EDC Education
Development
Center

Bringing Science Home with PEEP

Using Digital Media to
Foster Family Engagement
in Science at Home

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ABOUT EDC

Education Development Center (EDC) is a global nonprofit that advances lasting solutions to improve education, promote health, and expand economic opportunity. Since 1958, we have been a leader in designing, implementing, and evaluating powerful and innovative programs in more than 80 countries around the world.

ABOUT WGBH

WGBH enriches people's lives through programs and services that educate, inspire, and entertain, fostering citizenship and culture, the joy of learning, and the power of diverse perspectives.

ACKNOWLEDGEMENTS

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Introduction

Project Background

Within the United States, disparities in science achievement between children living in poverty and their more affluent peers are substantial. Even before they start school, kindergarten students living in poor households have less knowledge about the natural world than children from wealthier families, and this disparity in science-related knowledge widens as children reach high school (Morgan, Farkas, Hillemeier & Maczuga, 2016). Despite a growing body of research that engaging young children in science can provide them with an important foundation for future science learning, as well as more broadly for school readiness and academic achievement, young children have few opportunities to engage in science, particularly children from low-income families.

PEEP Family Science is a collaboration among the WGBH Education and Children's Media teams, Education Development Center (EDC) researchers and staff, and parents participating in programs with two home visiting organizations: AVANCE in Texas and HIPPY in Arkansas. The project aims to foster joint media engagement and hands-on science exploration among diverse, low-income 3- to 5-year-old children and their parents through the development and testing of an app-based science intervention.

PEEP Family Science capitalizes on the appeal of the public media program *PEEP and the Big Wide World*. Through an iterative research and development process, the project was designed to build new knowledge about the challenges faced and infrastructure needed to use digital media to inspire and support English- and Spanish-speaking, low-income parents and the home educators[1] with whom they work in conducting hands-on science investigations with young children. Moreover, the project explored how best to design, support, and disseminate parent and educator resources to support these experiences and ensure they are both useful and relevant to these audiences.

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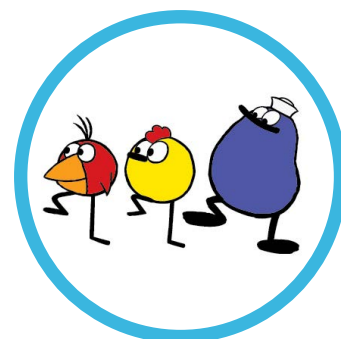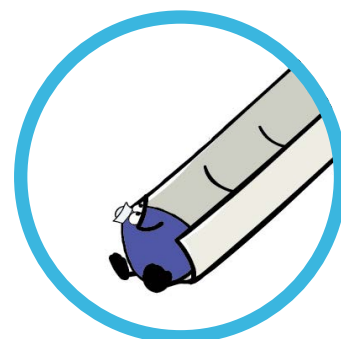
1   We use the term *home educators* throughout this document to refer broadly to educators in home visiting programs, including home educators, parent educators, and home visitors.

Research Approach: Design-Based Implementation Research

To ensure that families and home educators could easily implement the PEEP intervention, and to ensure that the intervention met the needs of children and families using it, the project used a design-based implementation research (DBIR) approach (Penuel, Fishman, Cheng, & Sabelli, 2011). Unlike traditional educational research, in which an intervention is often fully articulated by researchers and introduced into an educational setting for testing, DBIR requires identifying stakeholder priorities, practical problems and concerns, and the context in which the program is implemented, as well as engaging in an iterative, collaborative development process that responds to those priorities, concerns, and contexts. In developing the proposal for this project, WGBH and EDC worked closely with AVANCE and HIPPY and project advisors to meet a key goal: engage families in science exploration through joint media engagement and home visiting programs. The research took place over four phases:

PHASE 1: The project design team (i.e. the WBGH education and media team and EDC researchers) worked with stakeholders and members of our advisory board to specify a set of design principles to guide the development of PEEP Family Science, which was to incorporate hands-on activities, rich media experiences, and supports for parents and educators to guide engagement.

PHASE 2 AND 3: Researchers conducted two rounds of pilot testing, exploring the home visiting and family contexts in more depth and iteratively testing and refining the design and implementation of PEEP Family Science.

PHASE 4: The Implementation Study used a pre-/post-design with a comparison group of parents in home visiting programs who did not use the intervention to examine how parents use PEEP Family Science to engage young children in science exploration, how home educators support families in doing this, and the extent to which using PEEP Family Science is related to changes in the ways parents think about and do science with their child. At the end of this study, the research
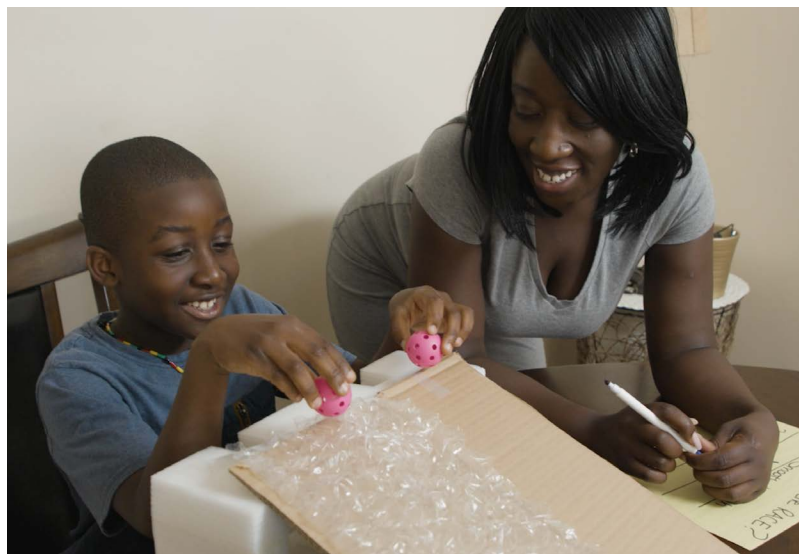
team met with project stakeholders and advisors to present the findings, gather feedback, and discuss the implications.

Implementation Study

This report presents the results of the final Implementation Study, which explored the ways in which families with young children participating in home visiting programs engaged in hands-on science learning through the use of digital media. During this study, low-income families who were enrolled in a home visiting program, either AVANCE or HIPPY, used PEEP Family Science over the course of three months to explore the concepts of ramps, colors, and sounds. The study is the final study in a two-year long research and development process designed to understand how families and home educators use the PEEP Family Science intervention to explore science with their young children and the supports that helped them do so effectively. The study also examined how parents' attitudes and knowledge about helping their young children learn science changed after using the intervention. Ultimately, the study aimed to build theoretical and practical knowledge about the challenges faced and the design and infrastructure needed to use digital media to inspire and support low-income parents from a range of backgrounds in conducting hands-on science investigations with their young children.

Background

Theoretical Framework

The design of PEEP Family Science rests on the assumption that with the right supports and scaffolds, parents can learn about and implement practices that support young children's science exploration and learning at home. The initial design and development of the PEEP Family Science model was based on theory and research about effective parent engagement strategies to support learning and how to prepare educators and parents to use new pedagogical practices through scaffolding and media. Specifically, the project design draws from theory and research across three broad categories:

1 **How parents can support their children's science exploration and learning**

The PEEP Family Science intervention model focuses on helping parents use three pedagogical engagement strategies:

a) Play and explore together,

b) Ask questions and talk about ideas

c) Explore more.

The strategies, described in more detail in the study intervention section, are based on research about effective means for supporting children's science interest and learning.

2 **How to scaffold learning**

PEEP Family Science provides resources to prepare parents and home educators to support children's science learning in the home. The design of these resources rests on theory related to effective scaffolding strategies that can help parents and educators learn to use these supports (Bransford, Brown, & Cocking, 2000;

Collins, Brown, & Newman, 1989; Wood, Bruner, & Ross, 1976). These strategies include:

a) Modeling engagement in science

b) Simplifying the activities and interactions among children, parents, and home educators, such as breaking activities into smaller steps

c) Connecting to what parents already know and do

d) Documenting and reflecting on learning

3 **How media can support child and family science engagement and learning**

The design of PEEP Family Science is predicated on the unique affordances of media to support science learning as it relates to motivation, engagement, and deeper learning. Young children increasingly interact with media in the home for significant amounts of time (Rideout, 2017). And media can help children learn science content under certain conditions (Schroeder & Kirkorian, 2016). Incorporating media and technology experiences into home visiting models may provide important motivation for families to engage in science learning. Additionally, engagement with characters and extended storylines can motivate children and their families and support the development of new knowledge and practices of new skills over time and across media (Jennings, Hunt, Altenau, & Linebarger, 2008; Richert, Robb, & Smith, 2011; Schiappa, Allen, & Gregg, 2007). Moreover, media resources can provide important scaffolds for learning, for example, by modeling disciplinary ways of thinking and talking (Troseth, Saylor, & Archer, 2006) and by providing opportunities for questioning and feedback to children through joint media engagement (Anderson et al., 2000; Crawley et al., 2002). In particular, the PEEP Family Science incorporates media for the following purposes:

a) Engage children and parents initially and over time

b) Model and provide guidance about how to engage in science exploration

c) Provide opportunities for questioning and feedback

The PEEP Family Science model operationalizes these theoretical constructs through a set of guiding principles that inform the design of resources to help educator and parents engage in and explore science.

Design Principles

As part of the PEEP Family Science design process, the WGBH media team, the EDC research team, project advisors, and stakeholders developed a set of principles to guide the iterative design of the intervention, which were then revised through two pilot studies. One purpose of the implementation study was to determine whether the project aligned to these design principles and, moreover, whether they were sufficient to ensure the project met the goal of fostering science exploration.

Following are the guiding principles:

1. Engage children in relevant, hands-on, and child-centered science explorations and investigations that build knowledge over time. Ensure that activities and resources support active learning and exploration and encourage questioning and reflection. Within each content area, design activities so they build upon each other to scaffold children's learning over time. To foster engagement, connect media experiences, such as familiar characters, to the hands-on activities.

2. Support the learning of parents and educators in home visiting programs through modeling, scaffolding, and reflecting. Model how parents can engage children in science learning, scaffold and simplify strategies for parents to use to engage their children in learning science, and provide opportunities for parents and home educators to reflect on their learning and their children's learning. Empower parents

to use and select strategies to support learning that they feel are best for their own contexts and children during use of the intervention and in other contexts.

3. Ensure that resources are easily available, culturally relevant, and appropriate for a wide variety of both language and digital literacy abilities. Furthermore, ensure that parents and children can easily relate the resources to their own everyday lives. Provide families with ideas about how and when to engage with science during their daily routines.

4. Recognize that science can be intimidating for parents and address this potential barrier. Some parents may lack confidence, comfort with, and knowledge about science. Support parents by explaining their role as co-learners rather than a traditional direct teaching role in which the parent explains and provides specific knowledge. Point out everyday examples of science explorations to make science less intimidating and more accessible to parents.

5. Ensure that resources are adaptable across multiple home visiting organizational contexts. Also, explore how to support the use of resources by parents who are connected to organizations that do not do home visits.

The conjecture map in Figure 1 outlines how the intervention operationalizes these theoretical constructs.

Figure 1. Conjecture

With supports that engage and scaffold their own learning, parents can learn about and implement practices that support children's science learning

EMBODIMENT	MEDIATING PROCESSES	INTERVENTION OUTCOMES
Home Visitor Activity Structure: › Meet with parents	**Home Visitors:** › Read facilitation guide › Watch parent and home educator videos of engagement strategies › Meet with parents › Model and explain 3 engagement strategies › Observe and provide feedback to parents regarding use of strategies	**Home Educators** understand how and are able to support parents' use of science engagement strategies
Parent/Child Activity Structure: › Play and Explore Together › Ask Questions and Talk About Ideas › Explore More!	**Parents:** › Practice 3 strategies and receive feedback › Conduct guided activities › Watch videos and animations with children on the App › Document and reflect on their child's learning and receive feedback	**Parents** understand how and are able to and regularly support their children's engagement in science
Materials and tools: › App with animated stories, live action videos of parent/child science engagement, hands-on activity sets › Written facilitation steps for home visitors and site coordinators › Parent videos that model 3 engagement strategies	**Children:** › Watch videos and animation with parents › Engage in 12 hands-on activities › Document and reflect on learning with parents	**Children** regularly engage in science exploration at home.

Research Questions

The purpose of the Implementation Study was to examine how parents[2] used PEEP Family Science to engage young children in science exploration, how home educators[3] supported families in doing this, and the extent to which using PEEP Family Science was related to changes in the ways parents thought about and did science with their child. The EDC research team conducted the study between February and May 2018 with families from two home visiting organizations—AVANCE in Texas, and HIPPY in Arkansas. The study employed a pre-/post-design with a comparison group and relied on data from multiple sources, including a researcher-designed parent survey; observations of the families and educators using PEEP Family Science; and interviews with parents, educators, and site administrators.

The PEEP study focused on addressing three research questions:

RQ1) What happens when educators use the PEEP Family Science and incorporate it into their existing routines and AVANCE and HIPPY's existing models and their practices? How do home educators adapt the PEEP intervention model, and why?

RQ2) What happens when families use the PEEP Family Science and incorporate it into their existing routines? How are parents already supporting learning and science at home, and to what extent does the PEEP intervention build on these practices and interactions? How do parents adapt the model and why?

RQ3) What is the relationship between use of the PEEP Family Science resources and parent attitudes about and knowledge of strategies that support children's science learning?

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2   We use the term *parent* broadly throughout the report to refer to parents, grandparents, caregivers, guardians, and others who participated in the home visiting programs with their children.
3   We use the term *home educators* inclusively in this report to include parent and home educators.

Method

Sample

A total of 217 families participated in the Implementation Study (121 families from AVANCE; 96 families from HIPPY). Of those 217 families, 170 participated in the intervention (96 from AVANCE; 74 from HIPPY), using PEEP Family Science as part of their weekly activities with their home visiting program. The remaining 47 families served as the comparison condition. Comparison families continued their regular weekly activities with their home visiting program, but they did not have access to PEEP. A total of 200 families (92% of the original sample) completed both the pre- and post-surveys, including 166 treatment families and 44 comparison families. The sample of families was ethnically diverse: 64% Hispanic/Latino, 23% White, 13% Black/African American, and 1% Other. Survey responses also indicated variation in the highest level of education completed by parents: 19% did not complete high school; 34% have a high school diploma or GED; 25% have attended some college or technical classes; 10% have an associate's or technical degree; 14% have a college or graduate degree. See Appendix A for additional information about the sample and the treatment and comparison families. A total of 20 educators participated in the study (8 from AVANCE and 12 from HIPPY).

The Intervention: PEEP Family Science

PEEP Family Science provided parents, educators, and site administrators with materials designed to guide families through three month-long science units that focused on content and science practices related to ramps and movement, colors, and sounds. In addition to this science content, the materials focused on fostering a set of pedagogical engagement strategies that parents could use when exploring these topics with their children. PEEP Family Science materials described these strategies as follows:

PLAY AND EXPLORE TOGETHER

Your attention and encouragement make a big difference!

How to do it:

> Notice what excites your child—and play along!

> Guide your child's science play—but don't take over!

> Put your child in charge—giving children more control keep them interested and having fun.

ASK QUESTIONS AND TALK ABOUT IDEAS

The more you talk together, the more your child learns.

How to do it:

> Take turns listening and speaking.

> Talk out loud about your ideas so your child can learn from listening to you. Start by saying "I wonder . . . ," "I think . . . ," and "What if . . .?"

> Ask questions to help your child think more about the activity. Start a question by asking, "What do you think . . .?"

> Connect what you are doing to something your child already knows.

> Take pictures or videos, or make charts or draw pictures of the activities. Then discuss them. To learn, children need to review what they did.

EXPLORE MORE!

Children learn new things each time they explore.

How to do it:

> Do the activity again! Repeating fun activities helps children learn.

› Add new materials to explore in a different way.

› Play indoors and outdoors. Explore the same science topic in a different place.

To guide families and educators through these experiences, study participants received materials for each of the three units: ramps and movement, colors, and sounds. Descriptions of these materials follow.

Parent guide in the form of an app. Each app features four weeks on one science unit (i.e., ramps and movement, colors, or sounds). Each week offers two days of science, and each day has two activities for parent and child: (1) watching and discussing a video and (2) doing a related science activity together. Once downloaded, the apps can be used offline—parents do not need to have Wi-Fi or to use their phone's cellular data. Each app includes the following content:

› Videos of animated stories from the TV show *PEEP and the Big Wide World*.

› Live-action videos featuring real children.

› Parent videos featuring parents engaging in science activities with their children, which model the pedagogical engagement strategies for parents when they do PEEP activities with their children.

› Hands-on activities encouraging parents and children to actively explore important and developmentally appropriate science concepts and practices together. The WGBH media team also produced printouts of all the hands-on activities, in case parents wanted to refer to a printout rather than the app while doing an activity.

The PEEP animated stories and live-action videos are meant to accomplish the following:

› Engage children and support multiple exposures to the content through repeated viewing

› Foster para-social relationships with children that motivate them to (1) watch or interact with the media over time and (2) mimic the science practices and activities the characters model

› Model science practices and ways of thinking and talking, thus providing important scaffolds for learning

An educator guide provides home educators with written facilitation steps and guidance on how to model child-directed science explorations for parents. Home educators are expected to read the guide prior to meeting with families. During their meeting, home educators are encouraged to model the parent strategies and to walk parents through the videos and activities on the app. (Each of the three science apps has its own separate educator guide.)

An educator overview video outlines the role educators play in supporting and encouraging parents doing PEEP Family Science. Educators can watch the video on their own, or their organizations can feature it during a staff meeting or orientation.

A site coordinator guide gives administrators an overview of the intervention, offers suggestions for introducing PEEP to educators at a staff meeting, and provides discussion questions to accompany the educator overview video. (Each of the three science apps has its own site coordinator guide.)

After the study is complete, **a website** will house these resources, including links to each app, educator guide, educator overview video, all the PEEP animated videos and the parent videos, printouts of the hands-on activities, and a printout of recommended books and online games. (In addition to providing these resources for the three science units, WGBH developed a fourth science unit on shadows that was not tested in this implementation study.)

Data Collection and Analysis

The study took place over 12 weeks, between February and May 2018. PEEP families (those in the treatment group) used the ramps and movement, colors, and sounds unit for four weeks each. To address the research questions, researchers collected data from multiple sources, including the following:

> Observations of 18 educators (9 from AVANCE and 9 from HIPPY) introducing PEEP activities to families (6 educators per each of the three units)

> Observations of 19 families (9 from AVANCE and 10 from HIPPY) using PEEP Family Science with children (six of these observations included home educators introducing PEEP to families)

> Observations of staff meetings where the site administrators introduced the intervention to educators

> Interviews of the 19 parents and 18 educators who were observed and two site administrators

> In-person Focus groups with 20 educators

> Telephone interviews with two site administrators

Finally, researchers administered pre- and post-parent surveys to a comparison group of parents in home visiting programs who did not use the intervention in order to better understand changes in attitudes and behavior of the treatment group of parents over time. Table 1 displays the data sources used to address each research question. See Appendix A for additional details about each measure and the researchers' analytical approach.

Table 1. Research Questions and Data Collection

	Parent survey	Ed-parent observation	Parent-child observation	Parent interview	Educator interview	Educator focus group	Site admin interview
RQ1: Educator use of PEEP Family Science		✔		✔	✔	✔	✔
RQ2: Family use of PEEP Family Science			✔	✔	✔	✔	
RQ3: Relationship between PEEP Family Science and parent attitudes and knowledge	✔			✔	✔	✔	

Analytic approach. To analyze the observation and interview data, researchers summarized the data thematically and identified cross-cutting themes. To assess the extent to which parents in the PEEP treatment group demonstrated stronger gains in science-related attitudes and behaviors compared to their counterparts in the comparison group, researchers analyzed responses to the parent survey, which included questions that probed parent perceptions and behaviors related to each outcome. Because the survey included multiple questions for each outcome, researchers performed an exploratory factor analysis, a commonly used data reduction technique (see Appendix A). A factor analysis allowed us to group related questions and to calculate a single weighted score for each outcome. Using these scores, we then fit five separate regression models, one for each outcome. In each model, the post-survey outcome score served as the dependent variable, with the pre-survey score and whether they participated in PEEP as covariates, which allowed us to determine if parent gains between the start and end of the study were higher for parents who used PEEP. See Appendix A for additional details on the analytical approach.

Findings

Research Question 1: Home educator use of PEEP Family Science

SCAFFOLDING EDUCATOR PRACTICES

The design of PEEP Family Science rests on the central conjecture that, with resources that engage and scaffold their own learning, parents can learn about and implement practices to support their children's science learning. Recognizing the central role that home educators play in helping parents engage in learning at home, PEEP Family Science incorporates a number of resources to enable educators to support parents effectively, including an *Educator Guide*, educator overview video, parent videos, and site coordinator guide. The design of these resources draws from theory and research on how to prepare educators to employ effective scaffolding strategies to support learning, such as modeling and simplifying home educators' facilitation practices with specific facilitation steps. Based on interviews, observations, and focus groups with educators, our findings suggest educators were able to access and use the resources easily, and that after a few weeks of using the intervention, most educators felt prepared to help families use PEEP Family Science and did not need additional information or supports.

Educator perceptions of PEEP supports and adaptations to the model. During interviews, most[4] educators reported that they felt prepared to help families use PEEP Family Science, and most did not indicate that they needed additional information or supports. Overall, educators indicated that they were able to access and use the PEEP Family Science resources easily, including the PEEP Family Science apps designed for use by parents. Educators reported that they were able to download and use the apps using the written guidance provided in the educator guide and without any technical supports from researchers. Educators reported that they valued the simple, step-by-step guidance the resources provided. Initially, multiple educators noted that the steps parents needed to take to use the PEEP resources were unclear to them, and some described being concerned that they would not have the technical knowledge to help parents use PEEP and troubleshoot issues. However, educators who said they initially felt less prepared indicated that they gradually became more comfortable as they progressed through the units. As one educator commented, this initial lack of confidence may have been due to the challenge faced whenever implementing a new intervention.

In describing the utility of particular resources, educators valued the educator video for modeling how to support parents in using PEEP, particularly the guidance about how parents should use the media, and the parent videos for modeling concrete examples of how to do PEEP. Educators used different resources as guidance, depending on their preferences and needs. Some felt the educator guide's step-by-step practical guidance and ideas for going beyond the app's activities were valuable. In contrast, others felt the guide was too lengthy and text-heavy. Instead, many of these educators primarily used the apps and their embedded videos and guidance for parents to prepare each week—an interesting finding given that educators were not necessarily the targeted audience for the parent videos. Given that educators felt prepared regardless of the guidance they used suggests that the intervention was sufficiently flexible to meet a variety of needs.

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4 In describing our qualitative results, we describe the variations in implementation and the variety of perceptions and approaches rather than present absolute quantities or counts. In reporting these kinds of patterns, we loosely define the terms used as follows: *most* refers to more than half of the cases being described; *many* refers to about half and more than a few; and a *few* refers to two or three cases.

Educator understanding of parent strategies. As part of the study, we explored the extent to which educators shared an understanding of the core goals of PEEP Family Science—potentially an indicator of how prepared educators were to support parents in using the three focal strategies with their children. When asked to identify PEEP's most important messages for parents, many noted one or more of the parent engagement strategies, and several described examples of parents using each of the strategies in ways that suggested that the educators understood the meaning of the parent strategies, a possibly important precursor to ensuring that educators integrate them in their educational practice. For example, when asked whether the "play and explore strategy" was clear to parents, one educator described the following:

> *It was clear because they would tell me that when they went to the park, they would explore more with their children. That before they would just go to the park and let their children play in the playground. But now they get involved in the slide, because they can talk about ramps and colors, about what color they are seeing around them, or what sounds things make. So, yes, it was clear.* - Educator

In response to a question about whether the strategy of asking questions and talking about ideas was clear to parents, another educator replied:

> *Just, if the parent had to build a ramp and the child had to...ask some questions. "What do you think will happen if we tilt it up some? What do you think will happen if we make it a little more higher up?" So I think that that was clear, that talk to your child, get your child to explore about what he might think will happen.* -Educator

A few of the educators, however, were not able to describe the strategies in any detail, or they were able to describe only one of them, and indicated that they did not fully understand them. It is not clear why they lacked understanding; for example, reliance on particular guidance materials or a lack of comfort with technology did not explain the finding, although some

of these educators were also ones who reported feeling the least prepared initially.

HOME EDUCATOR SCAFFOLDING OF FAMILIES' USE OF PEEP

Researchers also observed educators during their regular meetings with families to better understand the kinds of supports educators provided parents for using PEEP Family Science effectively. During observations, we saw educators provide extensive support to parents in ways that aligned to effective scaffolding for learning, including explaining, modeling, and connecting to parents' prior experiences. A few educators followed the educator materials and app closely when introducing the activities to families, while many others adapted the model, using the resources as a jumping off point, elaborating and, in some cases, adding more questions and opportunities for feedback from parents. Most of the educators that researchers observed modeled the hands-on activities for the upcoming week or weeks, and many educators explained the science concepts that were the focus of the activities and elaborated on the directions in the apps by giving suggestions for how the parents might do the hands-on activities. Many educators explained the parent engagement strategies and talked with parents about how they could enact them. However, a few educators explained parent strategies by reading the app script aloud to the parent and did not expand on those directions, such as prompting for understanding or connecting to families' existing practices. Educators also supported parents by connecting examples in the videos to parents' experiences; asking and answering parent questions; and, in a few cases, observing families trying the hands-on activities and providing them with feedback.

## Research Question 2. Family Engagement with PEEP

USING PEEP FAMILY SCIENCE IN THE HOME

Time spent using PEEP. PEEP Family Science was designed to be used weekly over the course of three months, in addition to the regular activities families were already doing as part of the home visiting

curricula. The intervention includes activities that can be completed in two 20–30 minute sessions, and survey findings suggest that most parents were able to dedicate sufficient time to using the intervention, and in some cases, they spent more time than was asked. To better understand parent and child use of PEEP, the parent survey asked parents to estimate how much time they had spent using PEEP during the week prior to taking the survey. Most parents completed the survey during the third or fourth week of the final sounds unit, so these estimates are most relevant for participation rates at the end of the program. Results suggest that the majority of parents (55%) spent between 30 minutes and 1 hour per week using PEEP; close to one-quarter of parents (22%) spent less than 30 minutes per week; 18% spent between 1 and 2 hours; and 5% spent more than 2 hours (Figure 2).

Figure 2. Time Spent Using PEEP During Prior Week (N = 145)

■ Less than 30 minutes ■ Between 30 minutes to 1 hour ■ Between 1 to 2 hours ■ More than 2 hours
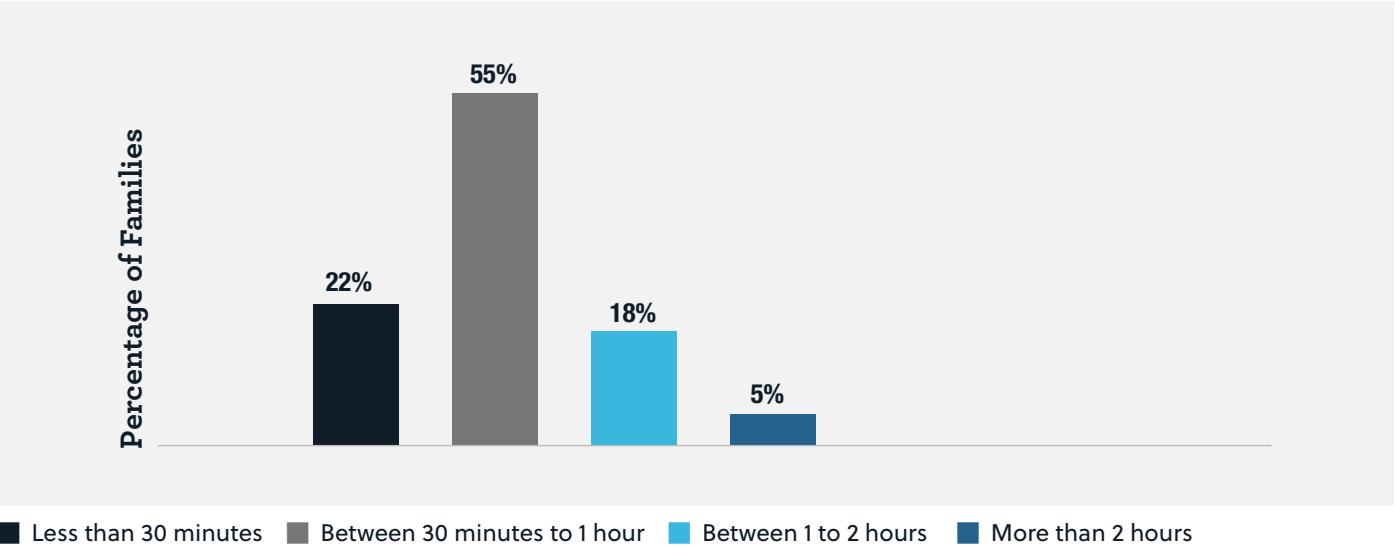
PEEP materials used. The parent survey also asked parents about how much of each unit they had used. Across all units, more than half of families reported that they used all of the PEEP materials for each unit, and more than 80 percent of families indicated they used most of the PEEP materials for each unit. Very few families (less than 3%) reported that they did not use a unit at all (see Figure 3). Parent reports suggest a very slight decline in use during the last unit. However, this drop is likely related to the fact that the survey was administered in the last two weeks of the program, and parents may not have finished the unit.

Figure 3. Caregiver Reports of Use of PEEP Family Science by Unit (N = 156)

■ Did not use   ■ Used less than half   ■ Used more than half   ■ Used all   ■ Missing
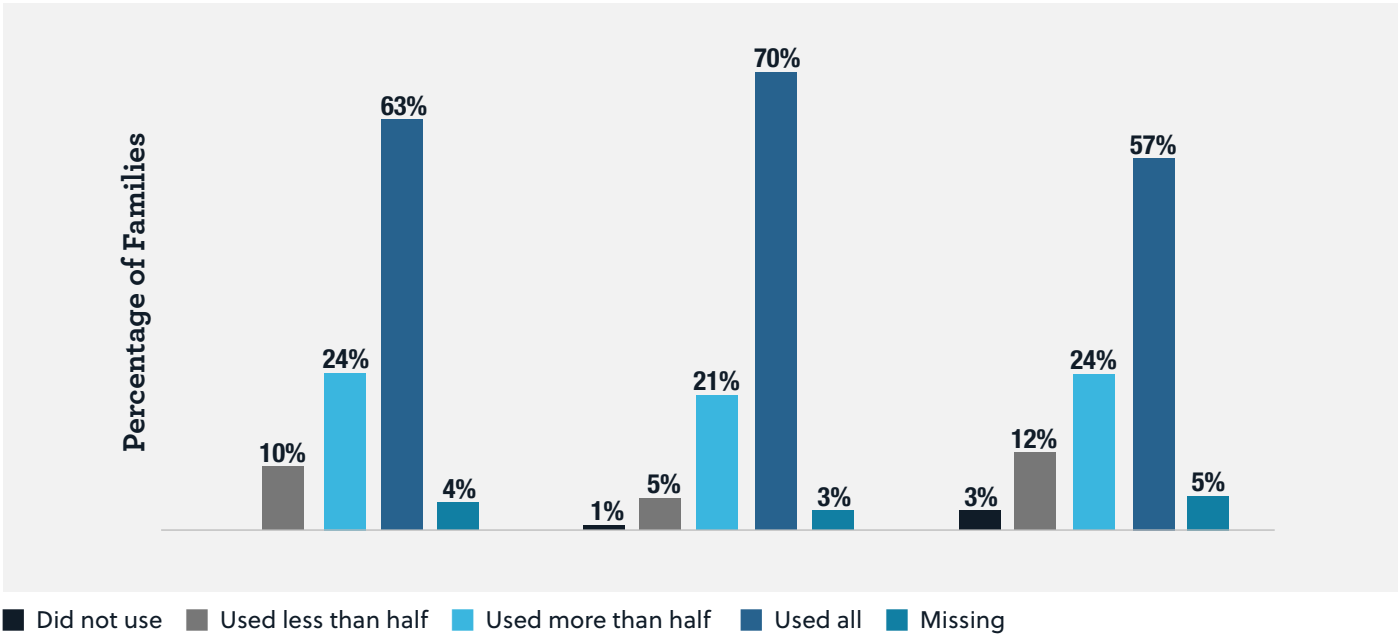
Accessing PEEP and ease of use. Although incorporating a technology-based intervention was a new experience for participating educators and parents, survey responses suggest that almost all parents were able to access and use the PEEP intervention with relative ease and few technical problems. The vast majority of parents and caregivers surveyed (91%) agreed or strongly agreed that the PEEP Family Science app was easy to use. Similarly, almost all parents (89%) agreed or strongly agreed that it was easy to fit PEEP into their schedule (see Figure 4). Findings from our interviews and observations echoed these survey

reports. In interviews, families indicated that they were able to access and use the PEEP app easily without any technical supports and that they found it easy to fit PEEP into their daily schedules and with what they were already doing in their home visiting program (i.e., AVANCE or HIPPY). Importantly, parents and educators appreciated that PEEP activities did not require special materials (with the exception of one activity that required paints). The fact that few families dropped out of the study also suggests that PEEP was relatively easy to incorporate into families' lives.

Figure 4. PEEP App Use

■ Strongly Disagree   ■ Disagree   ■ Agree   ■ Strongly Agree   Percentages of Families
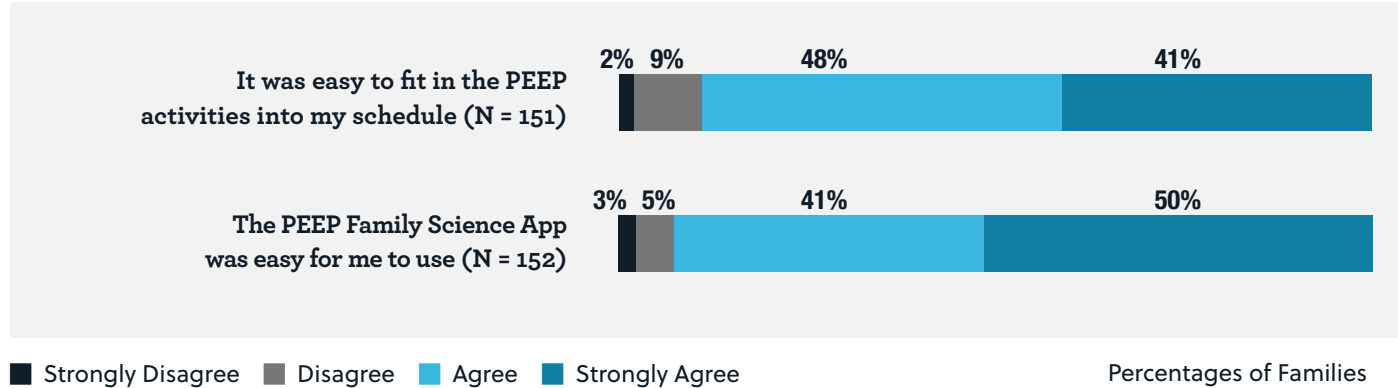
Because PEEP Family Science is unique in its incorporation of media-based resources, in addition to surveying parents, we also explored whether parents were able to access and use the technology during our interviews and observations of educators and families. Based on researchers' observations of families engaging in PEEP Family Science, as well as reports from educators, most of the parents who participated in the study used the PEEP apps on their smartphones and were able to download and access the apps without difficulty. Although some of the less tech savvy parents had some apprehension around using an app, reports from educators suggest that relatively few parents experienced issues with downloading PEEP. About half of the educators we interviewed reported that parents experienced an issue when downloading the app; however, in nearly every case, it was only one or two parents in each caseload who encountered technical difficulties. Most parents were able to download the app with ease. The educator-reported issues parents did encounter varied and included the following:

> Compatibility problems between the phone and app, often due to the age of the phone

> Lack of storage space on the phone (Some families expressed frustration that they had to delete personal photos to make space for the app on their phones.)

> Lack of Wi-Fi access or unreliable Wi-Fi access

Inexperience and apprehension with technology also emerged as a challenge for some families. Educators indicated that of the parents who did struggle with the app, almost all were able to work around the issue, either by themselves or with help from the educator. Most families with Wi-Fi issues were able to use Wi-Fi hotspots provided by the research team to download the app. A few parents who were unable to download the app onto their own device borrowed a tablet through their home visiting organization. Only 2 of the 19 families we observed used printouts of the activities and the website rather than the app.
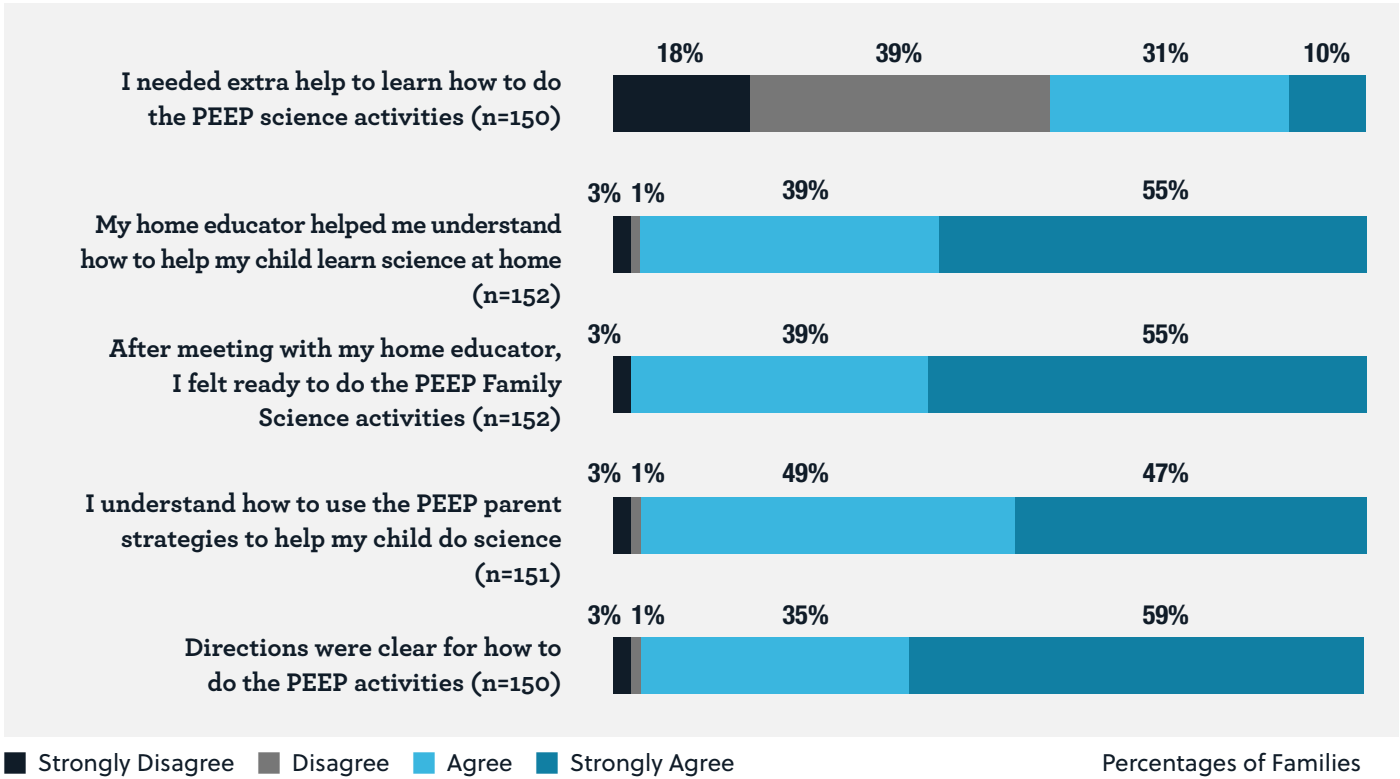
Of the parents who used the app during our observations, most did so with ease and with few technical problems. A few parents whom we observed struggled with navigating the app and following the progression of the activities. However, the home educator was able to assist these families (e.g., remind them of what they had already completed, find the next activity, find the correct video). One parent said her child sometimes had to help her with the app.

PEEP Family Science Supports for Parents

The PEEP Family Science intervention model focuses on helping parents learn to use the focal pedagogical strategies. Along with the home educators supports described above, the PEEP app serves as a parent guide that walks parents through the media and the hands-on activities and provides step-by-step guidance on how to engage in science exploration. Media embedded in the apps scaffold learning by modeling and providing guidance on how parents can use the strategies to explore science with their children. The parent survey and observation findings suggest that almost all parents felt prepared and had sufficient resources to engage in the intervention, and that the parent videos were particularly valuable in modeling science engagement.

In order to understand the value of these supports, the survey asked parents about the extent to which they felt prepared to use PEEP Family Science. Almost all parents (96%) agreed or strongly agreed that they felt ready to do PEEP activities after meeting with their home educator. A similar number of parents (95%) agreed or strongly agreed that the directions for how to do the PEEP activities were clear. While approximately 40% of families stated they needed extra help, virtually all indicated that their home educator was able to help them understand how to do the PEEP activities. (See Figure 5).

Figure 5. Parents' Perceptions of PEEP Family Science Supports

I needed extra help to learn how to do the PEEP science activities (n=150): 18% | 39% | 31% | 10%

My home educator helped me understand how to help my child learn science at home (n=152): 3% | 1% | 39% | 55%

After meeting with my home educator, I felt ready to do the PEEP Family Science activities (n=152): 3% | 39% | 55%

I understand how to use the PEEP parent strategies to help my child do science (n=151): 3% | 1% | 49% | 47%

Directions were clear for how to do the PEEP activities (n=150): 3% | 1% | 35% | 59%

■ Strongly Disagree ■ Disagree ■ Agree ■ Strongly Agree   Percentages of Families

The survey also asked parents whether their families had difficulty with PEEP Family Science. Only 13% of parents reported having difficulties. Most frequently, parents reported that their difficulties were technical and related to finding the PEEP app hard to use (8%) and/or that the app did not work (7%).

During observations and interviews, researchers explored how parents used and perceived of the parent support materials in more depth. During the observations, researchers saw that parents relied on the app to guide them through the PEEP Family Science activities—about half of the 19 families observed referred to the app while doing the activities, while others referred to the app before or after the activity. Most parents the researchers observed reported that they watched the parent videos, and many appreciated having a "play-by-play" of the activities they would be doing with their child. Educators reported that the parent videos were particularly valuable for parents who lacked strong literacy skills or who lacked confidence in doing science. However, although parents valued the videos as a model, multiple parents of young children

indicated that the age difference between their child and the children in the videos made it difficult for them to identify realistic expectations for the activities and the kinds of supports to provide their child, given the comparatively young age of their child.

Parent Perceptions of PEEP Family Science

Aligned to the high reported use of PEEP Family Science, virtually all parents (95%) agreed or strongly agreed that their child enjoyed using PEEP Family Science. These survey findings were reflected in interviews with both parents and educators. Virtually all of the educators and parents who were interviewed reported that parents and children enjoyed using PEEP Family Science and that the videos, PEEP characters, and hands-on science explorations were engaging and fun. Most of these families researchers interviewed indicated that they appreciated having access to vetted resources that support hands-on science exploration. Multiple parents said they valued the opportunities that PEEP provided to spend one-on-one time with their child and agreed that their child learned science by using PEEP.

As one parent explained:

> "[T]he program helps me because I spend more time with her. I dedicate her a little more time."

Similarly, one parent said:

> "I get to feel like a kid again. I get to enjoy my grand-babies and watch the smile on his face. That right there means more than anything is just seeing him happy. And know that he's learning."

Using media to foster engagement in science. The design of PEEP Family Science is predicated on the unique affordances that media offer in engaging and motivating children and families in science. Researchers' observations indicated that most children enjoyed watching both the PEEP animations and the live-action videos. Similarly, reports from most parents and educators suggested that children and parents thought the videos were fun and that they were excited to use them. Most parents reported watching the videos with their children, and some children watched the videos more than once on their own. Here are a few examples of parents' comments on the child videos:

> "Oh, we love it. Oh, he loves PEEP. That's one thing about it because he'll holler, 'Can we… Is it time for PEEP?' I said, 'Whenever you want to do PEEP, you know where the button is.' "

> "I think they are very good, because we don't use much vocabulary… sometimes you don't use these words, but now we are learning to use more words from the program."

> "What do I think? I think that it teaches kids so they learn what quiet means, or high, soft, etcetera. So they'll learn to differentiate and realize that they're not all… That they sound different, and know what makes the sounds different… that they learn. For example, when someone says to them, "sing softly" they need to know what 'soft' means, and when someone says, "sing loudly" they need to know what 'loud' means. That not everything is the same."

During interviews, most parents indicated that they had created media as well by taking photos or making videos of their child doing PEEP Family Science. A few of these parents further described using the videos to talk about the focal science concepts. For example, one parent described talking to their child about a video and asking, "What was different or what could maybe make [an object] go faster down a hill or slide"? A few other parents stated that they took the pictures and videos to share with family members as part of their regular practice of documenting and sharing their children's lives with them.

Another advantage of using media relates to para-social relationships. As children interact with videos and television shows, they develop emotional bonds with characters from their favorite televisions shows, treating them as their friends and interacting with them through pretend play. Research suggests that through these para-social relationships, these characters can serve an important educational role, as children naturally extend and relate the storyline to their own lives (Brunick, Putnam, McGarry, Richards & Calvert, 2016). PEEP Family Science promotes these extensions through activities that build on and draw from the animations. Results from this study indicate that this component— the use of media and characters as role models—is a strength of PEEP. Parents reported that their children enjoyed the videos and watched them multiple times and also referenced PEEP and other characters outside of PEEP activities.

Most parents and educators valued the PEEP videos because they engaged children and parents in science—a topic that many perceive as difficult. However, researchers' observations as well as reports from a subset of parents and educators also suggest that the engagement fostered by the media posed challenges for some parents. In particular, some parents had trouble moving their children from the videos to the hands-on activities.

Differences in engagement by age. Although PEEP Family Science is aimed at children four- to five years-old, the study included children as young as three years. (The age range of children in the study was lower than expected due to downward shifts in the ages of the children that home visiting organizations are serving, due in part to increases in pre-K availability for families.) While our observations suggest that parents of three-year olds were able to use the intervention to engage in science, if PEEP Family Science were to target three-year-old children, some parents may need additional supports for adapting PEEP to the needs of these younger children. For example, some of the youngest children in our observations had difficulty engaging in conversations and activities that required more advanced skills, such as revisiting predictions after an investigation or using a chart to track observation results. Some parents of the younger children were able to adapt these activities, but educators also suggested that PEEP could be improved by including more models of three-year olds doing PEEP Family science in the parent and live-action videos. Additionally, a few parents, as well as researchers' observations, suggested that some of the youngest children—young three-year-olds—did not have sufficient attention spans to watch the full videos.

Engagement in Science Content and Practices

The central goal of PEEP Family Science is to support families in exploring important science content and practices. In order to understand whether PEEP Family Science is an effective model for engaging families in science learning, researchers conducted an in-depth analysis of the science content and practices that parents focused on during our observations (see Appendix A for details about the analysis). The findings suggest that through using PEEP Family Science, families explored important science content and practices. Through PEEP activities, parents and children explored core disciplinary ideas in physical science such as testing and experimenting with how objects move on

inclines; describing, identifying, and comparing colors; and exploring differences in the pitch and volume of sounds. They also engaged in several science practices, including asking questions; planning and carrying out investigations; analyzing and interpreting data; using mathematics; and obtaining, evaluating, and communicating information. Researchers observed some families using science-related vocabulary during the activities. The following section presents examples of families exploring science content and engaging in science practices from each unit.

Ramps. Researchers observed families carrying out investigations that explored science content and practices related to observing differences in matter and the motion of objects. From the PEEP Family Science ramps unit, families engaged in activities such as:

> Making slides

> Exploring whether objects on a ramp roll, slide, or stay put

> Racing objects down a ramp

> Attempting to make objects go down one ramp and up another

> Exploring how the surface and texture of ramps affects how objects roll or slide down them

The understanding gained through these types of explorations helps provide foundational knowledge for later science learning related to properties of matter and the motion of objects.

Most of the ramp investigations that researchers observed involved exploring how different objects move down a ramp and how different types of ramps affect the movement of objects. For example, the following is an observation of a parent and child working on the *Roll or Slide?* activity, which asks them to place objects on a ramp to determine whether the objects will roll, slide, or stay put.

PEEP Family Science in Action

Roll and Slide
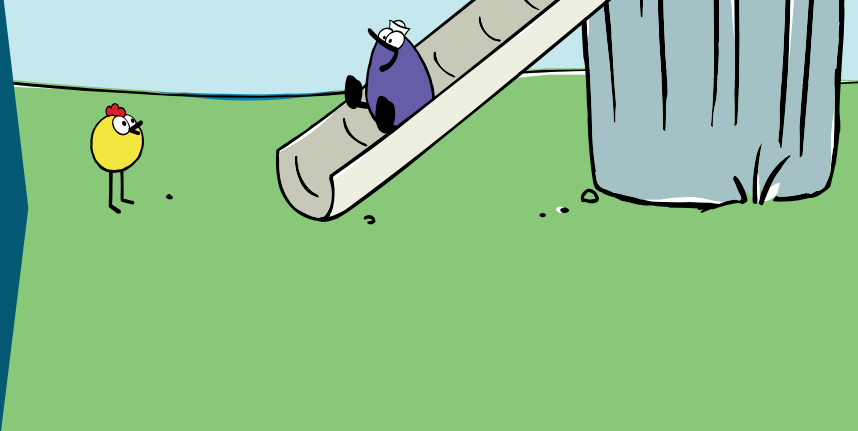
A mother and daughter experimented with rolling and sliding different materials and objects—stuffed animals, balls, dominoes, a scarf, and an apple—down a ramp at different inclines. To illustrate the effect of a ramp's incline on speed, the mother first laid the ramp flat and then made the incline steeper. After the child selected and sent an object down the ramp, the parent used chart paper to record the object's material and whether it slid or rolled down the ramp. The child was animated, smiling and laughing throughout the activity, and made sounds like *"weee!"* The child was engaged in the activities throughout the observation, with one exception—she did not use the recording chart that the mother used to record their experiments. The mother appeared to be engaged in the activity, although her body language suggested she was not completely comfortable—perhaps due to the researcher's presence. The mother asked her daughter questions throughout the activity. This excerpt is from the beginning of the activity, when the mother and daughter made predictions about what would happen when they rolled objects down a ramp and then they discussed factors that would affect the speed.

P: If we put them higher, they will go more quickly. Why do you think that they will go more quickly? Look. It's higher. Slide it.

C: Yes.

P: Is it going to go fast or slow? Slow or fast?

C: Fast.

P: Fast? Let's see.

C: Fast!

P: Yes! It goes very fast. Do you want to try it? … If we make it flat, will it slide? Will it slide or won't it slide?

C: It won't slide.

P: It won't slide. So, the surface needs to be a little bit elevated. If we put this here, try it. It slides, but it goes very slow.

Researchers also observed parents asking children different types of questions related to the investigations: questions that asked children to make predictions about what will happen (*"Which one do you think is going to go faster?"*), questions about the investigation itself (*"Why do you think the ball is going down this one and going up this one like that, but when you do it on this side, it doesn't go up this hill?"*), and questions that led to design changes or new investigations (*"Do you think it will slide if we put the ramp higher?"*).

Throughout most of the investigations, researchers observed both parents and children analyzing and interpreting data by describing the results of the activity as they occurred or following the activity (e.g., the speed at which objects rolled down a ramp and how the surface of the ramp affected the speed; whether objects slid, rolled, or stayed put; or whether a ball went down one ramp and up another). During these investigations, parents often posed questions to their children about what they were observing, and the children would respond. In addition to analyzing data, some families

obtained, evaluated, and communicated information about objects or events related to the investigation, such as the smoothness or roughness of surfaces, the size of objects, and the height and steepness of different ramps. One family was observed engaging in mathematics as they counted and sorted the child's toy cars prior to doing their ramp activity. During the investigations, many parents and children observed the properties of different objects and how they moved down a ramp; some families used science-related vocabulary such as *fast, slow, up, down, roll,* and *slide* in their observations.

Colors. Researchers observed families carrying out investigations in which they engaged in science practices and content related to observing, identifying, describing, and comparing colors. Researchers observed families conducting activities from the PEEP Family Science colors unit, such as:

> Mixing colors to form new colors

> Identifying different shades of the same color

> Observing objects through colored water

> Making colored light

> Playing hide-and-seek with different colored objects

> Creating color collages to explore how colors contrast with or blend into their environment

In some cases, families applied the concepts to activities outside of PEEP, such as coloring Easter eggs or making slime. The understanding gained through these types of explorations helps provide foundational knowledge for later science learning related to the nature and behavior of light energy and matter.

Throughout most of the investigations, researchers observed both parents and children analyzing and interpreting data by describing the results of the activity as they occurred or following the activity (e.g., what new colors formed by mixing paint, or whether they saw an object through colored water or observed colored light) and comparing and contrasting the objects used during the activity (e.g., discussing different colored objects during hide-and-seek or characteristics of objects collected for the color collages). In these cases, parents often posed questions to their children about what they were observing and the children would respond. We observed some families using science-related vocabulary such as *color, different,* and *same.*

The vignette on the following page is one notable observation, which occurred in the context of a video (*Hide and Go Peep*) and a hands-on activity (*Bug Hide-and-Go-Seek*) that asks families to create different colored "bugs" out of paper then hide them against backdrops that were the same color and different colors and analyze how easy or hard they were to find.

Some families observed other differences besides color by obtaining, evaluating, and communicating information about objects or events not directly related to the color activity. During the *Bug-Hide-and-Go-Seek* activity, we observed parents and children discussing the size of the "bugs" they had created. Families were also observed making color collages using leaves, twigs, grass, and rocks they had collected. In addition to comparing the objects against green and brown backgrounds and analyzing the colors of the objects (particularly different shades of the same color), a couple of families made additional observations, such as counting the number of objects they had; comparing the weight of different rocks; and sorting rocks, twigs, and leaves by color, size, and shape. In these examples, parents and children engaged in mathematics as well as cross-cutting themes in physical science dealing with scale, proportion, and quantity.

PEEP Family Science in Action

Colors

The child sat close to her mother during the video and both smiled and laughed while watching. About halfway through the video, the child took the mother's phone to watch, while the mother looked over her shoulder. When the video ended, the mother commented that the video was cool and asked the follow-up questions suggested by the app:

P: You remember when Peep hid in the flowers? Why do you think it was hard for Quack to find him?

C: Because he was yellow and the flowers were yellow.

P: Really? So they were the…

C: Same color.

P: Same color. Good job. But why was it is easy for him to find Chirp?

C: Because Chirp is red and flowers are yellow.

P: Yeah, so he's….

C: Different color

. . . .

After watching the video, the child and parent completed the *Bug Hide-and-Go-Seek* activity, hiding the bugs throughout the rooms in the house. The child was engaged throughout the activity and appeared to especially enjoy decorating the bugs. She took her time hiding the bugs from her mother in different rooms, sometimes in camouflaged places, such as a dark bedspread, and other times in hidden corners. She seemed gleeful about how long it took her mother to find her hidden bugs. In the first round of the activity, the mother was careful to hide the bugs on top of colors that were different from the bugs, and in the second round, she hid the bugs on colors that were similar to the bug. The child led the activity with some guidance from her mother and did not want to stop playing hide-and-seek at the end of the observation. After they had finished playing—each taking a few turns to hide and then look for bugs—the mother asked the child to reflect on the activity:

P: When we were hiding our colors, why do you think it was so hard to find the blue? And the purple?

C: Because the purple was underneath my daddy's machine and it was dark and purple is dark.

P: Mmm hmm. Good job.

C: And the blue one was so light and grandma's bedroom was light.

P: Ok. Good job.

Sounds. During the sounds observations, researchers observed parents and children engaging in science practices and explorations of science content related to observing, identifying, describing, and comparing sounds, including their pitch and volume. Families watched videos and did hands-on activities from the PEEP Family Science sounds unit that focused on listening, making, or manipulating sounds and describing their similarities and differences. The understanding gained through these types of explorations helps provide foundational knowledge for later science learning related to the nature and behavior of sound energy.

Some families discussed science-related content while watching the PEEP videos. For example, while watching Chirp imitate different bird sounds in the video *Chirp, Chirp, Tweet, Tweet, Chirp*, a parent asked, *"Can you make the sound? What's the sound that the cardinal [Chirp] makes?"* to which the child responded, *"Tweet, tweet, tweet."* When watching the *Give Me a Call* video, a parent pointed out that the crows' singing was so loud that Quack had to cover his ears with acorns. When the child asked why, the parent explained, *"Because the sound of the raven [crow] was very loud; it went 'caw, caw!' and they had to cover this part so that it wouldn't keep on listening."*

Families carried out investigations by engaging in PEEP activities, such as detecting sounds made by different objects, singing at different volumes and pitches, talking and singing through tubes, and making and playing with maracas and drum sets. Throughout most of the investigations, both parents and children were observed analyzing and interpreting data by describing the results of the activity as they occurred or following the activity (e.g., how sounds differ when you change the volume or pitch from loud to soft or high to low, which sounds are made by which objects, and whether objects or actions produce sounds that are the same or different). Parents commonly posed questions to their children about what they were observing during the investigation and the children would respond. We also observed some families using science-related vocabulary such as *sound, loud,* and *quiet* or *soft*. In addition to science practices, families engaged in science content related to investigating sounds made by different objects and materials and identifying ways to manipulate objects to change the volume and pitch.

During an activity called *Talking and Singing Through Tubes*, which asks families to talk or sing through a tube to explore how it changes their voice, researchers observed a parent and child describing differences and categorizing observable phenomena based on sound.

PEEP Family Science in Action

Sounds

The mother and child played with three different tubes—a toilet paper roll, a paper towel roll, and a roll they made from poster board. The mother and child talked and sang the owl song into the different tubes, and the mother put the toilet paper tube by the child's ear to help distinguish whether the sound was loud or quiet.

C: *Singing through tube.

P: How does it sound?

C: Fine.

P: Is it quiet or loud?

C: Quiet.

P: Quiet?

C: Yes.

P: And when you are not wearing this, how does it sound?

C: "The mother owl is saying sh." And I hear it.

P: And you hear it. But do you hear it louder or softer… How do you hear it?

C: Loud.

P: Loud?

C: Yes.

P: And without this tube, how does it sound? Let's use the tube to sing.

C: "The mother owl, the mother owl, is saying shh, is saying shh. Everybody quiet, like the mother owl."

P: How did it sound: quiet or loud?

C: Quiet.

P: Did you hear it louder with the tube or without it?

C: Without it.

P: Without it? Does the voice sound different or is it the same?

C: It sounds the same.

Use Of Parent Engagement Strategies

To support the acquisition of science content, PEEP Family Science focuses on fostering a set of pedagogical engagement strategies that parents can use when exploring science topics with their children, and the observations of a subsample of parents suggest that almost all parents were able to employ these strategies when using the intervention. Researchers observed parents using elements from all three parent engagement strategies while watching the videos and doing the hands-on activities, as well as using joint media engagement strategies, such as explaining the animations and connecting the animation to something in the child's life.

Play and Explore Together: Most parents researchers observed were very attentive while watching the videos with their child, observing what made their child excited or laugh, and matching their enthusiasm by smiling or expressing wonder. Many of the children sat either close to their parents or in their parents' laps. During the hands-on activities, the majority of parents seemed comfortable playing along with their child,

also expressing interest and excitement during the explorations. Most children expressed delight at the prospect of a new activity, smiling, laughing, dancing, and running to get the necessary materials, although a few children did not want to engage in the activities. During one activity from the ramps unit, one parent set up two ramps, first demonstrating the activity for the child. The child and parent then began racing their balls down each ramp. The game aspect of the activity seemed especially engaging—both the parent and child enjoyed debating who won, while the child ran around the room laughing. During another observation of the sounds unit, the child and parent danced and sang as they played the instruments they had made.

Most parents were able to guide their child's play without taking over and allowed their child to make choices that determined the structure of the activity. The PEEP apps provided clear step-by-step instructions for parents to implement the activities—and parents and educators noted this level of detail as a strength of PEEP. Although the nature of the step-by-step directions meant that parents were guiding the activities, the apps provided prompts for parents to engage their child through open-ended questions and opportunities for the child to make choices and lead aspects of the activities based on their own interests. For example, during the colors unit, researchers observed children taking the lead in mixing the colors while parents asked open-ended questions to guide and focus their children without telling them which colors to use (*"Do you remember when we created purple last time?" "Keep trying to experiment to see if you make pink" What color do you think it's going to be?"*). Observations indicated that children appreciated having their own agency when playing with their parents. Their body language and expressions of delight suggested they were especially proud when they completed parts of activities that encouraged independence (e.g., hiding bugs) or when they helped their parents do things such as mixing colors and pouring water. When their parents introduced a new activity, the majority of children showed excitement. Finally, a few parents were more directive in their approach.

Ask Questions and Talk about Ideas. All parents asked their children numerous questions during the hands-on activities and, to a somewhat lesser extent, while watching the videos. The kinds of questions and ideas parents asked and talked about varied. Researchers observed all parents talking about and asking questions that directed their children's attention to descriptions of what they saw, heard, or felt and the labeling of the science activities they were engaging in together. For example, parents asked questions and talked about what was happening in the videos they were watching together (e.g. *"What color is Quack?"* and noticing, *"His ears are covered with big acorns!"*) or during the hands-on activities, such as asking the child to label the colors of the paints they were using, describe the sounds they were listening to (*"Is it quiet or loud?"*), or the materials they were using to create ramps, such as describing or asking a child to describe a ramp as smooth or rough or steep. Almost all parents asked their children questions about the results of their investigations, most often asking the child to describe what happened and then following up with their own descriptions, such as asking how far a ball went down a ramp or the color that resulted from mixing two paints. Many of these questions prompted children to compare what they were observing, such as asking the child which ball was faster down a ramp, whether colors a child made after mixing looked *"a lot or a little the same,"* or how two sounds were different. Some of these parents also connected these kinds of observations to children's prior knowledge or experiences, such as noting how a color was similar to the color of the child's favorite fruit, asking a child about the songs of different birds that he knew, or connecting a hands-on activity to the related videos they had watch earlier.

Researchers also observed about half of the parents asking and talking about ideas that were more conceptual in nature, or that required higher level reasoning. For example, many parents asked children to explain the larger patterns or relationships they were observing, asking "why" questions, such as *"Why do you think the ball rolled down this ramp faster than the other ramp?" "What does it mean that one ball could go up and the other could not?"* or *"Why does the light pass through this color [but not the other]?"*

or explaining that a ball went more quickly down a ramp because the ramp is smooth. Many children struggled to answer these kinds of questions, and parents often offered their own thinking. For example, one parent asked a child to explain a concept related to camouflage in one of the videos they watched together: *"...And the butterfly says I am the best hide and go seeker there is. Why do you think the butterfly said that? Hey, why do you think the butterfly said that? Was it because he was the same color as the other flower he was just by?"* In the context of their investigations, some parents asked children to make predictions about what would happen next and in a few cases extended the conversation to ask the child why: *"Which [ball] is going to cross first? Why?"* and *"Smooth. What do you think? Could we get one of these balls up to the top? What do you think?"*

Explore More. Parents as observed by the researchers were comfortable expanding on the activities suggested by the PEEP app. Some were observed adding new materials to the planned activities during observations, such as mixing different colors of clay, painting Easter eggs, or collecting leaves and sticks outside. Because researchers only observed each family once, for approximately one hour doing the instructed activities, and because we asked them to show us how they use PEEP Family Science, there were not many opportunities to capture the parents exploring more with their children during the observations. The majority of parents did, however, report in interviews that they expanded on the PEEP activities on their own. Most of the parents explored more by going outside and finding ramps, colors, or sounds in the park or their yard.

> *...now it's everything, he looks for sounds everywhere. Not long ago he was going on about how bananas make sounds, everything. Now he's all about sounds, everything makes sounds.* –Parent

Some parents reported trying new experiments using examples on the Internet, such as making slime, using different ramps, or mixing household items to make volcanoes or bouncing eggs.

> *I got the idea to use lids, and not just with lids, you could also use paper towel rolls to make ramps. Anything that is disposable. For example, with plastic water bottles you can make closed-in ramps by cutting off both ends and joining them together. You can join them with glue or tape and make closed-in ramps.* –Parent

Research Question 3. PEEP Family Science and Changes in Attitudes and Knowledge

PERCEPTIONS OF CHILD LEARNING

Virtually all parents surveyed (97%) agreed or strongly agreed that using PEEP helped their child learn important science topics. Almost all (97%) parents agreed or strongly agreed that the PEEP Family Science intervention gave them ideas about strategies to use with their child to help them learn science, how to do science activities using different materials and how to do science outside of the PEEP activities (Figure 6). Similarly, almost all families (96%) agreed that PEEP helped them ask their child questions about science and to see what gets their child excited about science.

Figure 6. Parents' Perceived Value of PEEP

	Strongly Disagree	Disagree	Agree	Strongly Agree

Percentages of Families
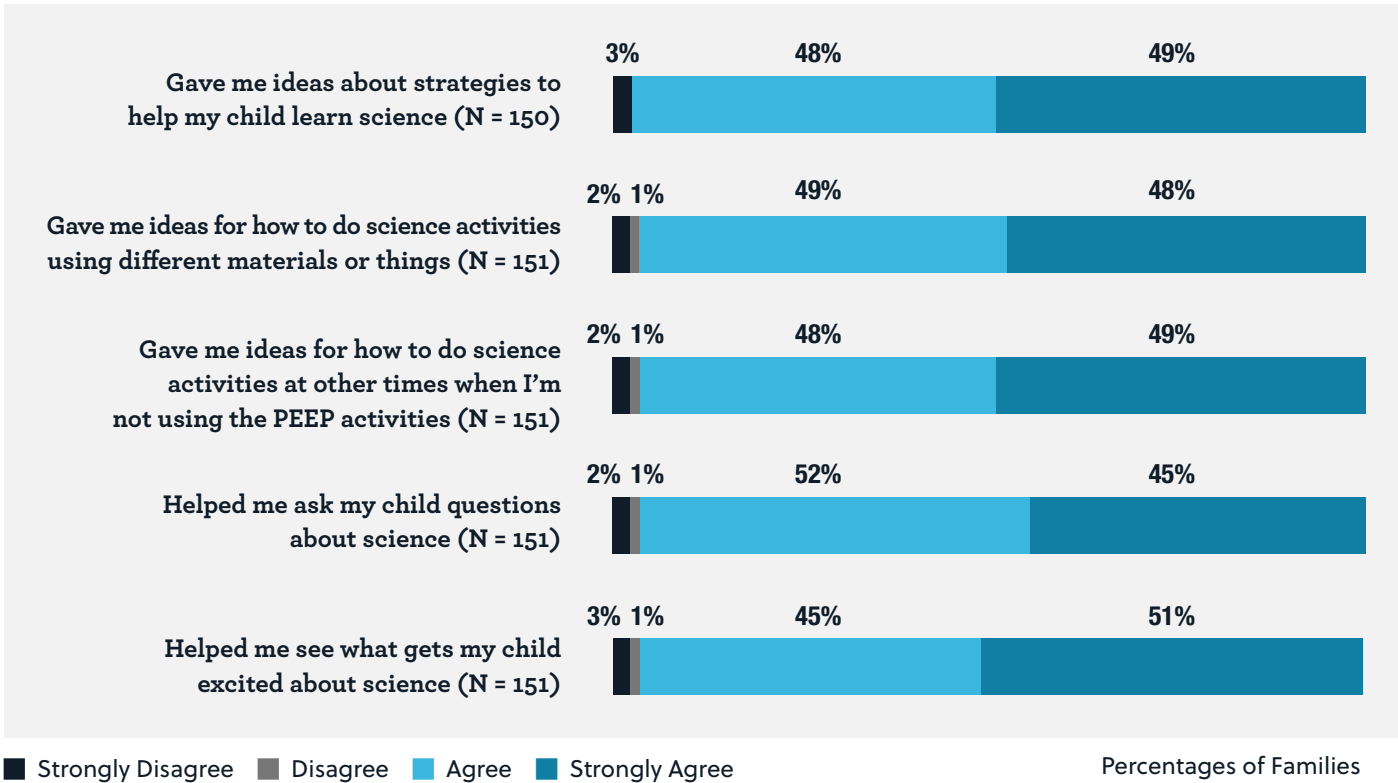
Changes in Parent Attitudes, Knowledge and Behavior

Perceptions of science. To understand how parents' broad conceptions of science might have changed after using PEEP Family Science, the parent survey asked parents to respond to the question: "When you hear the word *science*, what does that mean to you?" Researchers categorized responses by content of focus—physical, life, earth, engineering and/or technology, using technology, general science, and not science—and by science practices when they referred to actively engaging in science-related activities through investigation, exploration, or discovery (using words such as *describing, exploring* or *engaging in the world, discovering, analyzing, exploring* and *creating*). Responses that described science as a topic (e.g. space) did not fall into the active category.

Families who used PEEP were more likely than the comparison group to refer to active science practices in describing their conception of what science is (68% of PEEP parents, compared to 45% of the comparison parents, p < .05). We found no differences between the comparison and treatment groups in parents' descriptions of what science is as it relates to science content pre- and post-intervention. The study did not find significant differences between PEEP Family Science families and the comparison group when examining parent perceptions of the importance of early science learning.

Changes in attitudes and behavior. To further examine the potential impacts of PEEP Family Science, researchers explored how parents' attitudes and reported behaviors changed between the start and the end of the study. Researchers compared these changes to those of families in the comparison group who did not use PEEP and focused their analysis on five key outcomes:

1. Parent confidence in their ability to engage their child in science
2. Parent use of engagement strategies
3. Frequency of parent engagement in science activities

4. Parent perceptions of the importance of early science learning
5. Joint media engagement

The study revealed that families who used PEEP Family Science showed differences on each of the five outcomes as compared to the comparison group.
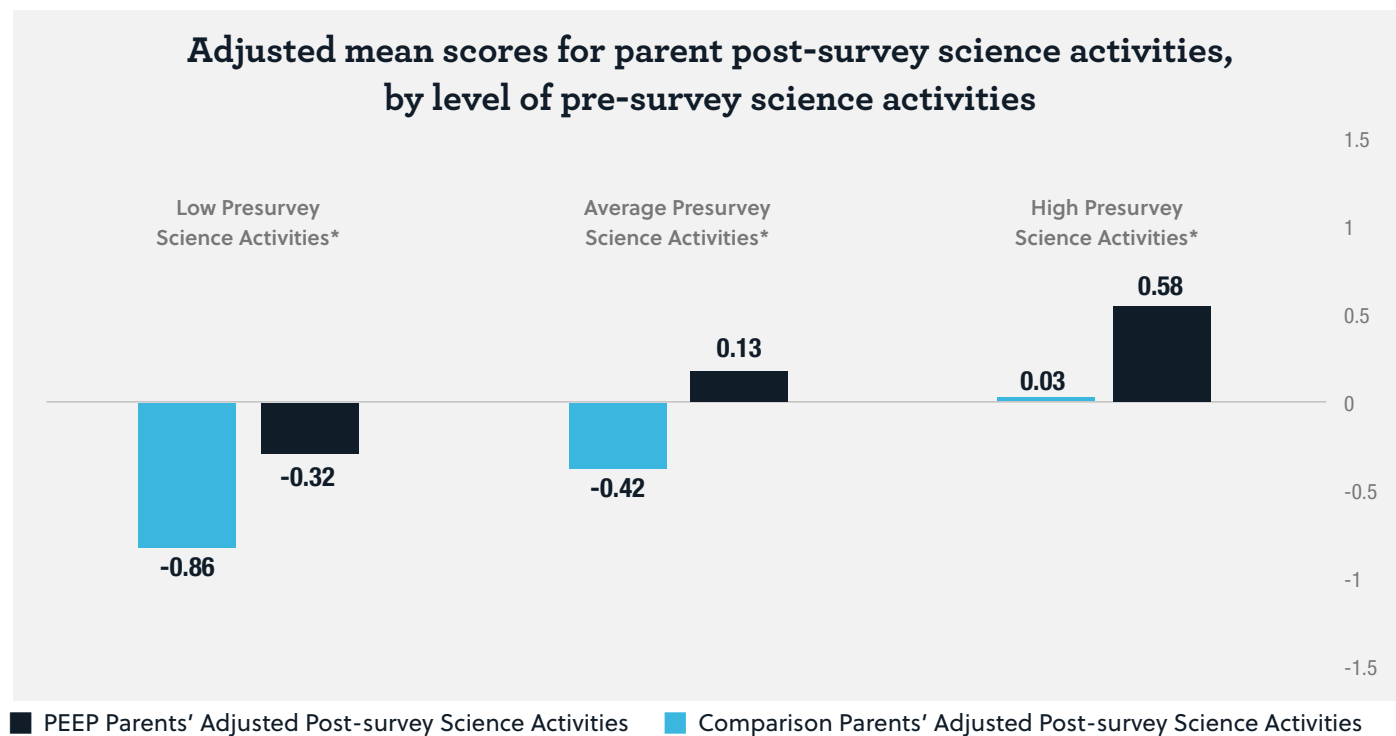
PEEP parents reported doing substantially more science activities with their child and an improved ability to support their child's learning through joint media engagement, as compared to comparison parents.

Some effects of PEEP Family Science depended on the parents' attitudes and behaviors prior to study participation. Results suggest that PEEP Family Science is associated with an increase in parents' use of target engagement strategies, but only for parents who reported low usage of these strategies before the study. A similar pattern emerged regarding parent confidence: after using PEEP Family Science, parents who were initially less confident in helping their children learn science were more likely to feel confident about helping their child learn science after participation in the study. Those parents that were already confident did not show the same gains as compared to the comparison group. In other words, parents with lower use of engagement strategies and less confidence seemed to benefit more from the program, while parents who already had such knowledge or enacted such strategies did not benefit as much. Finally, PEEP Family Science families who gave low ratings regarding the relevance of early science for their child gave higher relevance ratings on average, compared to comparison families at the end of the study, and vice versa: PEEP Family Science families with high relevance ratings at the beginning of the study gave slightly lower ratings at the end, compared to comparison families.

Figures 7–11 display the relationship between use of PEEP and parent outcomes, displayed as the average scores for PEEP and comparison parents across different pre-survey scores.
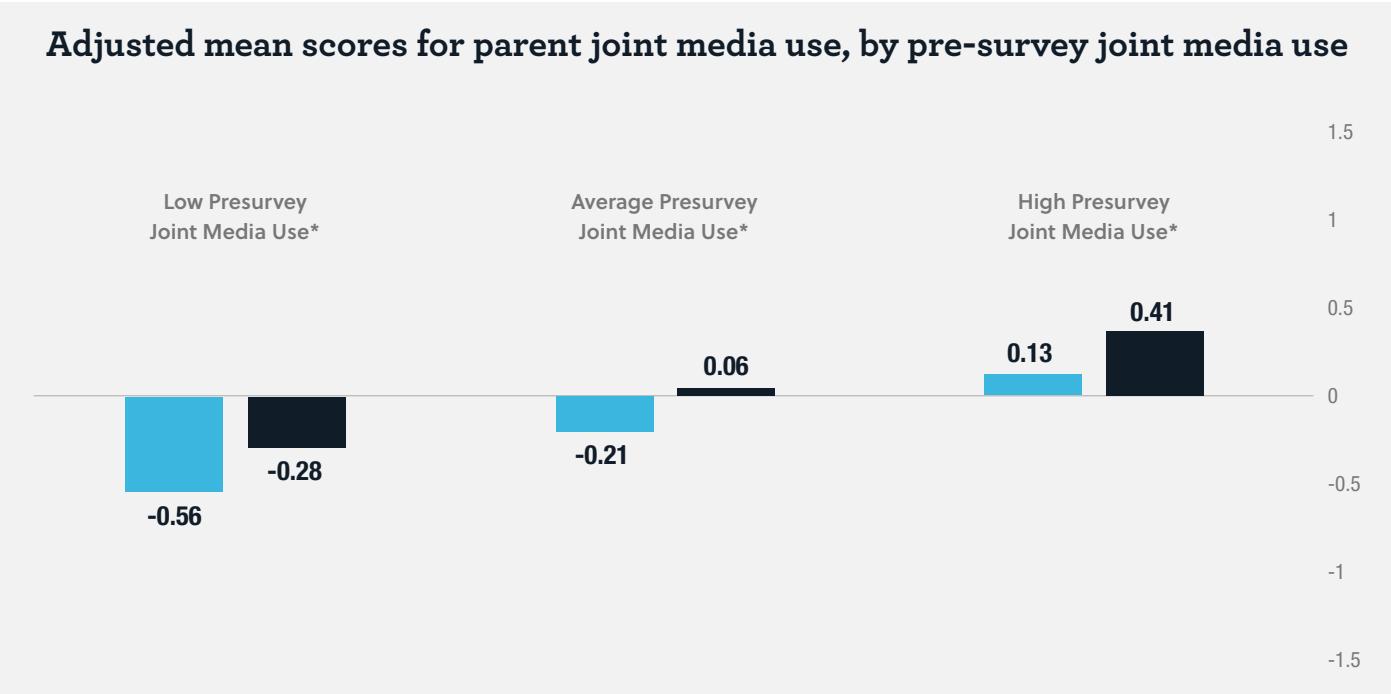
Figure 7. Predicted differences between treatment and comparison parents' post-survey science activities, by pre-survey science activities

Adjusted mean scores for parent post-survey science activities, by level of pre-survey science activities

- PEEP Parents' Adjusted Post-survey Science Activities
- Comparison Parents' Adjusted Post-survey Science Activities

Note: Adjusted scores are standardized (z-scored) and are calculated at the overall average for covariates (race/ethnicity and site). Observations=178.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Figure 8. Predicted differences between treatment and comparison parents' post-survey use of joint media strategies, by pre-survey use

Adjusted mean scores for parent joint media use, by pre-survey joint media use

Low Presurvey Joint Media Use*

Average Presurvey Joint Media Use*

High Presurvey Joint Media Use*
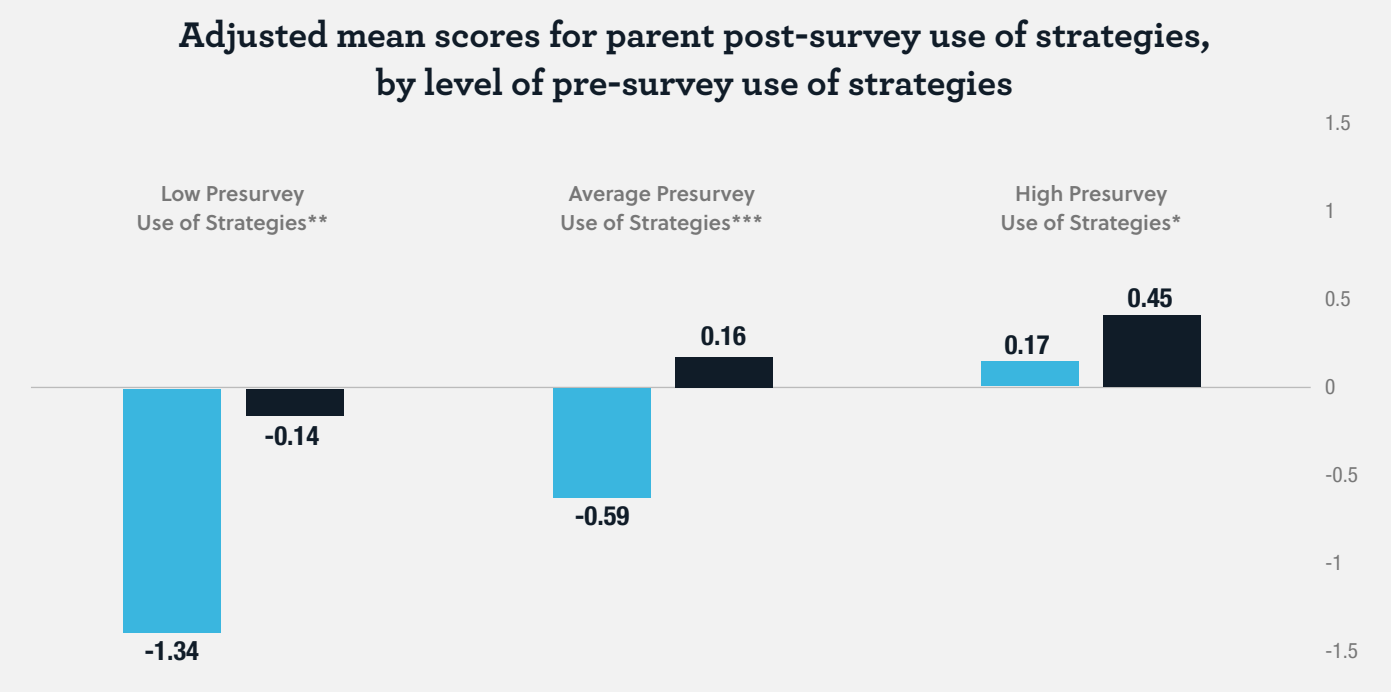
-0.56
-0.28
-0.21
0.06
0.13
0.41

■ PEEP Parents' Adjusted Post-survey Joint Media Use   ■ Comparison Parents' Adjusted Post-survey Joint Media Use

Note: Adjusted scores are standardized (z-scored) and are calculated at the overall average for covariates (race/ethnicity and site). Observations=190.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Figure 9. Predicted differences between treatment and comparison parents' post-survey strategy use, by pre-survey strategy use

Adjusted mean scores for parent post-survey use of strategies, by level of pre-survey use of strategies

Low Presurvey Use of Strategies**

Average Presurvey Use of Strategies***

High Presurvey Use of Strategies*
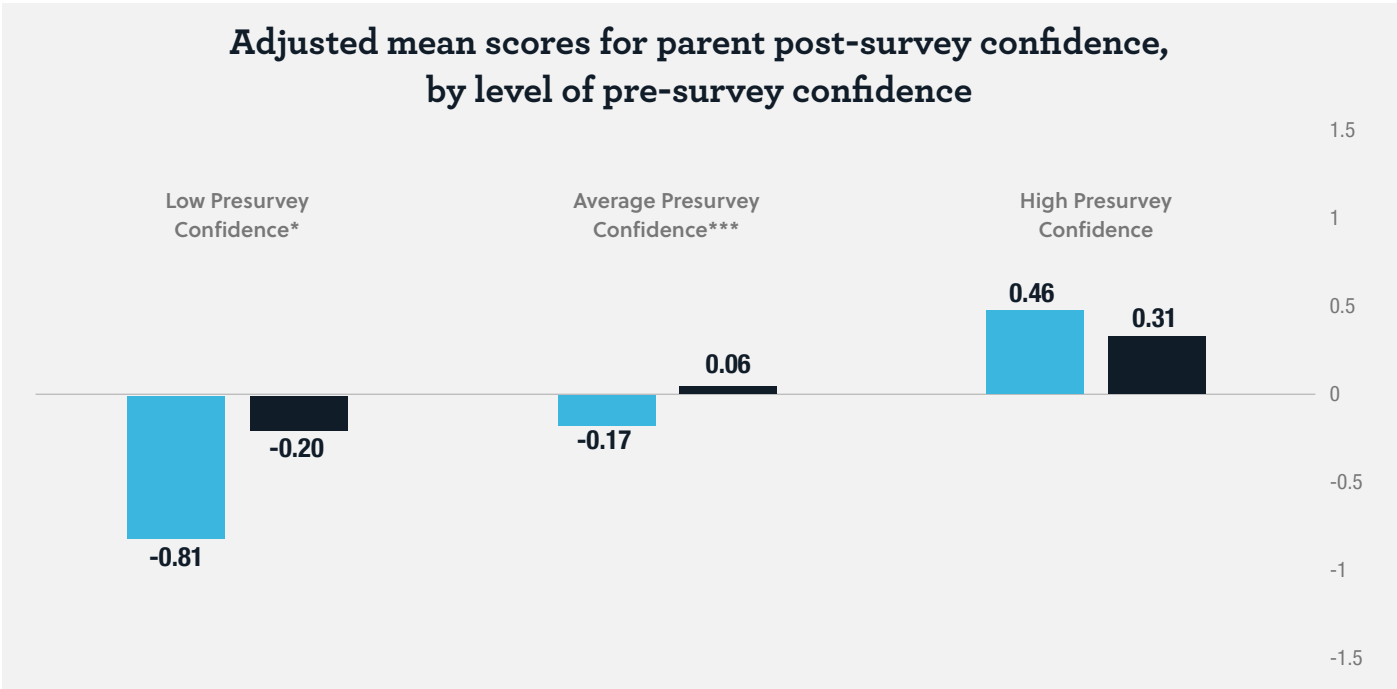
-1.34
-0.14
-0.59
0.16
0.17
0.45

■ PEEP Parents' Adjusted Post-survey Use of Strategies   ■ Comparison Parents' Adjusted Post-survey Use of Strategies

Note: Adjusted scores are standardized (z-scored) and are calculated at the overall average for covariates (race/ethnicity and site). Observations=166.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Figure 10. Predicted differences between treatment and comparison parents' post-survey confidence, by pre-survey confidence

Adjusted mean scores for parent post-survey confidence, by level of pre-survey confidence

Low Presurvey Confidence*
- -0.81 (Comparison)
- -0.20 (PEEP)

Average Presurvey Confidence***
- -0.17 (Comparison)
- 0.06 (PEEP)

High Presurvey Confidence
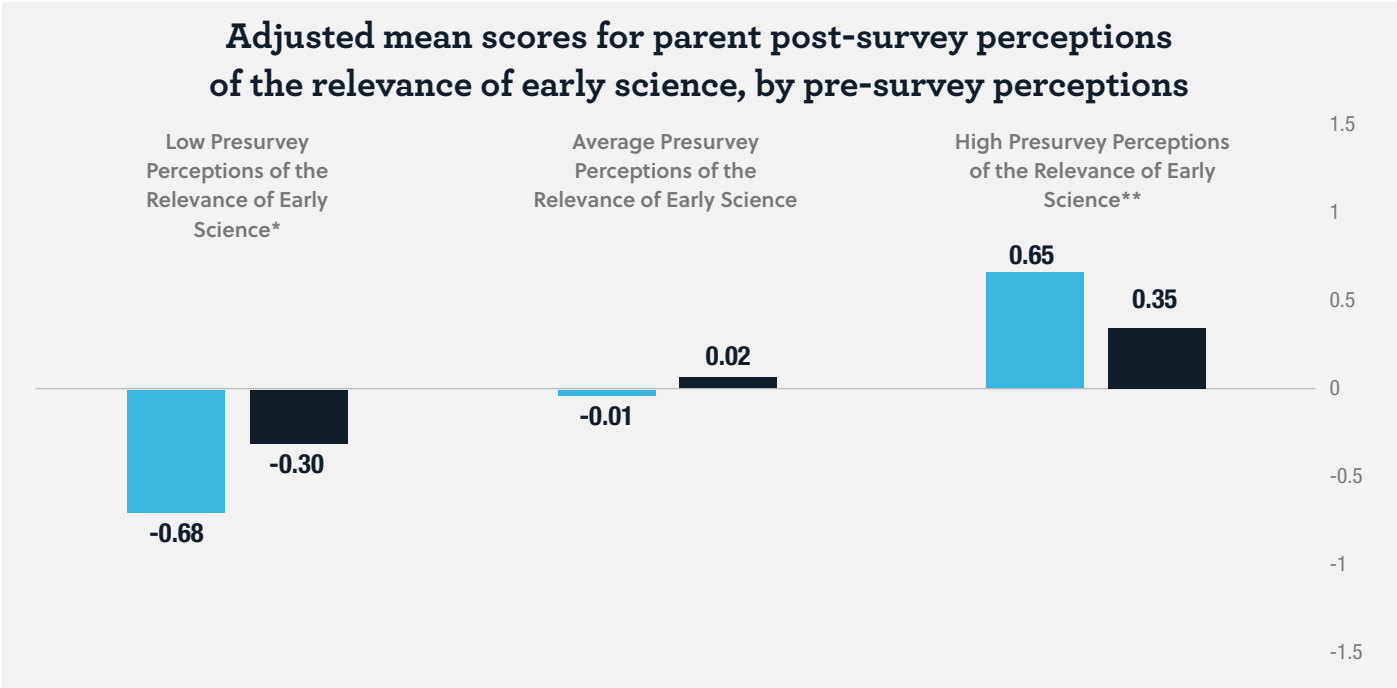- 0.46 (Comparison)
- 0.31 (PEEP)

■ PEEP Parents' Adjusted Post-survey Confidence ■ Comparison Parents' Adjusted Post-survey Confidence

Note: Adjusted scores are standardized (z-scored) and are calculated at the overall average for covariates (race/ethnicity and site). Observations=193.
* p < 0.10, ** p < 0.05, *** p < 0.01.

Figure 11. Predicted differences between treatment and comparison parents' post-survey perceptions of the relevance of science for their child, by pre-survey perceptions of relevance

Adjusted mean scores for parent post-survey perceptions of the relevance of early science, by pre-survey perceptions

Low Presurvey Perceptions of the Relevance of Early Science*
- -0.68 (Comparison)
- -0.30 (PEEP)

Average Presurvey Perceptions of the Relevance of Early Science
- -0.01 (Comparison)
- 0.02 (PEEP)

High Presurvey Perceptions of the Relevance of Early Science**
- 0.65 (Comparison)
- 0.35 (PEEP)

■ PEEP Parents' Adjusted Post-survey Perceptions of the Relevance of Early Science

■ Comparison Parents' Adjusted Post-survey Perceptions of the Relevance of Early Science

Note: Adjusted scores are standardized (z-scored) and are calculated at the overall average for covariates (race/ethnicity and site). Observations=191.
* p < 0.10, ** p < 0.05, *** p < 0.01.

Scaling Up and Program Fit

A final purpose of the study was to develop an understanding of how to implement PEEP across different home visiting programs. The PEEP Family Science engagement model aims to fit multiple home visiting programs and family contexts. To test this possibility, researchers explored the implementation in two home visiting organizations that differ in the way they structure interactions between educators and parents. For example, HIPPY conducts weekly home visits and monthly group meetings, and AVANCE conducts weekly group meetings and monthly home visits. Therefore, the ways in which educators at AVANCE and HIPPY introduced parents to PEEP Family Science differed by program. HIPPY educators reviewed PEEP activities during each weekly home visit. AVANCE educators introduced and reviewed an entire month of PEEP activities (one unit) during one weekly group meeting and checked in with families about these activities during the monthly home visit.

Our findings suggest that the PEEP Family Science model was flexible enough to effectively engage families in science regardless of how AVANCE and HIPPY structured their home visiting programs. Parents reported on surveys and in interviews that they were able to incorporate PEEP Family Science into their everyday schedules. Educators from both organizations indicated that the parent engagement strategies connected well to the learning practices they already promoted. Educators also indicated that their programs encouraged parents to approach activities with their children in ways that were similar to the Play and Explore Together and Ask Questions and Talk About Ideas strategies.

However, reports from educators and parents also pointed to a few potential challenges programs are likely to face when adopting the program, particularly in relation to available technology resources and fit within existing home visiting programs, curricula, and philosophy. For the most part, both educator programs were able to address these challenges during the pilot, but they are highlighted here because they have implications for planning any scale-up or use outside of the research project and funding.

Technology and materials. Although families who participated in PEEP were low-income, almost all were able to use their own smartphones in the implementation study. Only a few families did not have a smartphone and so borrowed tablets. Organizations using PEEP will need to ensure that the technology is available. However, given that relatively few families in the pilot needed to borrow tablets, the costs should not be extensive (researchers spent approximately $120 per tablet, although less expensive tablets can be purchased). Educators used Wi-Fi hotspots when they met with parents to ensure they all could download the apps (a cost of approximately $840/site). Organizations may need to purchase a few other inexpensive materials needed for the hands-on activities that low-income families might not typically have at home. In this study, the needs were limited to paint and chalk.

Time. During interviews, respondents indicated that using PEEP required educators and parents to spend more time than they typically do preparing for or using their home visiting curricula (some educators estimated they took an extra 15–30 minutes per week). This additional preparation time for educators may lessen after they have used PEEP for a second or third

time and become more familiar with the content, engagement strategies, and the resources. The low attrition rate of parents suggests that time might be less of a concern for parents. A few educators felt some families who were already stretched for time, such as those with many or new children, might not have sufficient time to use PEEP and did not include them in the study. Because these parents were not included in the study, more research is needed to understand the extent to which time is a prohibitive factor for a broader set of both parents and educators.

Incorporating PEEP in the home visiting process and practices. By piloting the program first, both home visiting organizations were able to test out approaches to incorporating PEEP into existing practices and also made some substantial revisions to the second round of implementation. That programs made substantial revisions to their second implementation suggests that new organizations that adopt PEEP need to consider where and how PEEP fits into their curriculum and unique structural processes for supporting educators and working with parents and children.

Using media-based resources. A few educators indicated during interviews that they felt the technology detracted from important bonding time between the parent and child that the home visiting program promoted (although as noted above, multiple other educators and parents reported that participating in PEEP helped to promote stronger family connections). Programs should take into account parents' and educators' ideas and attitudes about using media with young children and explicitly address concerns about how best to use media to support learning.

Conclusion

Our central conjecture was that with resources designed to engage and scaffold their own learning, parents can learn about and implement practices to support their children's science learning. The differences between the treatment and comparison groups regarding changes in parent attitudes and knowledge suggest the following:

› The PEEP Family Science resources enabled parents to learn about practices and use them to support their children's science learning.

› PEEP was particularly helpful for parents who (1) initially lacked confidence in their abilities to help their children do science and (2) were not already engaging in science with their children.

How parents used PEEP Family Science to engage young children in science exploration

Early science. During researchers' observations of families using PEEP Family Science, children and parents (and sometimes siblings and other family members) engaged in important science content and used science practices together. Researchers observed parents and children exploring core disciplinary ideas in physical science, such as testing and experimenting with how objects move on inclines; describing, identifying, and comparing colors; and exploring differences in the pitch and volume of sounds. Researchers also saw families using several science practices, including asking questions; planning and carrying out investigations; analyzing and interpreting data; using mathematics; and obtaining, evaluating, and communicating information.

Virtually all parents surveyed agreed that using PEEP helped their child learn important science topics and that the PEEP Family Science intervention gave them ideas about strategies to use with their children to help them learn about science, how to do science activities using different materials, and how to do science outside of the PEEP activities.

Parent engagement strategies. Researchers observed parents using elements of all three focal parent engagement strategies while watching the videos and doing the hands-on activities. Most parents were able to guide their child's play without taking over and allowed their child to make choices that determined the structure of the activity. Researchers observed all parents talking about and asking questions that directed children's attention to descriptions of what they saw, heard, or felt and the labeling of the science activities they were engaging in together. Many parents asked questions and talked about ideas that were more conceptual in nature or that required higher level reasoning. Researchers observed some parents adding new materials to the activities they had done, and most parents who were interviewed explored more by going outside and finding ramps, colors, or sounds in the park or their yard. Almost all parents surveyed agreed that the PEEP intervention helped them use these parenting strategies with their child, and that PEEP helped them to ask their child questions about science and to see what excited their child.

Engagement with the intervention. Almost all parents surveyed agreed that their child enjoyed using PEEP Family Science—that the videos, PEEP characters, and hands-on science explorations were engaging and fun. Most of the families interviewed indicated that they appreciated having access to vetted resources that supported hands-on science exploration, and multiple parents said they valued the opportunities that PEEP provided to spend one-on-one time with their child.

Ease of Use. Almost all parents surveyed agreed that the PEEP Family Science app was easy to use and that they found it easy to fit PEEP into their daily schedules and with what they were already doing in AVANCE/HIPPY. Most parents whom researchers interviewed and observed indicated that they were able to access and use the PEEP app without technical supports (educators used Wi-Fi hotspots when they met with parents to ensure everyone could download the apps, which could be used offline subsequently), and virtually all parents, although they were from low-income households, had smartphones to use the app. Parents also reported that they were able to incorporate PEEP Family Science into their existing routines, and virtually all parents indicated they were still using the intervention by the end of the three months of the program, suggesting attrition was not a significant problem.

How home educators supported families in engaging in science

Ease of use. Educators were able to easily access and use the PEEP Family Science resources. Most educators reported that they felt prepared to help families use PEEP Family Science and did not need additional information or supports. Many valued the modeling provided in the parent videos.

Educator supports. Most of the educators researchers observed provided extensive support to parents, including modeling the hands-on activities, explaining the science concepts, and discussing the parent engagement strategies and how parents could enact them.

The relationship between PEEP Family Science and changes in parent attitudes and knowledge

Changes in parent supports for early science.
Following the use of the intervention, families who used PEEP Family Science showed positive differences on all five post-survey outcomes as compared to the

comparison group, including greater frequency of science activities, confidence in their ability to help their children learn science, use of the parent engagement strategies, use of joint media engagement strategies, and perceptions of the relevance of science for their child. Specifically, PEEP parents reported doing substantially more science activities with their child and greater ability to support their child's learning through joint media engagement, as compared to comparison parents. PEEP seemed to benefit parents who had initially low confidence about doing science or initially low levels of engagement in science. On average, the use of PEEP Family Science was associated with an increase in parents' use of target engagement strategies for parents who reported low usage of these strategies before the study. Similarly, parents who were initially less confident in helping their children learn science were more likely to feel confident about helping their child learn science after using PEEP, while parents who were already confident did not benefit as much. Parents who were less likely to feel that science was an important subject for their child were more likely to value the subject after they used PEEP Family Science compared to families who did not use PEEP Family Science, while parents who initially felt science was important did not benefit.
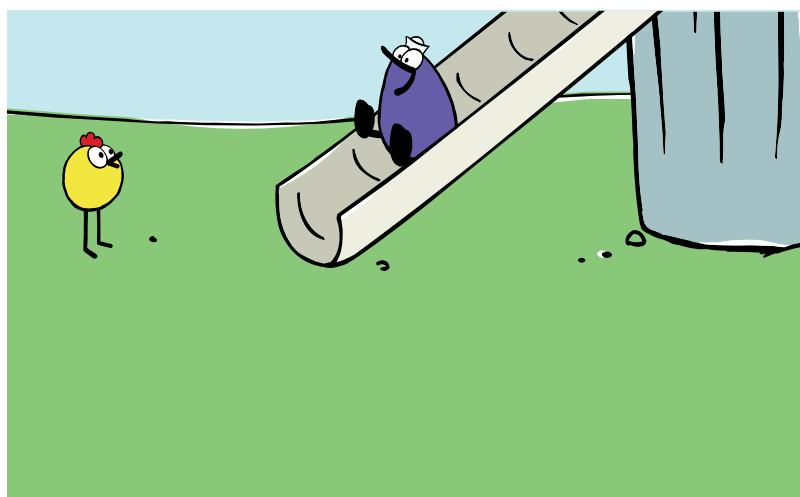
Challenges and Recommendations

Our study also identified a few challenges that organizations considering PEEP Family Science for their home education programs should be aware of.

Ensure adequate resources: Some educators and administrators noted that educators needed additional time to become comfortable implementing the technology and the new program. Organizations need to ensure that adequate resources are available, including (1) time for educators to learn about and get comfortable with a new program and (2) the small amount of technology needed for families to access and use the app, such as hotspots to enable families to download the app each month.

Consider how PEEP fits existing program: Through a few pilot studies, AVANCE and HIPPY were able to try out and adapt their implementation of the intervention so that it fit into their existing practices. Thus, prior to adopting the program, organizations should consider where and how PEEP fits into their existing curriculum, structures, and time with parents. They should also take into account parents' and educators' ideas and attitudes about using media with young children and explicitly address concerns about how best to use media to support learning.

Adapt PEEP for younger children: Although PEEP was designed for use by four- and five-year-olds, our study included three-year old children because they were a large part of the population that AVANCE and HIPPY currently serve. If PEEP Family Science decides to target this age group, reports from educators and families of some young children indicate a need to provide additional supports for families with three year olds to engage effectively with the PEEP activities, which were designed for slightly older children. Parents may need help in understanding how to adapt activities for young children and in developing expectations for what engagement in science should look like for this age group.

Identify best practices for using media with young children broadly: During our study, some parents and educators expressed apprehension about using media with young children, and some educators felt incorporating media distracted from building a relationship between parents and children. Reports from some parents and educators also suggested that some parents faced difficulty in disengaging children from the media. Organizations should use PEEP Family Science as an opportunity to talk with parents and educators explicitly about how to incorporate the use of media and technology to help young children learn and to model how to use media as an educational tool. Incorporating media-based resources such as PEEP Family Science into home visiting programs poses an opportunity to address the growing role that media plays in young children's lives by helping parents and educators understand and develop practices and approaches that can help children benefit from using media and avoid the potentially detrimental effects. By using PEEP media with educator support, parents can see models, practice, and get feedback on how to use media to create conditions for learning and how to handle challenges, such as transitioning between media and the real world.

While PEEP incorporates these best practices implicitly, our findings suggest that it would be valuable to provide more explicit support so that parents and educators can incorporate these practices not only

when using PEEP but also when selecting and using other media resources. For example, in response to these study findings, developers added a section to the *Educator Guide* called "Using Educational Media with Children." This section discusses why using media is helpful for learning science, explains how the PEEP intervention uses media, and offers guidelines that educators can share with parents about screen time limits and how to effectively use media with children. A parent handout was also created for each science unit that lists recommended books and online games and offers parents guidelines and tips for using online games and other media. Developers might also consider incorporating more design elements into the app to help parents and children manage their media use, such as nudges for a child to talk to their parent after watching a video. Finally, an additional design principle—the framework that guided the intervention design—to address media literacy and media mentorship might be needed to ensure family engagement models like PEEP can meet parents' and educators' needs.

LIMITATIONS AND FUTURE RESEARCH

First, it is important to note that the group-comparison study design does not allow for causal conclusions about whether using PEEP had an impact on parent learning and attitudes. Because we did not use an experimental design that randomized families to the PEEP intervention, it is possible that differences in the survey outcomes between parents in the treatment and comparison groups were due to differences between the groups and not the intervention, such as more motivated or more experienced home educators. Future research should examine more closely the impact of PEEP Family Science on both parents and children.

Second, while the study findings are promising, particularly given the large sample of families, because educators selected families to participate, we cannot generalize these findings to the full population of families who are enrolled in HIPPY and AVANCE. It is possible that parents who participated in the study are more motivated and interested in science compared to parents who elected not to participate. Similarly, while observations also suggested that parents were able to implement the pedagogical strategies, these observations are not necessarily representative of what all parents might be able to do, given that parents who volunteered to participate are likely among the most motivated families. Future research should examine program implementation more broadly.
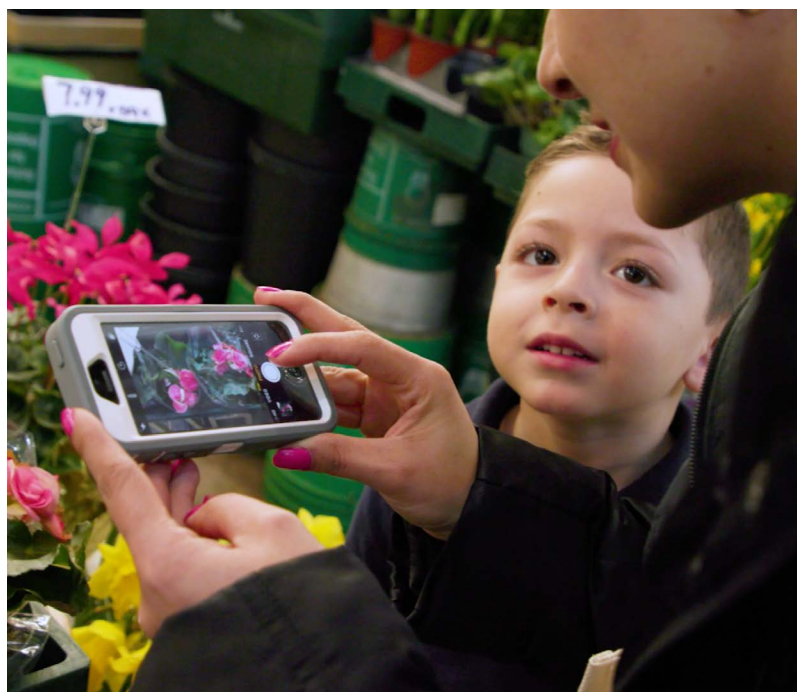
Broader Implications

Our findings suggest that the engagement model holds substantial promise for engaging low-income families and their young children in science. In addition to providing targeted feedback to inform the design of PEEP Family Science, a central focus of this research was to build practical and theoretical understanding more broadly, related to the following:

1. effective family engagement models in science learning

2. types of supports that families and home educators need to implement these models

3. how to implement these models across various home visiting programs

Findings from this study hold some implications about effective means to improve parent engagement in science by developing a better understanding of how to help diverse, low-income families with young children do science and, more specifically, how to use media to do so.

BACKGROUND

Existing research indicates that engaging young children in science sets the stage for later science achievement and also supports language development, math skills, executive functioning, and persistence (Bustamante, White, & Greenfield, 2017; Kuhn, 2011; Nayfeld, Fuccillo, & Greenfield, 2013; Peterson & French, 2008; Wright & Neumann, 2014). Yet recent research on family engagement in science suggests that many parents are not confident about helping their young children explore science, that they do science-related activities with their children less frequently than other content areas such as literacy and math, and that most parents do not think science-based media help their children learn a lot (Silander et al., 2018).

Supporting parent engagement in science. Although there is a large body of research related to helping parents use effective literacy practices to help their children learn (Doss, Fahle, Loeb, & York, 2017; Lonigan, Shanahan, & Cunningham, 2008), and growing evidence about effective ways to help parents support their children's mathematics learning (Berkowitz et al., 2015; Vandermaas-Peeler, Ferretti, & Loving, 2012), little is known about effective means to foster parent engagement in science with young children, including knowledge and attitudes to support these practices. Much of the research that does exist around family science engagement takes place in learning settings such as museums (e.g., Haden et al., 2014). However, these studies generally draw from the limited sample of parents who visit museums, and findings may not apply to the ways in which diverse families engage in science in other contexts.

Supporting parent mediation practices. Similarly, although research on the effect of media on children's learning suggests that learning from media is maximized when adults use the media with children (Dore et al., 2018; Krcmar, Grela & Lin, 2007; Linebarger & Vaala, 2010; Strouse, O'Doherty & Troseth, 2013), little is known about effective approaches to helping parents use these media engagement strategies in ways that support learning. This lack of knowledge is due in part to the relative dearth of research on interventions to support mediation practices, as well as to the limited scope of interventions that have attempted to change parents' mediation practices. For example, studies on media mediation and literacy interventions that target parents have found inconsistent impacts on both parent practices and child outcomes (Krcmar, Grela, & Lin, 2007; Linebarger & Vaala, 2010; Rasmussen et al., 2016; Strouse, O'Doherty, & Troseth, 2013). The limited and mixed findings suggest a lack of knowledge about necessary parent supports for

effective media mediation practices that can support learning. Moreover, to date, no research has examined how to help parents co-use media for the purpose of supporting science learning.

Based on the lack of knowledge in the research literature related to effective ways to engage low-income, culturally diverse families in early science through media, and the successes and challenges identified by this study, our findings have implications beyond the development of this specific intervention. In particular, these findings may be relevant for media producers and educators wishing to provide low-income families with effective educational media resources as well as lessons for how to help families with young children do more science together.

DESIGNING EFFECTIVE MEDIA INTERVENTIONS FOR LOW-INCOME FAMILIES

Our findings suggest that the promise of technology and media to support low-income families hinges on the accessibility of the design: Without accessibility, the resources will exacerbate rather than ameliorate inequalities. Apps, in particular, can be a valuable learning tool for low-income families and their educators. Virtually all of our low-income families had access to a smartphone, and were able to use the app with ease and with few technical difficulties. The accessibility features we describe below are not reflected systematically in the current app market—this lack of accessibility holds true even for many public media resources. We argue that together these features should serve as the default design for any media-based resource that is intended for family use. Below, we describe a few aspects of media design that our findings suggest are important to ensure families are able to use media-based resources.

App-based interventions should be usable offline. Many families did not have reliable data or Wi-Fi access. In contrast with providing access to Web-based videos (the project's original dissemination plan), parents with unreliable Wi-Fi access can download apps once (for example, at a public location such as a library or

McDonald's, or by using an educator's mobile hotspot) and use them over the course of a month without needing additional Wi-Fi access. It is difficult for parents to know whether apps require Wi-Fi or data access once downloaded, and while some apps are available for offline use, many are not. For example, we were unable to incorporate the existing PEEP digital games fully into this intervention because they require online access while playing, and most families were not able to access the games because of this limitation. Similarly, **to address families' resource limitations, the app should work on older operating systems and require little memory to store**.

Additionally, we found that the **intervention design should take advantage of the modality of an app to scaffold parent learning**. For example, an app does not use dense text, and because of the small screen size of a smartphone, the app is broken into smaller incremental steps—an important scaffolding technique to support learning—as parents swipe through the experience. The app therefore allowed educators and parents with a range of educational backgrounds, technical expertise, and experiences to use the app to engage in science.

Using videos to model science practices. Parent media-based interventions should include videos that model—another essential scaffolding strategy—the kind of parent-child interactions that can support science learning and academic readiness. Although using videos to model pedagogy is a relatively common practice with educators, parent engagement interventions using media to model school readiness-related practices is a small but growing practice and one that is relatively under-researched (Hall & Bierman, 2015). For example, recent high-profile media-based parent intervention studies have focused on texting initiatives in literacy and math (e.g., Doss, Fahle, Loeb, & York, 2017; Gennetian et al., 2019; LeFever et al., 2017). Similarly, parent apps—such as the widely-used Daily Vroom or Daniel Tiger for Parents—use text embedded in an app to help parents with young children. Of the existing video-based interventions for parents, most target parenting practices to support

social emotional and behavioral health (Breitenstein, Gross, & Christophersen, 2014). Science likely requires additional supports such as video modeling, given that many parents, especially parents with lower levels of education, are not very confident about how to help their young children learn science. Videos can be important resources for modeling ways of engaging in, talking about, and supporting science explorations for both educators and parents.

The media-based intervention should put the parents at the center of young children's media experiences. Most apps that target children's learning embed parent tips within an app that is primarily designed for children to use. In a departure from this typical practice, the PEEP Family Science apps are designed primarily for parents, with the child as a secondary user. In this design, by default, the parent mediates his or her child's media experiences.

Related to designing apps for co-use, one of the challenges that our study results uncovered suggests that **families need support in understanding strategies to use media-based resources with their children in ways that can support learning**. Some families indicated that this was the first time they had used an educational app, while others expressed apprehension about using technology with young children. Moreover, national studies examining parent mediation suggest that less than one-third of families report co-using media with their young children most of the time while they are using media (Connell, Lauricella & Wartella, 2015). Incorporating a media-based intervention should be used as an opportunity to model best practices for educators, parents, and children as they relate to media use. Although it sounds redundant, videos of parents watching videos with their children and talking about what they are watching can provide powerful guidance. Finally, parents also need help in identifying high-quality and age-appropriate media.

DESIGNING SUPPORTS TO ENGAGE FAMILIES IN SCIENCE

The challenges that families face in doing science are related to their perceptions that science is a complex topic and that they lack the knowledge and the special materials to do science. These challenges were evident in the first phases of our research, which focused on gathering information about families' existing practices related to science, and also are echoed in the research literature. Parents tend to believe that science is not appropriate for younger children and that parents do not play an important role in helping their children engage in science. They face anxiety and lack confidence about their abilities related to science, and need help understanding how to engage in early science explorations with minimal time and resources (McClure et al., 2017).

Our research findings suggest that providing families with engaging materials that connect to their everyday life is a way to overcome these barriers and support the notion that parents need not have technical science training or special materials to engage young children in science at home or in other naturalistic settings. We found

that providing families with easy entry points—such as science investigations that use everyday objects and that connect to families' regular live—can lead to successful experiences with science. Additionally, science investigations should incorporate materials that are readily available in most homes, and guidance should provide recommendations for alternate materials.

This study's findings also suggest that parents need specific, developmentally appropriate guidance about what science exploration can look like with young children. In the pilot studies, many parents indicated that they lacked models of science engagement with young children. And in interviews, some parents described science as a complex topic that was not relevant for young children. For parents of young children, the guidance may be most effective if it focuses on a relatively narrow target age range. For example, feedback from interviews suggests that many parents relied on the parent videos to guide their interactions with their children. When a few videos used older child actors (five years of age instead of four) parents requested younger children because they wanted models that would provide accurate examples of conversations and hands-on investigations for their children. Additionally, prior to using the intervention, most educators did not share an understanding of

important early science learning concepts and skills. Providing videos that model the kinds of science play, conversations, and explorations that are possible at each age may help both parents and educators develop a better understanding of child development as it relates to science.

Many parents also need targeted scaffolds to support use of the kind of science-related academic talk that can help children be ready for school. Examples of these scaffolds include small prompts or question starters, to help parents ask open-ended and higher-order questions and to engage in guided play rather than using approaches that are closer to direct instruction. For example, during the initial phases of the study, results from our observations indicated that a few parents struggled with building conversations beyond short responses to deepen thinking and with engaging the child in answering a question or responding to an answer that was not correct. Young children might not respond to these kinds of questions in the moment, so parents also can take advantage of opportunities to return to the conversations at a later time, when they gain more experience with the materials and concepts. Scaffolds for this kind of academic talk might be particularly important for parents with less formal education and less familiarity with this kind of discourse.

Designing Accessible Technology

A particular focus of this project was to create an intervention that is scalable and accessible to as many families as possible, and low-income families in particular. The version of the PEEP Family Science intervention used in this study reflects several revisions made in response to findings from the two prior pilot studies, which identified the specific resources that families typically were able to access and the limitations they faced in using a media-based intervention. The original design of the intervention used a printed guide to direct parents through the steps of the intervention; the videos and online games were provided on a website for downloading to tablets and smartphones. In response to initial pilot study findings that not all families were able to access the Internet regularly to download the resources, the developers embedded the materials and instructions for parents in apps that could be downloaded once and then used offline.

In addition to creating apps that would allow families to access media content offline, developers designed the apps to be usable for parents with limited time, resources, and literacy levels. In creating the app, it was necessary to simplify and shorten directions from the prior pilot print guides as the app format limited the amount of text developers could use. This simplification was also necessary to address feedback from some parents and educators in the pilot rounds that the amount of text in the written parent guide was overwhelming for parents with low levels of literacy. Importantly, the app technology also allowed for verbal prompts to highlight the parent engagement strategies (unlike the print guide that only had written prompts).

Embedded in the apps were parent videos, which were designed to model parent pedagogical strategies. Responses from educators and parents in the pilot studies suggested that embedding these videos in the app would provide important guidance for parents on how to do the hands-on activities with their children and that the video-based guidance was particularly valuable for parents with lower reading abilities. Parents in the pilot study indicated that the video gave them a better understanding about how to do the activities, such as the materials to use and the steps to take, and in one case, the video helped the parent understand the concepts and vocabulary. (One pilot study parent reported watching the parent video "more than 20 times" so that she understood how to do the activity.) These pilot study findings align with findings about how parents often report using video-based sources such as YouTube to find ideas for how to do science with their children.

Findings from our pilot studies suggested that almost all parents who participated in the home visiting programs had access to smartphones and tablets. For the few who did not have access, developers made the PEEP Family Science resources (videos and hands-on activities) available through a website, which could be accessed from locations such as the library, and through printouts.

PEEP Family Science in Action:

Colors

This is an excerpt from an observation of a mother and her 3-year-old daughter working on a colors activity. The family spoke only Spanish and sat across from one another at a child-sized table in the family's living room. The mother had prepared the table with clear plastic cups, bottles of water, food coloring, and a flashlight. The mother began the activity by explaining the investigation (or exploration). Evidence of the use of parent strategies was apparent as the mother asked her daughter several open-ended questions and added her own explanations throughout the activity. The mother also asked the child to recall prior activities they had done with colors and what the PEEP characters had done in the color videos. The daughter was allowed to lead the activity with gentle guidance from her mother. They began the activity itself by mixing food coloring to make different colors in clear cups of water.

P: What is this?

C: Yellow.

P: Yellow and we are going to put...

C: Blue!

P: Let's see, what do you think it will make?

C: Uhm..

P: A little bit.....Ok! What do you think it will make? What color? What do you think?

C: Uhm.

P: Yellow and blue...

C: Mmmm...

P: Uhh... What will it make, what will it make?

C: Green?

After three rounds of mixing different colors, the mother brought out the flashlight to discuss and experiment with the concept of lighter and darker colors, and whether light could pass through the colored water. They took turns using the flashlight and looking through the cups of colored water to see if they could see the light on the other side by holding up their hands on the opposite side to the light.

P: Green! Ok, look! We formed green and green... Do you think green will pass if we see it through the light? Does it pass the light or doesn't pass the light?

C: No, I think not.

P: Why? Why do you think it won't pass?

C: Because it is dark.

P: It is dark...

C: It is dark green.

P: Dark green... Let's see, let's see if it passes... Look...

C: Yes, it passes through the light.

P: Look, it doesn't pass...it doesn't pass much...you see, because it is a dark color. If you see through a dark color, do you see something?

C: No

After they found that the light could not pass through the dark green water, the mother suggested making a very light color mixture to compare to the dark. They created a new cup of orange water by mixing red and yellow food coloring, and experimented with the flashlight again.

P: They made orange. Now, will the light pass through?

C: Yeees!

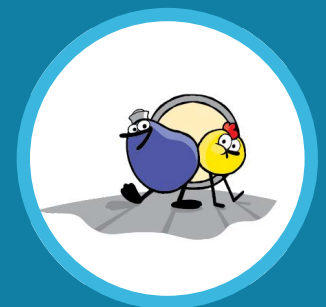**P:** Look! The light passes what color?

C: Orange.

P: Look...the orange light passes... Why does the light go through?

C: Because it is lighter.

P: The color...aha...and this one doesn't because it is...

C: It is dark.

....

The mother related the final investigation back to the PEEP video.

P: Dark... Look, but it doesn't go through...so if you see through this...imagine that they are glasses like the one...

P: (Laughs) Let's see, who had those glasses? Remember?

C: Quack.

P: And they discovered that seeing through this you can see the world in colors...of this...the grass no longer looked green, remember?

C: Aha.

P: What color was the grass?

C: Orange.

P: Because the colors mix.

C: Yes.

P: Now, you see that the grass was green and if you see through these it looks orange...

PEEP Family Science in Action:

Ramps

This is an excerpt from an observation of a grandmother and her grandson working on an activity from the ramps unit. The grandmother and child worked on their PEEP activities and lessons on the two days the grandmother takes care of the child. This week's activities included watching a video (*Marble Mover*), where Peep and his friends try to roll a marble up a hill, and doing a hands-on activity (*Up and Down*), which involves trying to make a ball go down one ramp and up another.

The grandparent and child began by watching the video on the grandparent's iPad. The child was excited to watch the video, announcing, "*We're gonna watch the slide!*" They sat closely on the floor in the foyer, which is where they always do their PEEP activities; about halfway through the video, the child moved to the grandparent's lap. They watched the video together attentively and made comments throughout. When the child smiled or laughed, the grandmother responded by smiling. When Peep and Quack were trying to get the marble up the hill, the child said things like, "*You can't kick a marble. You can't kick it; you have to roll it with your fingers.*" and "*It's [the marble] going down because it [the hill] looks like a ramp.*" The child laughed when the marble rolled back down the hill. When Peep and Chirp were discussing what a marble was, the child noted the marble's colors—blue and purple. While Chirp was zigzagging up the hill with the marble, the grandparent said: "*Watch what he does. He's going back and forth, isn't he? Watch. He didn't go straight up; he's going back and forth.*"

After watching the video, the grandparent asked the follow-up questions from the app, first as they were written, then she rephrased them and offered real-world examples.

G: I wonder why it was so hard for Peep and Quack to get the marble up the hill. What do you think? Why was it hard for these two to get it up the hill?

C: I don't know.

G: You don't know? How were they pushing it up the hill? Were they trying—how would you get it up the hill? Could it be because they were trying to push too hard one way or the wrong way?
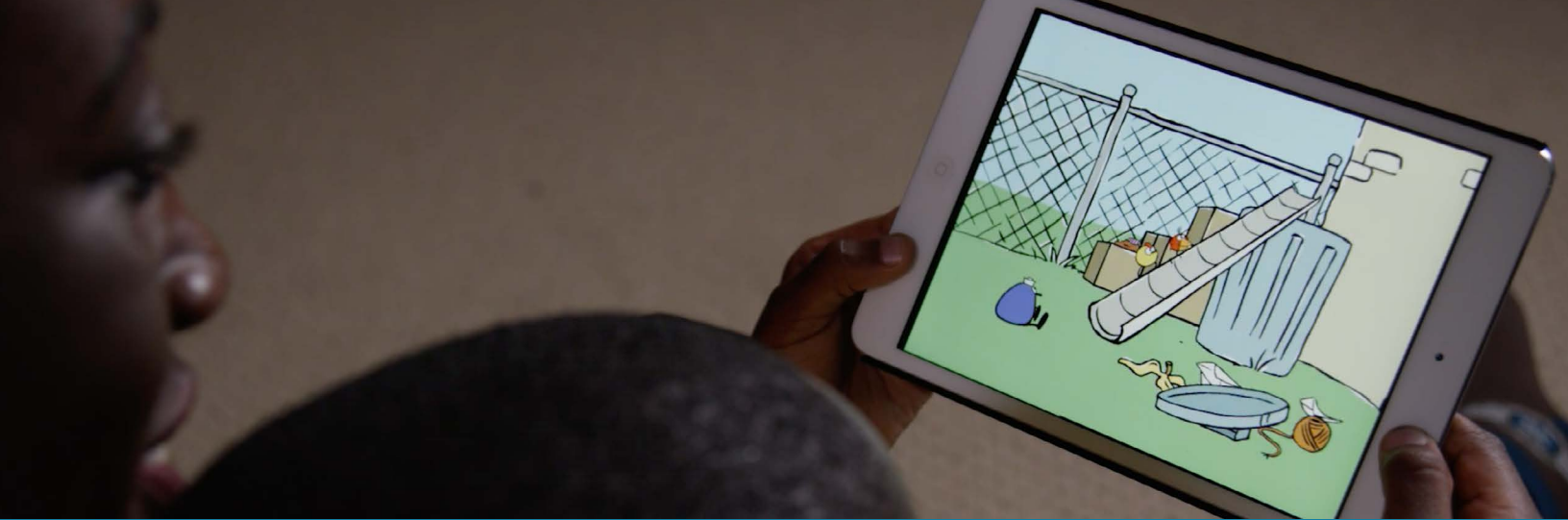
C: I show you.

G: Oh, you want to show me?

C: I would do this and then kick it. *mimics kicking the marble.

G: You wanted to kick it? Did it work when they kicked it?

C: No.

G: Nope, it didn't, did it?

In addition to rephrasing the questions, the grandparent also gave real-world examples to illustrate the concept being described.

G: How did Chirp get it up the hill? Did he go straight up the hill or what did he do?

C: I don't know.

G: Yes, you do.

C: No, I don't.

G: Okay. Did he go straight or what is it on my sewing machine when the stitch doesn't go straight? Sometimes it goes back and forth, back and forth. What's that called? Back and forth like this?

C: Back and forth.

G: Look at my finger. Like this and like this.

C: That's back and forth.

G: Right, that is back and forth, but what is this design?

C: No, this is—it was right and left.

G: Right and left, that's correct, right and left. Not straight up, but right and left, that's right. And do you know what that's called?

C: Mm-hmm.

G: That's called zigzag, okay?

C: Zigzag.

G: Uh huh, mm-hmm, that's sometimes when you're sitting in my lap when I sew, that's what you call it.

....

After completing the video activity and answering his grandmother's questions, the child became distracted and lost interest in PEEP. He asked his grandmother if he could play games on her iPad. The grandmother remained patient and, in her response, connected the upcoming hands-on activity to the video they had just watched. The child followed his grandmother's lead and become more enthusiastic about doing the activity.

G: We're going to play something else. Watch this. We're going to do like they did. We're going to make our own ramp, okay?

C: Our own ramp?

G: Uh huh. Can we make—do you think we can make a ball go up one ramp and then up another?

C: Yeah.

The grandparent was enthusiastic and expressed interest throughout the activities, and she and the child appeared to be having fun together.

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Appendix: Study Design

Recruitment and Sample Characteristics

Recruitment

As with earlier phases in the PEEP project, the EDC research team worked with two home visiting organizations: AVANCE in an urban area of Texas, and HIPPY in a rural area of Arkansas. Site administrators from each organization selected a group of home educators to pilot PEEP Family Science with the families they work with. Finally, the research team worked with site administrators to select a subsample of 19 parents and 19 children (9 from AVANCE; 10 from HIPPY) to participate in observations and in-depth interviews. Families and educators received a small stipend for their participation based on the level of their participation.

Sample Characteristics

A total of 217 families participated in the implementation study (121 families from AVANCE; 96 families from HIPPY). Of those 217 families, 170 (96 from AVANCE; 74 from HIPPY) used PEEP Family Science as part of their weekly activities with their home visiting program. AVANCE and HIPPY each selected one geographic site for the implementation study; administrators selected sites that would meet the sample size requirements for the study (approximately 100 families) and whose local site staff had the time and availability to participate in the program. Home educators within each of the two sites were asked to invite 8–10 families who had children in the target age within each of the home educators' caseloads. Home educators in nearby sites administered the surveys to between 2 and 10 of the families in their caseloads in the home visiting program but who did not participate

in the intervention and served as the comparison group. A total of 47 families served as the comparison condition. Comparison families continued their regular weekly activities with their home visiting program, but did not use PEEP Family Science. A total of 20 educators participated in the study (4 AVANCE parent educators and four AVANCE home educators; 12 HIPPY home-based educators). Some home educators in the treatment group administered pre-surveys to families in their caseload who opted not to participate in the intervention; we ultimately excluded these participants from the comparison group because we believed they would be too different from the treatment group in terms of attitudes and interests.

Child and Parent Characteristics. At the beginning of the study, the parents/caregivers in both the treatment and comparison conditions completed a survey with questions about basic demographics and perceptions of and engagement in science exploration with their child. The research team received pre- and post-survey responses from 200 of 217 families. Table 3 and Table 4 show the demographic characteristics of participating families, broken down by treatment and comparison groups. The sample was ethnically diverse: 64% Hispanic/Latino, 23% White, 13% Black/African American, and 1% Other. Survey responses also indicated variation in the highest level of education completed for parents/caregivers:

> 19% did not complete high school

> 34% have a high school diploma or GED

> 25% have attended some college or technical classes

- 10% have an associate's or technical degree

- 14% have a college or graduate degree

At the pre-test, the average age of the children was three years and six months. The large majority (90%) of parents/caregivers reported that they were the child's mother.

Educator Characteristics. A total of 20 educators participated in the study (4 AVANCE parent educators and 4 AVANCE home visitors; 12 HIPPY home-based educators). All home educators were female with varied experience.

Table 3. Participant Demographics (N = 200)

Family and Child Characteristics	Treatment (N = 156)	Comparison (N = 44)
Children's Gender		
Male	47%	46%
Female	53%	54%
Children's Age		
3 Years	58%	50%
4 Years	35%	43%
5 Years	7%	7%
Caregiver's Ethnicity		
Hispanic/Latino**	66%	49%
White	25%	17%
Black/African American**	8%	32%
Other	1%	2%
Caregivers' Relationship to Child		
Mother	92%	86%
Father	3%	2%
Grandmother	3%	7%
Guardian	0%	2%
Other	1%	0%
Caregivers' Education		
8th grade or less	7%	15%
Some high school	12%	2%
High School diploma or GED	33%	37%
Some college or technical school classes	25%	24%
Associate or technical degree	10%	10%
Bachelor degree	9%	7%
Graduate or professional degree	5%	5%

*** p < .001; ** p < .01; * p < .05. Standard errors are in parentheses

Table 4. Parent Pre-Survey Attitudes and Knowledge by Condition (N = 200)

Parent outcome	Treatment (N = 156)	Comparison (N = 44)
Parent confidence (z-score)	.01 (.08)	-.04 (.19)
Parent strategies (z-score)	.00 (.09)	-.01 (.16)
Science activities (z-score)	.04 (.08)	-.14 (.17)
Child need for science (z-score)	.07 (.08)	-.27 (.17)
Joint media engagement (z-score)	-.01 (.08)	.02 (.16)

*** p < .001; ** p < .01; * p < .05. Standard errors are in parentheses

Establishing Baseline Equivalence

We compared the background characteristics of families in the treatment group and the comparison group to determine if the two groups were equivalent. We conducted an independent-samples t-test to examine differences in average child's age between the treatment and comparison conditions. The results suggest no difference between the two conditions (p > .05). We also conducted chi-square tests of independence, Fisher's exact test, and Kruskal-Wallis H test to examine differences between the treatment and comparison groups for the following characteristics: child's gender, caregiver's relationship to child, caregiver education, and caregiver's ethnicity. We found no differences for child's gender or caregiver's relationship to child (p > .05). Results do suggest, however, differences in ethnicity between the treatment and comparison group (p < .01). For this reason, we include ethnicity as a control in all of our regression models that explore differences in outcomes between treatment and comparison families.

Methodology

To address the research questions, the research team collected data from multiple sources, including a pre-survey and a post-parent survey, observations of educators using PEEP Family Science with parents, observations of parents using PEEP Family Science with children, parent interviews, educator interview, educator focus groups, and interview with site administrators. Specifically, during the study, researchers observed six families each using the ramps and colors unit, and seven families each using the sounds unit. Researchers also observed six educators introducing the units to families. Researchers interviewed parents during each observation and conducted follow-up interviews with the educators after each observation. At the end of the study, researchers conducted focus groups with all educators and interviewed the site administrators from AVANCE and HIPPY. Table 5 displays the data collection timeline.

Table 5. Data Collection Timeline

Data Source	February 2018	March 2018	April 2018	May 2018	August 2018
Parent survey (pre)	✓				
Parent survey (post)				✓	
Educator-parent observation	✓	✓	✓		
Parent-child observation	✓	✓	✓		
Parent interview	✓	✓	✓		
Educator interview	✓	✓	✓		
Educator focus group				✓	
Site administrator interview					✓

Measures

Parent survey. To assess differences between the treatment and comparison conditions on our target outcomes, the research team administered a parent survey developed by the EDC research team at the beginning and end of the three-month study to participants in both the treatment and comparison conditions. The research team developed and tested this survey with families during the Phase 2 and Phase 3 pilot studies and also conducted a series of cognitive interviews with a subsample of parents with demographic characteristics similar to that of our sample. The pre- and post-surveys collected information on family engagement in science exploration, use of parent engagement strategies, perceptions of ability to support child's science learning, and joint media engagement. The pre-survey included demographic questions about the child's sex, the respondent's relationship to the child, the child's age, the respondent's highest level of education completed, and the respondent's race-ethnicity. The post-survey asked for feedback on the PEEP intervention.

Parent-child observation protocol. To understand how families use PEEP Family Science, we conducted observations of parents from the treatment group using the PEEP resources with their child. The protocol was open-ended and divided into seven sections:

1. Use of the PEEP app or the PEEP website
2. Engagement in the animated and/or live action PEEP video
3. Use of hands-on activities
4. Parent-child documentation and reflection on activity
5. Other activities
6. Adaptations made to PEEP activities
7. Overall impressions and interpretations

Parent-educator observation protocol. To understand what happens when educators use PEEP Family Science resources and incorporate them into their existing routines, including how parents adapt the PEEP model and why, the research team conducted observations

with all educators and a subset of families. The observation protocol was open-ended and included five sections:

1. Review of activities from prior week
2. Introduction to activities for current week
3. Review of parent video
4. Modeling of activities for current week
5. Overall impressions and interpretations

Parent interviews. Researchers conducted in-person parent interviews to understand more about parent use of and perceptions about PEEP Family Science. The first part of the interview was conducted before each observation; the second part at the end of the observation. The first part of the interview asked parents to describe their child, when and where they do HIPPY/AVANCE activities, and the types of science activities they do with their child outside of PEEP. During the second part of the interview, researchers asked for impressions and feedback on PEEP Family Science.

Educator interviews. Following each observation, the research team conducted telephone interviews with the educator of the family observed. The purpose of these interviews was to understand more about how educators use PEEP Family Science and incorporate it into their existing routines; adaptations educators make to the PEEP model; and educator perceptions of how using PEEP supports parent attitudes about and knowledge of strategies that support children's science learning. During the interview, researchers asked educators for their overall impressions of PEEP Family Science, how they prepared to use the PEEP resources, how they introduced PEEP to families and supported them in using PEEP, and how well PEEP fit into their program.

Educator focus groups. At the end of the study, the research team conducted focus groups with the educators who used PEEP with their families. The purpose of these focus groups was to further explore and understand educators' perceptions of PEEP, their impressions of PEEP's impact, their overall experience

using PEEP, how they prepared to use the resources, how they introduced PEEP to families and supported them throughout the study, how PEEP supported home educator needs, and suggestions for improvement.

Analytic Approach: Observations and Interviews

All interviews and focus groups were audio-recorded and transcribed. The research team coded the observation, interview, and focus group data thematically, based initially on our research questions, and identified and summarized cross-cutting themes across each data source. To describe the parent engagement strategies and the science concepts and practices parents and children explored together, we used a coding scheme based on the PBS KIDS Science Framework, a framework for pre-K science learning that draws on both the K–12 National Next Generation Science Standards (NGSS) as well as the pre-K Head Start Early Learnings Outcome Framework. Two researchers coded each transcript using qualitative coding software and also met to resolve differences.

Analytic Approach: Parent Survey

Factor analysis. Because there are multiple items on the parent survey that probe each outcome, we needed to combine multiple items to create a single score for each outcome. To do this, we conducted an exploratory factor analysis of all close-ended items related to our hypothesized constructs: parent confidence in their ability to engage their child in science, use of engagement strategies, frequency of family engagement in science activities, parent perceptions of the importance of early science learning, and joint media engagement. Because all items in this analysis are ordinal and incorporating them as is would violate the assumption that variables are continuous and normally distributed, we employed a principal axis factor analysis with a promax rotation using polychoric correlations. Polychoric correlations assumes there is an underlying continuous distribution and allowed us to reduce the likelihood of underestimated factor loadings and biased estimates of standard errors. Importantly, because we did not test whether the theoretical

constructs were separate factors, it is possible that some of the outcomes may be related. In other words, we cannot assume that parents experienced five different kinds of changes. The factor analysis resulted in five scores—one for each construct (see Table 6)—which we then used as outcomes in our regression model to test the relationship between providing access to PEEP Family Science and parent outcomes.

Table 6. Survey Questions in Each Construct

Construct 1: Parent Confidence	1. I am confident I can help my child learn science
	2. I know the science skills my child should be learning
	3. I know enough to help my child learn science
Construct 2: Use of Engagement Strategies	1. I played along with my child
	2. I talked about science with my child
	3. I asked my child questions about science
	4. We did the same science activity more than once
	5. We did the same science activity more than once but with different materials
	6. We did the same science activity in different places
Construct 3: Engagement in Science Activities	1. We read about science or nature in books, magazines, or on the Web
	2. We did a science activity such as building a block tower, making shadows, planting and watching a plant grow
	3. We explored science in the outdoors, such as looking at animals, insects, plants, or the weather
	4. We explored science in everyday activities, such as talking about freezing and melting when cooking, noticing what sinks and floats during bath time, talking about the seasons when going to school
	5. We watched a science TV show or video
	6. We played with science apps or science online games
Construct 4: Parent Perception of Relevance of Science for their Child	1. My child is old enough to learn about science
	2. My child likes learning about science, such as nature, animals and plants, and how the world works
	3. I think my child could have a science job in the future, such as a scientist, doctor, engineer, or mechanic
Construct 5: Use of Joint Media Strategies	1. Watch a show or played an online game or app along with your child
	2. Talk with your child about a show or app that you watched or played together
	3. Talk about how a show, app, or game is like or similar to something you do in your everyday life

To assess the extent to which changes in the target outcomes between the beginning and end of the study varied between the treatment and comparison groups, we fit five separate multiple regression ordinary least squares (OLS) models with the post-survey outcome measures as the dependent variables and the associated pre-survey outcome scores as the covariates. In order to make comparisons across the measures, we computed z-scores for each pre- and post-outcome measure so that they have a mean of zero and a standard deviation of one. We included a dummy-coded treatment indicator (treatment = 1; comparison = 0) as a covariate to measure differences between the treatment and comparison groups. To improve the precision of the model estimates and to account for potential influence of demographic and background characteristics, we controlled for the following variables: site, parent education, ethnicity, child age, and child gender. Finally, to test if differences between the treatment and comparison groups varied based on the initial outcome scores from the pre-survey, we included an interaction term of the pre-survey outcome scores and the treatment indicator. All models included robust standard errors and errors were clustered at the site level (AVANCE and HIPPY). In the interest of model parsimony, we removed any covariates that were not statistically significantly related to the outcome at the $p < .10$ level; our final models only included covariates for ethnicity and site.

Table 2 displays the effect sizes for each outcome of interest. Figures 7–11 display the relationship between use of PEEP and parent outcomes, displayed as the average scores for PEEP and comparison parents across different pre-survey scores.

Table 2. Relationship Between Using PEEP and Parent Knowledge, Behaviors, and Attitudes Related to Helping Their Children Learn Science

	Parent confidence	Parent strategies	Science activities	Relevance of science for child	Joint media engagement
Treatment: PEEP Family Science	0.230*** (0.000)	0.740*** (0.000)	0.549* (0.053)	0.037 (0.022)	0.278* (0.032)
Pre-confidence by treatment interaction	-0.379 (0.064)				
Pre-parent strategy use by treatment interaction		-0.456***			
Pre-parent perceptions of the relevance of early science for child by treatment interaction				-0.340** (0.017)	
R²	0.245	0.269	0.284	0.204	0.132
Observations	193	166	178	191	190

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.010$. Standard errors are in parentheses. Outcome measures are standardized (z-scored). Models include controls for parent ethnicity and program site. Standard errors are robust and clustered by site.

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