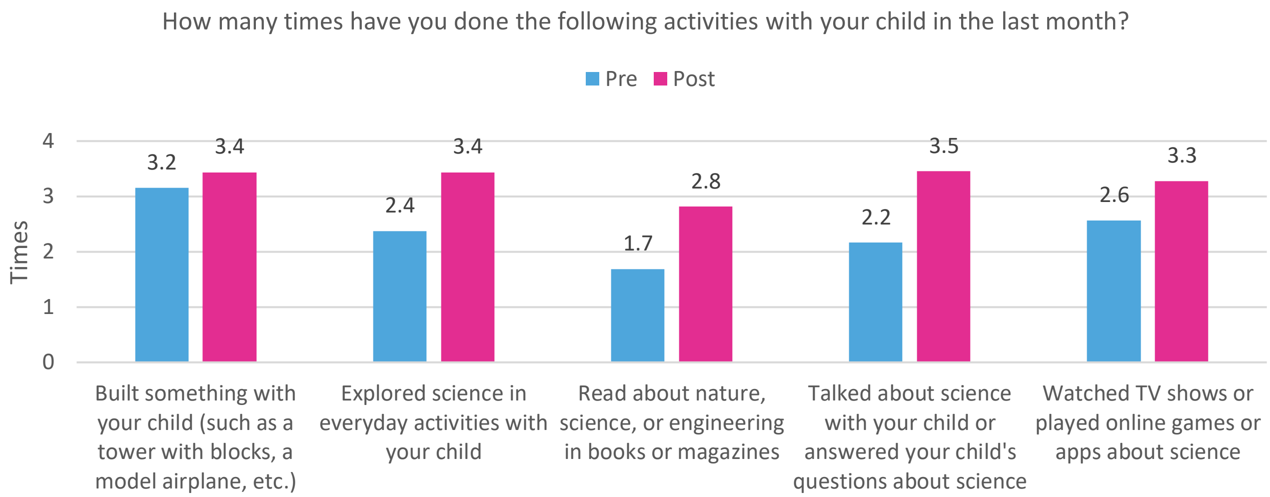
In discussions during the second family night, one parent described how the *Play & Learn Science* app and supports encouraged her child to talk: "[My child] has some speech issues. I love the way these games and activities got her so excited to talk about what she was doing." Other parents reported that their children engaged in science activities related to the *Play & Learn Science* app and supports. One parent said, "As soon as [my child] got in the bathtub, he started filling things up with water and testing things to see if they would float or sink." Another parent described a child's explorations with ramps: "[My child] tested the slides at the park to see which ones he would go faster and slower on. He figured out that he went faster on the big kid slide because it was steeper than the baby slide."

Parents/caregivers and children doing science

The frequency with which parents reported engaging in science- and engineering-related activities with their children increased from the pre- to post-experience survey (Exhibit 16).[13]

[13] We did not test whether this difference is statistically significant.

Exhibit 16. Parent-reported frequency of parent-child science activities



Note: N = 32 children for all items except "Talked about science with your child…" (N = 31). One parent did not respond to this item on the pre-experience survey; this parent's post-experience survey response was omitted for consistency.

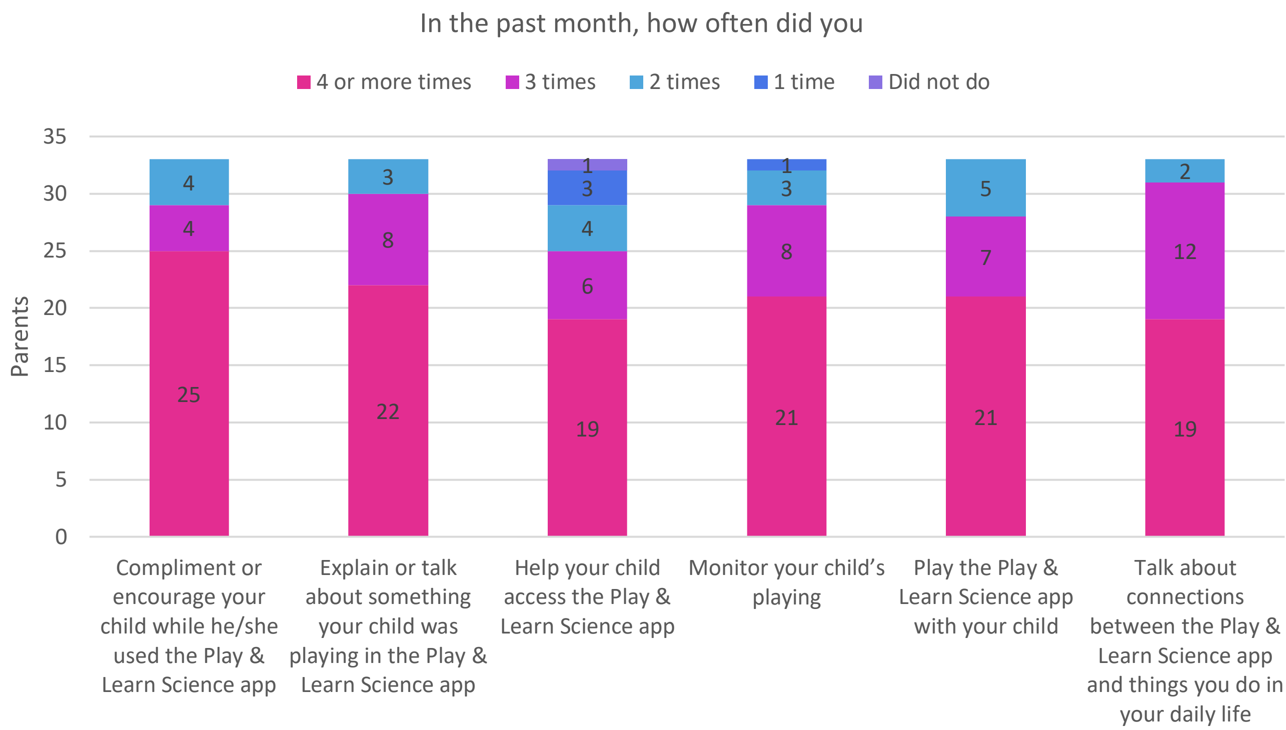
At the second family science night, parents described engaging in science activities related to *Play & Learn Science* with their child. One parent reported engaging in both the digital and hands-on versions of an activity: "We played sink/float on the tablet and at bath time. We like to guess. We ask each other and guess." Another parent and child described exploring ramps together. Their discussion illustrates parent-child talk about the family science experience.

> Parent: "We set up a ramp on the living room rug and placed the target at the end. What happened?"
>
> Child: "The ball rolled so so so fast and hit the target."

Parental mediation of *Play & Learn Science* app usage

On the post-experience survey, most parents indicated that they frequently mediated their child's use of the *Play & Learn Science* app in a variety of ways, including complimenting or encouraging their child's use of the app, playing the app together, and talking about connections between the app and daily life (Exhibit 17). In addition, of 33 parents who took the post-experience survey, 32 reported that their child talked with them about *Play & Learn Science* games or hands-on activities either a little or a lot.

Exhibit 17: Parent-reported past-month mediation behaviors



Note: *N* = 33 children.

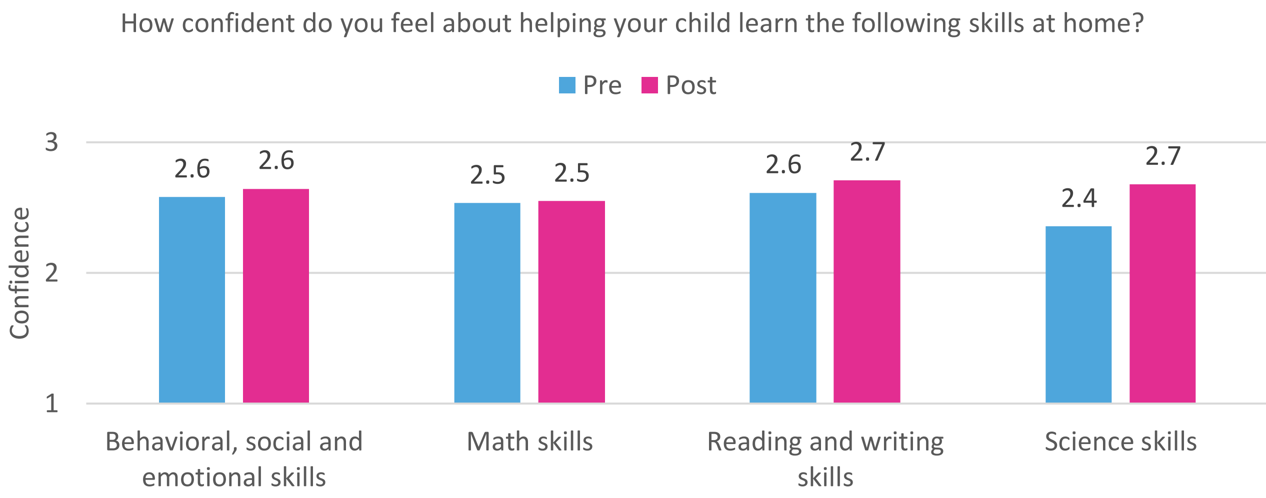
To what extent do parents report that four weeks of exposure to the PBS KIDS *Play& Learn Science* app and supports improved their confidence in or ability to support their child's science/engineering learning?

PARENTS REPORTED INCREASES IN CONFIDENCE IN SUPPORTING THEIR CHILD'S SCIENCE LEARNING.

Parents reported pre- to post-experience increases in their confidence supporting science skills (Exhibit 18). These increases were modest, but larger than parent-reported increases in confidence supporting other skills. Similarly, modest pre- to post-experience increases were reported for parents' past-month confidence helping their child with a new science or engineering game or activity (Exhibit 19).[14]

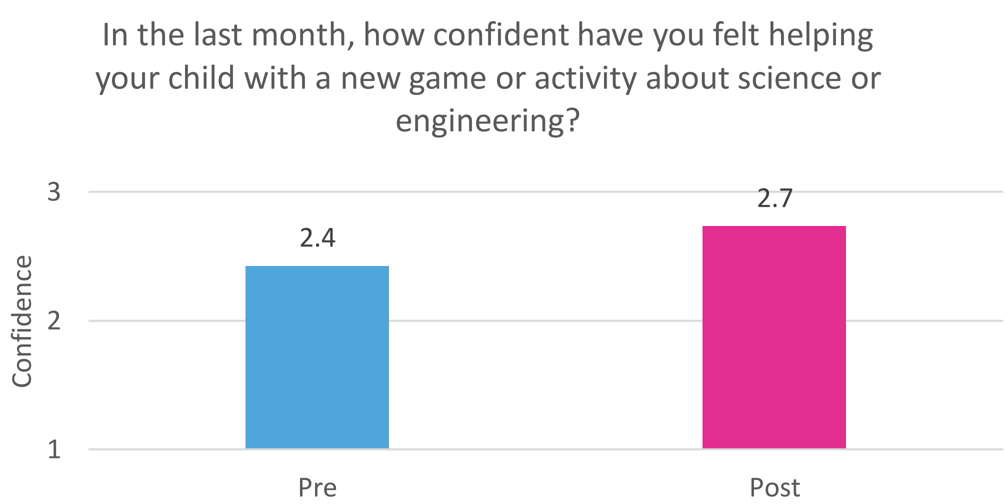
[14] We did not test whether these increases were statistically significant.

Exhibit 18: Parent confidence by domain



Note: *N* = 31 parents for all items except math skills (*N* = 30). One parent did not respond to this item on the pre-experience survey; their post-experience survey response was omitted for consistency.

Exhibit 19. Parent confidence supporting a new science/engineering activity



Note: *N* = 26 parents. Pre- and post-experience survey responses are omitted for parents who responded that this “did not come up in the past month.”

At the second family science night, one parent told facilitators that the experience had increased her science knowledge, stating, “I’m learning too.” Another family said that before participating in the experience they did not know they could engage in science explorations with household objects.

Discussion

As part of the CPB-PBS Ready To Learn Initiative, the PBS KIDS *Play & Learn Science* app is intended to support families in exploring, thinking, and talking about science together. The app is one of several PBS KIDS media properties and outreach programs designed to promote family science engagement, funded by a Ready To Learn grant from the U.S. Department of Education. Findings suggest that when used in a supported context, the *Play & Learn Science* app can benefit both children and their parents. These results add to a body of research that demonstrates the potential of educational media to support children's learning, particularly when adults support their children's media use.

Child outcomes

Child assessment and parent survey data indicated gains in children's understanding of science content and practices after four weeks of exposure to the *Play & Learn Science* app and supports. We found a statistically significant pre-experience to post-experience gain in children's scores on performance-based tasks aligned to *Play & Learn Science* content. Parents reported that their child learned something new about the topics covered in the app and that the app positively affected their child's STEM skills.

Three data sources indicated pre- to post-experience increases in children's vocabulary related to app content. From pre- to post-experience, there was a statistically significant increase in children's scores on the vocabulary assessment and in their use of vocabulary terms during the performance-based assessment. Parent survey responses indicated an increase in the number of app-related vocabulary terms used over the past month.

Parents also reported that the *Play & Learn Science* app positively affected their child's excitement about STEM. Further, parent survey responses indicated that children did or talked about both app-specific and more general science activities more frequently during the study than prior to the study.

Parent outcomes

Parents reported that they engaged in science- and engineering-related activities with their children more frequently during the study than prior to the study. Most parents also reported that they mediated their child's use of the *Play & Learn Science* app. Parents reported modest increases in their confidence in supporting their child's science learning.

Limitations

Several study design characteristics should be considered when interpreting these findings.

- This study's single-group design limits our ability to make claims about causation and does not meet What Works Clearinghouse evidence standards (What Works Clearinghouse, 2017).
- The sample is not nationally representative.
- We cannot claim that these findings would extend to average users of the *Play & Learn Science* app, because this study included additional supports aligned to the app.
- The researcher-developed measures are closely aligned with the *Play & Learn Science* app content; we cannot say how participants would perform on less aligned measures, such as academic assessments.
- We did not measure inter-assessor agreement in either the assessment or scoring process.
- Small studies, single-group studies, and those with closely aligned measures tend to report larger effect sizes than studies with other research designs (Bakker et al., 2019).

Implications for Practice and Future Research

Our findings suggest that a digital app can be a catalyst for families' science exploration and learning, when it features rich interactive content and it empowers parents with knowledge and skills to effectively facilitate and extend their children's digital and real-world science experiences. The study adds to a body of research that points to young children's capacity for engaging in science and engineering practices and for exploring, thinking about, and talking about science concepts at developmentally appropriate levels. This study has the potential to speak directly to families, and to the teachers and child-care providers who work with them, as it illustrates how families benefit from the types of resources that parents have identified as essential to supporting science engagement in prior research studies. Our findings suggest that parents will actively engage in doing and learning science with their children when they are provided with a quality app and additional supports for using it to the fullest.

This is exactly what is taking place in 30 communities across the country as part of the CPB-PBS Ready To Learn Initiative Community Collaboratives for Early Learning Media. Children and their parents are participating in family science events that provide similar parental supports to those included in this study, including guidance for navigating an educational science app, models of the hands-on science activities and suggested interactions in the app, and structural supports and encouragement for using the app in a connected and sequential manner. Public media's fundamental approach to working with families is to provide these educative supports within nurturing community contexts, an approach reflected in this study as the intervention was embedded within two community child-care centers. This study suggests that many community-focused organizations, particularly those such as child-care centers, schools, and libraries that seek to empower, educate, and engage families, could benefit from using the *Play & Learn Science* app as a model for designing their own family-focused science events. The app can support experiences that may be particularly valuable in underserved communities with limited access to high-quality science education and science-related activities.

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Appendix A

Performance-Based Assessment Tasks by PBS KIDS Science Learning Framework Standards

Performance-based task	Physical science	Earth/Space science
Ramp and Roll: Explore the Roll	Matter and its interactions: Understand that different kinds of matter exist and that they can be described and classified by their observable properties. Motion and stability; forces and interactions: Understand that pushes and pulls can cause objects to move. Understand that pushing on an object can change the speed or direction of its motion and can start or stop it.	
Water Games: Sink or Float	Matter and its interactions: Understand that different kinds of matter exist and that they can be described and classified by their observable properties. Motion and stability; forces and interactions: Understand that pushes and pulls can cause objects to move. Understand that pushes and pulls can have different strengths and directions.	

Performance-based task	Physical science	Earth/Space science
Shadow Play: Guess the Shadow	Waves and their applications in technologies for information transfer: Begin to understand that some materials block all the light creating a dark shadow on any surface beyond them, where the light cannot reach.	
Gear Up: *Gear Up*	Matter and its interactions: Understand that different properties of materials are suited to different purposes.	Earth's systems: Understand that weather is the combination of sunlight, wind, snow, or rain and temperature in a particular region at a particular time and can be measured by people to describe and record the weather and to notice patterns over time.
Gear Up: The Amazing Umbrella	Matter and its interactions: Understand that different kinds of matter exist and these can be described and classified by their observable properties. Understand that different properties of materials are suited to different purposes.	

Appendix B

Assessment Scoring

Vocabulary assessment

Multiple-choice vocabulary items were scored as correct or incorrect. To identify items exhibiting a ceiling effect, we set a threshold of 95% correct responses in the combined pre- and post-experience assessment scores. We excluded one item that exceeded this criterion. Scores were computed as each child's average of correct responses on the remaining 18 items, excluding two training items. Using averages rather than sums enabled us to count items as skipped (e.g., if the child did not complete the assessment) without deducting points. According to our scoring rules, if a child gave incorrect responses to five items in a row, the assessor discontinued the assessment and all remaining items were scored as zero rather than skipped. Appendix C presents descriptive statistics for all items included in the final vocabulary assessment.

Performance-based tasks

The performance-based tasks were scored by the two study leads. Scorers established a rubric that defined and provided examples of correct and incorrect responses. As a calibration exercise, scorers scored six child responses in common, or 10% of the dataset. We used this as an opportunity to refine the scoring rubric. Each scorer then scored 50% of the remaining data set.

As for the vocabulary assessment (described above), we set a ceiling effect threshold of 95% correct responses in the combined pre- and post-experience assessment scores and excluded one item that exceeded this threshold. Total scores also omit a series of three questions intended to provide a second chance to identify an object that both rolls and slides for children who did not initially identify one. Only one child correctly identified an object that rolls and slides during the second chance; these three items therefore did not contribute meaningful variance to the performance-based task scores.

As for the vocabulary assessment (described above), scores were computed as the average of correct responses for all assessment items. All items were scored out of one point; those initially assigned more points for scoring simplicity (e.g., a count of how many objects the child identified) were rescaled to one point.

Vocabulary use during performance-based tasks

Assessors were told to write down all relevant vocabulary used during the performance-based tasks. We extracted child utterances from other assessor notes and then used an automated word search to count instances of key vocabulary terms in children's performance-based task responses (see Appendix C).

We generated an initial list of vocabulary terms from key terminology used in the *Play & Learn Science* in-app and hands-on activities. We then analyzed the frequency of all words children used during the performance-based task and identified additional content-specific terms that appeared three or more times in the data set. Appendix C presents the final word set. Alternative endings were counted for all terms.

Parent survey

Vocabulary words included on the parent survey are listed in Appendix C. This report omits a parent post-survey item that asked about the impact of *Play & Learn Science* games and activities on the child's interest in science activities such as "asking questions about the world around them" and "investigating or experimenting to learn about the world." The response options were reversed relative to a similarly structured item directly previous. As a result, responses were overwhelmingly negative. We suspect that this was due to the order of the response options and does not reflect parents' actual experiences because it is inconsistent with responses on other similar items.

Appendix C

Item-Level Descriptive Statistics for Vocabulary Measures

Vocabulary Word	Parent Survey		Performance Based Assessment		Vocabulary Assessment	
	% of Children who Used the Word		Frequency of Word Use		% of Children Correct	
	Pre	Post	Pre	Post	Pre	Post
Explore the Roll						
Flat	44%	72%	3	3		
Round	72%	88%	2	6		
Steep	13%	28%	0	0	35%	26%
High	91%	97%	2	0	87%	84%
Low	66%	81%	1	0		
Ramp	47%	75%	1	0	58%	87%
Roll	63%	97%	28	38	77%	94%
Slide	94%	100%	16	14		
Target	38%	59%			52%	71%
Sink or Float						
Down			22	20		
Up			15	24		
Sink	69%	94%	17	48		
Float	59%	100%	25	34	68%	81%
Liquid	41%	50%				
Glass			1	0		
Metal			2	5		
Heavy	97%	97%	13	19	90%	97%
Guess the Shadow						
Big			8	15		
Small			2	9	71%	81%
Close	84%	84%	0	4		
Far	69%	81%	0	2	42%	43%
Dark	94%	91%	3	3		
Light	91%	88%	6	2		
Shadow	53%	88%	9	9	68%	77%

Vocabulary Word	Parent Survey		Performance Based Assessment		Vocabulary Assessment	
	% of Children who Used the Word		Frequency of Word Use		% of Children Correct	
	Pre	Post	Pre	Post	Pre	Post
Shape	78%	78%	5	3		
Gear Up						
Weather	78%	88%	5	6		
Cold	100%	97%	18	24		
Cool	81%	91%	0	2		
Warm	90%	97%	9	13		
Hot	97%	97%	19	25	71%	74%
Sun	100%	100%	15	22		
Rain	100%	97%	36	41	68%	71%
Snow	78%	88%	4	3		
Wind	78%	94%	2	0		
Temperature			5	10		
Degrees			0	4		
Thermometer	31%	69%	9	16	58%	70%
Boot			1	5		
Hat			3	5		
Jacket			6	10		
Shirt			0	3		
Shoe			1	2		
Sleeve			3	4		
Umbrella			9	8		
The Amazing Umbrella						
Absorb	9%	31%	0	0	13%	30%
Repel	0%	6%	0	0		
Soak	31%	59%	2	1		
Liquid					32%	30%
Fabric			0	0		
Felt			0	0		
Plastic			4	5		
Sponge			1	3		
Wood			0	3		

Vocabulary Word	Parent Survey		Performance Based Assessment		Vocabulary Assessment	
	% of Children who Used the Word		Frequency of Word Use		% of Children Correct	
	Pre	Post	Pre	Post	Pre	Post
Fluffy			0	2		
Hard			8	6		
Soft			14	15		
Hole			20	32		
General Terms						
Circle			17	14		
Oval			3	4		
Square			4	4		
Diamond			3	1		
Side			1	3		
Compare	16%	34%			16%	19%
Observing					26%	33%
Long	97%	94%				
Short	84%	88%				
Object	31%	63%	1	3	45%	60%

Note: Words are grouped by focal topic for display only. Blank cells indicate that a word was not included on an assessment. Words were excluded from the performance-based assessment only if they were not spoken by any children. Some measures used alternate word endings (e.g., *rolling* versus *roll)*; terms are collapsed for simplicity. The parent survey specified that alternate endings should be counted in parents' reports. Alternate endings were counted on the performance-based assessment. On the vocabulary assessment only, the assessor spoke the terms; there was no need to count child-produced alternate endings.