Ruff FAMILY SCIENCE

Prototype Testing Phase Report

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Introduction

RUFF FAMILY SCIENCE is a project funded by the National Science Foundation (NSF) that aims to foster joint media engagement and hands-on science exploration among diverse, low-income parents[1] and their 4- to 8-year-old children. The project is using a research and design process to create an implementation model and prototype resources (digital media, hands-on activities, and supports for educators) to build new knowledge about the potential for digital media to inspire and support intergenerational science learning among vulnerable families.

WGBH and Education Development Center, Inc. (EDC), along with our partners the National Center for Families Learning, Kentucky Educational Television, and Alabama Public Television, are collaborating through three phases of research: Needs Assessment Phase, Prototype Development Phase, and Prototype Testing Phase. This report summarizes the findings from the Prototype Testing Phase, which investigates how the program model and prototype multimedia resources support acquisition of target attitudes, knowledge, and behaviors in parents and children, and how they support educators in implementing RUFF FAMILY SCIENCE in target partner programs.

The following research questions guided the study:

1. To what extent do the prototype Activity Sets and implementation model promote enthusiasm for and interest in science exploration among parents and children?
2. To what extent do the prototype Activity Sets and implementation model promote parents' comfort and confidence in exploring science with their children?
3. What evidence exists that the prototype Activity Sets and implementation model promote science knowledge in both parents and children?
4. What evidence exists that the prototype Activity Sets and implementation model promote parents' and children's engagement in science practices?
5. To what extent do the training materials and educator supports enhance adult and family educators' ability to engage adults and children in science learning?
6. What factors work together to support or impede effective use of the prototype materials as part of existing adult education programs?

Resources

The project team developed two new sets of resources or "Activity Sets" that could form the basis for joint parent/child engagement in science. Both Activity Sets focus on the scientific concepts (or "Big Ideas") of force and motion and contain the following components.

- **Introductory video.** Intended to capitalize on the appeal of a popular PBS animated character, Ruff Ruffman, this video serves as an introduction to a particular science topic. In the

[1] Throughout the report, we use the term *parent* in a way that is inclusive of all adult learners who participated in the research. The term also refers to adults who serve in other caregiving roles for children (e.g., grandparents, guardians, or stepparents). We acknowledge that a percentage of adult learners are not parents or caregivers for children.

animated portion, Ruff attempts to solve a problem or accomplish a goal; in the live-action portion, real families engage in a related science exploration in order to help him out.

- **Hands-on activity.** The activity consists of simple instructions for a hands-on science exploration that learners can do together with minimal materials and preparation. One Activity Set provides instructions for creating a sail car, and the other for rolling bottles down a ramp.
- **Online game.** Intended to deepen the learning from the hands-on activities in both Activity Sets, the online game consists of an intergenerational two-player game, accessible by computers or mobile devices.
- **Follow-up video.** Intended to inspire families to continue exploring the Big Idea at home, the follow-up video uses a combination of animated and live-action portions to provide a call to action and to offer ideas on how families can extend the hands-on exploration.
- ***Explore More at Home* handout:** Intended to direct families to the online game and follow-up video, this handout provides tips, an extended hands-on activity, and key science vocabulary translated into several languages. In this report, the combination of resources and activities promoted by this handout are often referred to as "at-home" components.
- **Educator supports.** Intended to support facilitation of the Activity Set in various settings, the educator supports consist of an educator video that introduces educators to the RUFF FAMILY SCIENCE model and materials, and a pair of educator guides that contain suggestions for using the materials in two different educational settings: an adult education program (like an adult basic education, ESL, or family education program) and a family education workshop. Both versions provide suggested prompts for introducing science concepts and practices. The version of the educator guide for adult education classes also includes connections to learning standards (CCRSAE and ELP)[2]. Prior to the model's implementation, WGBH also conducted a webinar with participating educators, which included an overview of the goals of RUFF FAMILY SCIENCE and guidance for how to access all of the program resources.

For a more detailed description of each prototype Activity Set, see Appendix A.

Program Model

Our initial research from the Needs Assessment Phase showed that intergenerational learning programs require both resources and structure in order to effectively engage families in science learning. Therefore, the project team created an implementation model that provides direction on how to implement the above resources in a way that addresses parents' lack of confidence in doing science with their children. In the model, parents are first introduced to the RUFF FAMILY SCIENCE resources in an adult education class (referred to as "adult session") and then given the opportunity to explore them again with their children in a facilitated family workshop (referred to as "family session"). To further promote ways for families to continue exploring at home, the project team created handouts with additional support and activities for at-home use. Participating programs were encouraged to follow this program model during this Prototype Testing Phase.

[2] The College and Career Readiness Standards for Adult Education (CCRSAE) are a subset of the national Common Core State Standards. The English Language Proficiency (ELP) standards provide language support to meet college and career readiness standards.

Methodology

Data were collected through two consecutive visits to five participating sites. Below, we describe our recruitment and data collection procedures, and analysis methods; provide demographic information about the study participants; and describe implementation patterns across partner program sites.

Recruitment

Five adult or family education partner program sites in Kentucky (*n* = 2), Nevada (*n* = 2), and Massachusetts (*n* = 1) participated in the Prototype Testing Phase. Sites were selected based on the recommendations of key project partners who work closely with these programs. Of the five partner program sites, three focus their educational efforts on promoting family literacy and two on promoting credentials and skills for adults (e.g., adult basic education or English language learning). In this report, we refer to the former as "family education programs" and the latter as "adult education programs." Each program committed to presenting a series of RUFF FAMILY SCIENCE hands-on science explorations to adult learners enrolled in their programs and to their children.

Testing prototypes in these settings allowed the research team to investigate the capacity of each setting to incorporate an intergenerational learning model into their programing, and to learn more about the unique characteristics of the adult learners enrolled in these programs and how they can be better served with intergenerational science programming.

Procedures

The following data collection efforts were taken to address the research questions of interest.

Program site visits. Researchers visited all program sites to observe the adult and family sessions for each Activity Set except for one that did not implement on-site family sessions,[3]. During these observations, researchers followed a structured observation protocol to document the extent to which the implementation of the sessions matched the guidance provided and to document evidence of the instructional strategies utilized by educators. Researchers also recorded example behaviors and verbalizations exhibited by parents and, when relevant, by their children.

Focus groups. At the completion of the second adult session, EDC conducted semi-structured focus groups at each of the five program sites. The focus groups, each lasting for about 45 minutes, were designed to elicit conversations about parents' experiences with RUFF FAMILY SCIENCE and to channel the topics that emerged organically into the pre-established research areas of interest.

Educator interviews. All five educators who facilitated the RUFF FAMILY SCIENCE sessions participated in an hourlong post-event interview to share their feedback on the experience. The interviews began by asking educators about their previous teaching experience, and moved

[3] This program site faced logistical difficulties implementing an on-site family session. Instead, it provided participants in the adult session with instructions and activity materials to replicate the hands-on Activity Sets at home.

progressively into a discussion of their experience teaching science specifically, and then about their experience implementing RUFF FAMILY SCIENCE with their learners. All of these educators are currently charged with delivering or supervising adult education or family education programs.

Parent surveys. Three distinct types of surveys were collected from participants. At the beginning of each session, a demographics survey was collected from each parent to understand the demographic makeup of session attendees. After the second adult session, a survey was implemented to understand parent perceptions of the adult sessions. Following the second family session, a supplemental survey was implemented to understand parents' perceptions of the family sessions.

Parent interviews. Ten parents were randomly selected[4] to participate in a 20-minute phone interview about their experiences using the RUFF FAMILY SCIENCE handouts at home. The interviews were conducted one or two weeks after the second adult session. Given that one audio file was damaged and no verbatim record of it exists, the current report reflects the contributions of nine parent interviews.

Analysis Methods

The research team utilized a mixed-methods approach to analyze the various sources of data. Researchers summarized observation notes for each session, yielding descriptive evidence of implementation fidelity. Then, researchers created cumulative summaries to produce a set of implementation strengths and challenges that generalize across sites. Researchers coded transcripts from focus groups, educator interviews, and parent phone interviews using a set of *a priori* content codes that were guided by the semi-structured interview protocol. Researchers also allowed additional codes to emerge from the data. They then created a set of major themes summarized by each research question. Researchers analyzed survey responses descriptively utilizing SPSS statistical software, with qualitative survey responses pulled out for further review.

Participants

A total of 88 adults attended at least one RUFF FAMILY SCIENCE program session and provided demographic data. Fifty-seven percent of these participants (*n* = 50) were from family education programs and 43% (*n* = 38) from adult education programs.

Table 1 presents some demographics for the 88 adults who provided demographic survey data.

Table 1. Participant Demographics (*N* = 88)

Parent gender	
Male	22%
Female	78%
Language spoken at home	

[4] These parents were randomly selected from a sub-sample of participants who were found to have a child within the target age range.

English only	57%
English and other language equally	11%
Mainly other with some English	19%
Other language only	5%
Missing	8%
Parent education	
Some high school	25%
High school diploma or GED	25%
Some college or technical school classes	17%
Associate or technical degree	6%
Bachelor degree	10%
Other	13%
Missing	3%
Parent age	
Below 20 years old	1%
20–29 years old	17%
30–39 years old	38%
40–49 years old	24%
50 years old or above	19%

Family composition. Ninety percent (*n* = 79) of these adults reported having at least one child in his or her care. These adults were asked to provide the ages of the children whom they care for; however, the data were not complete. Of the 79 participants who reported having a child in his or her care, only 41 provided ages for these children. Of that sub-sample, 38 adult learners have a child within the 4–8 target age range in their care.

Child participants. Data collected about participating children were limited to researchers' observation notes. According to rough estimates from observers, 71 out of 82 children who attended the family sessions were within the 4- to 8-year-old range. Forty-five children attended the first family session and 37 children attended the second family session. However, given that the demographic surveys were not directly administered to children nor did they ask the adults to report if the child attended multiple sessions, it is unclear how many of the participating children attended more than one RUFF FAMILY SCIENCE family session.

Fidelity of Implementation Patterns

In this section, we provide details about the two different environments used for RUFF FAMILY SCIENCE observation: adult sessions and family sessions. We describe some typical patterns of implementation within each type of environment.

Adult sessions. Adult sessions presented the first point of contact between participants and RUFF FAMILY SCIENCE. The goals of these sessions were to introduce parents to the learning goals and to prepare parents for the family sessions. Each adult session was designed to enact one Activity Set. The average adult session lasted 55 minutes, was attended by 12 parents (range: 3–25), and was facilitated by a lead educator who was often supported by other program staff.

Family sessions. Family sessions were designed to offer a facilitated environment where parents could guide their children's science learning with educator support. Like adult sessions, the family session focused on a single Activity Set. The average family session lasted 41 minutes and was attended by nine parents and eight children within the target age range.

Table 2 presents a summary of observational evidence for fidelity of implementation. As noted earlier, four out of five sites hosted family sessions. Because one program site was not able to facilitate family sessions, the project team provided parents in that site with materials for families to recreate the RUFF FAMILY SCIENCE family session at home. This accounts for the reduction of the family sessions to eight in Table 2.

Table 2. The frequency of educator implementation of key Activity Set components

	Adult sessions (*N* = 10)	Family sessions (*N* = 8)
Screened the introductory video	9	7
Introduced/framed the lesson	10	7
Introduced the featured vocabulary	9	7
Introduced the science concepts in the activity	10	8
Introduced the hands-on activity	10	8
Conducted Part 1 of the hands-on activity	10	8
Conducted Part 2 of the hands-on activity	9	6
Conducted wrap-up discussion	8	6
Introduced *Explore More at Home* ideas	8	6
Distributed *Explore More at Home* handout	5	8

High fidelity. As shown in Table 2, educators *consistently implemented* the introduction of science concepts, the introduction of the hands-on activity, and Part 1 of the hands on-activity—meaning that educators in 10 out of 10 adult sessions and eight out of eight family sessions did these activities. The video, although highly popular, was skipped once in each type of session because of technical difficulties. The introduction of the featured vocabulary was skipped once, also across adult and family sessions, because of time constraints.

Medium fidelity. Educators varied in their implementation of Part 2 of the hands-on activity (implemented in 15/18 sessions), the wrap-up discussion (14/18 sessions), and the introduction of the *Explore More at Home* ideas (14/18 sessions). Given researcher observations and educator accounts, it is believed that most of these components were omitted more than once because of session time constraints. As will be shown in the results section, the difficulties educators faced in getting families back together for discussion after the group work contributed to their decision to cut these components.

During both adult and family sessions, observers noted that educators consistently reserved time to make RUFF FAMILY SCIENCE relevant to their class. In family education programs, educators highlighted the role of parents as children's first teachers and the importance of extending learning at home. In adult education programs, educators most often highlighted the connections between science knowledge and program goals (i.e., high GED scores).

Low fidelity. The only component that was consistently low in implementation fidelity was the distribution of the *Explore More at Home* handout, with educators in 5 out of 10 adult sessions using this resource. At the end of the sessions and when time allowed, educators appeared to use their best judgment to decide how and when to distribute this handout. Some encouraged their learners to further their children's science learning by following the suggested at-home activities. Others, however, placed the handout by the exit door and framed it as more of an optional activity. In some instances, educators were observed forgetting this piece entirely. The focus on intergenerational learning is more novel to educators who facilitate adult education programs than to those in family education programs, which could help explain why educators in adult education programs were more likely to overlook the handout delivery. However, additional research would be needed to confirm.

The low rate of *Explore More at Home* handout distribution made it difficult to discern the true value of the at-home resources promoted by the handouts (i.e., the online game and follow-up video) to extend the use of science practices. During follow-up interviews with parents, about half of the interviewed parents reported that they did some of the suggested activities at home. This limits the research team's ability to understand the successes and challenges around implementing the at-home resource components.

Results

Our study results present a comprehensive picture of the RUFF FAMILY SCIENCE implementation. Below, we address each of the study's research questions of interest.

Promoting Enthusiasm for and Interest in Science Exploration among Parents and Children

Parents found the Activity Sets to be highly appealing and engaging.

- Parents thought that the videos provided helpful, effective, and approachable introductions to the science concepts. While speaking with researchers, parents said that they liked the videos because they use a combination of animated characters and real people.
- Parents reported that the videos increased their enthusiasm, motivation, and confidence to do science and to help their kids do the activities in ways that would support kids' learning. Parents also thought that the videos helped to prevent "chaos" by clarifying what was to happen next during scientific investigations.
- Parents liked how the hands-on activities are playful in nature and use everyday materials that are easy to obtain. They enjoyed how the activities provide the chance to engage in science experiences and to use critical-thinking processes. Parents also thought that the Activity Sets do a good job of highlighting the relevance of science in everyday life.
- Parents and children also enjoyed practicing soft skills such as teamwork, patience, and collaboration as part of the RUFF FAMILY SCIENCE activities. The activities gave families the chance to spend quality time together and engage in positive "bonding time." In some groups,

this included the ability to use RUFF FAMILY SCIENCE as an opportunity to reinforce important home values like being disciplined, working in an orderly manner, and following instructions. When asked about the things they appreciated most from their sessions, a number of parent responses focused on this area:

> - *"It helps with social skills too . . . Showing how the adults and the kids work together." – Parent focus group participant*
> - *"It's time set aside that is kind of a form of discipline. . . . 'We're going to do this activity together' . . . So it's a bonding time, and it's a form of discipline too." – Parent focus group participant*
> - *"You spend quality time. Much more quality time with your child." – Parent interview participant*

These secondary outcomes may make it more appealing for parents to engage in science learning with other adults and with their children.

Parents engaged in science exploration in their adult education programs and maintained a high level of interest throughout the experience. Researchers documented that the competitive nature of the activities provided opportunities for teamwork, and they frequently heard words of encouragement exchanged between adults. During focus groups, many parents responded positively to the question of whether they felt excited about doing science. Several parents said how much they enjoyed the opportunity to be playful during the learning process.

> *"I was excited, because I feel like a little kid, because I was rolling the bottle of water." – Parent focus group participant*

Children enthusiastically engaged in scientific exploration in family education settings, and parents reported that their children were interested in the videos and activities. During video viewing, researchers observed that children were frequently attentive to the videos and contributed thoughts or answered questions when prompted by their parents, by the educator, or by the animated characters. Children also appeared to be engaged during the hands-on activities. They appeared most excited when testing their sail car model against those made by other families and when rolling their water bottles down the ramp to see how far they would go. During follow-up interviews, parents said that they could tell their kids were interested because they saw their child staying engaged with the activity and working through a process of figuring things out.

In addition, parents were excited to note how their children took initiative by reminding them about the at-home activities.

> *"He told me, 'I love those videos. I want to see more.' He actually wants to try the experiment at home." – Parent interview participant*

Despite the observed variability in how educators emphasized the use of Explore More at Home materials, parents responded favorably to the model's idea of doing science at home. Researchers confirmed that all interviewed parents received the at-home resources at the completion of their sessions. During phone interviews, parents expressed a lot of enthusiasm about the at-home materials (these include the tips, vocabulary, game, and video that the *Explore More at Home* handout promoted, as well as the hands-on activity materials that some parents received). Around half of the interviewed parents (*n* = 5) acknowledged using the handouts to some extent: two of them had watched the videos exclusively; two of them did the hands-on activities.

> *"We were able to do the water bottle one . . . We had one that was full [of] water; we had one that was a little less. And then we stuffed, I think it was just more like paper in another one, just to see how far they would roll. And we kind of measured out what went the farthest. Kind of talked about why they went farther than the other."*
> *– Parent interview participant*

The other half of interviewed parents (*n* = 4) did not use the at-home resources, but it is unclear if this was influenced by their educator's lack of encouragement to use the materials or by their discomfort with the materials themselves. As reported in the prior section, several educators did not spend much time introducing the at-home materials to parents at the end of their sessions. This may have influenced how important the parents perceived this at-home work to be. When discussing why they did not engage in doing the activities at home, parents reported time limitations and language constraints as the main causes. One parent said that she would feel "much more comfortable" if she could talk to her children and do science at home "in my language, of course."

Several interviewees adapted the Explore More at Home activities to create their own at-home variations. Some examples of these variations included modifying the materials and/or the way that they conducted their prototype tests.

> *"We was [sic] able to build a better ramp and stuff like that at home, and do the water bottle thing with different things that we found at home—like filled it with pennies and filled it with cotton balls—and we was [sic] able to have a little bit more, you know, things to use." – Parent interview participant*

Despite some inconsistency in the use of the at-home materials, parents reported that they continued exploring science with their children through everyday activities such as shopping, cooking, collecting items, and riding bicycles**.** These situations provided opportunities for parents to reinforce scientific concepts and practices outside of the classroom environment. Specifically, parents discussed how the videos and activities made them and their children enthusiastic and interested in science learning, and how they prepared them to engage with science outside of school. Although some families adapted the activities to better fit their daily routines, others used the concepts in them as a springboard for new activities. In one case, a parent described how his experience with RUFF FAMILY SCIENCE led to additional science-based projects, such as one described here about volcanoes:

> *"[The activity] kind of made us ready for being inquisitive that way once we started to do the exercise with the gravity exercise. It kind of led to, 'Okay, well, what if we did this? What if we did that?' So we kind of led that into what we were doing with the volcano exercise, so it just made it more easier for him to ask questions and ask why this happened. 'Can we do more of this?' It just kind of led to a lot more once we introduced the ability to ask questions while we're doing things . . . " – Parent interview participant*

Similarly, another parent noted the following when asked to elaborate on what made it easier to engage in science:

> *"I think being hands on in that first exercise led us to being more hands on in the next one, and it kind of just trickled down into more of an interest in doing it. Now he's building things on his own and trying to make predictions on his own. It's pretty cool." – Parent interview participant*

Parents also reported that they enjoyed exploring science at home because it allowed them to explore science in a different way than in the facilitated sessions. Parents reported that they liked the opportunity to involve different family members, and to investigate in a more focused way.

> - *"We was [sic] able to get Dad involved too because he has his job. His job has prevented him from attending the parent-teacher meeting . . . So we was able to get him involved. So he was eager to show his dad what we got into on that." – Parent interview participant*
> - *"What we usually do is when we get those papers, I always take them and we redo the whole science project at home . . . Even though we enjoy doing it with other parents and people around, you get the full effect when it's just you and your kid at home. So that's why I came home and we'd redone it, so she could kind of get an understanding of really what we were doing." – Parent interview participant*

Still, some parents reported mixed enthusiasm about being able to engage in additional science activities at home with their children. Many parents discussed examples of how RUFF FAMILY SCIENCE inspired them to try new things at home with their children, but others had not done so yet. Some said that, although they have not yet tried the at-home resources, they had the intention of doing the activities or using the digital games with children at a later time. However, some parents expressed doubt that they would use the resources at home. The most common obstacle for engaging in at-home activities was time. Others reported that they are "bad at homework," suggesting that some parents think of these kinds of activities as an assignment and less as a fun or exciting at-home learning opportunity.

As noted, parents often cited time, language fluency, and confidence with science as reasons keeping them from using the at-home resources. For example:

> - *"I kind of didn't get to it because I've been mostly busy. I wasn't able to actually have that designated time to sit and do it. Mostly when I do get home, it's kind of too late for the kids." – Parent interview participant*
> - *"My problem is English, you know? . . . I'm not comfortable but I can try to improve." – Parent interview participant*

It's important to note, however, that families' tight schedules likely present challenges for all kinds of family learning, not just RUFF FAMILY SCIENCE.

Promoting Parents' Comfort and Confidence in Exploring Science with Children

Most parents reported that they felt more comfortable and confident exploring science with their children after participating in the adult sessions. Parents' overall levels of confidence were high across both adult and family sessions (see Table 3). It is important to note that parents' concerns for addressing their children's science questions in family education settings may be attributable to a greater sense of responsibility for supporting their children's learning; however, additional research is necessary to understand this more deeply.

Table 3. Post-event survey responses from parents related to confidence

Adult Session Survey Item	Percentage of Agree/Strongly Agree Responses (*N* = 58)	Family Session Survey Item	Percentage of Agree/Strongly Agree Responses (*N* = 33)
I felt confident talking about science.	86%	I felt confident talking about science with my child(ren).	78%
I was worried I wouldn't know how to answer science questions.	34%	I was worried that I wouldn't know how to answer my child(ren)'s questions.	45%
I felt confident that I could learn from the activities.	95%	I felt confident I could help my child(ren) learn from the activities.	94%

Parents regarded the adult sessions as an important step in preparing them to feel comfortable in guiding their children's experiences. Specifically, the sequencing of sessions (adult session first, family session next) was perceived as a strategic way to equip parents with the necessary tools to support their children's learning.

- *“[The video] made you more comfortable . . . the minute you see that it can actually be fun to do with your kid, or something that’s not as hard to do with your child or children.” – Parent focus group participant*

Showing parents how to do science played an important part in supporting parents’ confidence. Parents’ initial notions that the subject matter would be challenging appeared to change as the program unfolded. In post-event focus groups and interviews, parents acknowledged having had initial concerns about doing science with children because they themselves were never very good with science, but they eventually stated a conviction—often without prompting—that the sessions had improved their comfort with science. Specifically, they noted that the videos and hands-on activities helped to debunk common notions of science as a difficult and inaccessible subject.

- *“I’m interested in wanting to learn more. It’s helping me to want to be more engaged instead of thinking this is challenging for me.” – Parent focus group participant*
- *“[Science] isn’t as challenging as I thought it was.” – Parent focus group participant*

Parents also made it clear that having continual assistance from trained professionals was essential to successful intergenerational engagement. One parent, when asked about his or her confidence level during the family sessions, rated it as “Eight out of ten . . . It was nice having [educator name] kind of check in with us, though.”

Parents were less confident about the prospect of doing new lessons on their own and of guiding children outside the program’s target age range. During interviews, some parents were uncertain about their own science literacy, questioning their ability to succeed with more advanced science concepts for older children or to facilitate the development of younger children’s science skills.

Additional instances where parents’ confidence with science was challenged included:

- When asked to read text-heavy instructions
- When the expected results of an activity were hard to replicate (details in pp. 17–19)
- When families’ predictions were incorrect
- When families’ predictions or ideas were different from those of others
- When time constraints put pressure on families’ ability to produce results

Across visits, researchers observed that modeling played an important role in supporting parental confidence. Some educators brought in and shared with their learners the photos and videos of the models that educators had built at home. This, along with the live-action portions of the video clips that depicted real families working together, appeared to be instrumental in building parents’ sense of confidence. Parents noticed and valued that the activities were “tried-and-true” and viewed the program’s preparedness as reassurance that the lessons, though challenging, were feasible.

Promoting Science Knowledge among Parents and Children

Most parents reported that they learned science as a result of their participation in RUFF FAMILY SCIENCE. Before participating in RUFF FAMILY SCIENCE, about a third of parents (37%) noted that they didn't know enough about science to actually do science with their children. When reflecting on their RUFF FAMILY SCIENCE participation, 61% (*n* = 35) of all participants who completed surveys after the adult sessions reported that they learned a lot about force, gravity, and motion; another 32% (*n* = 18) said that they learned a little about these topics. Among those who completed surveys after family sessions, 54% (*n* = 18) agreed that they learned a lot about science with their children and another 39% (*n* = 13) said that they learned a little about these topics with their children.

Parents and children demonstrated science learning in various ways. Parents' reports about learning are reinforced by qualitative data from focus group sessions and observations. During focus groups, parents were heard using domain-specific vocabulary to illustrate the kind of learning they took from RUFF FAMILY SCIENCE. During observations of family sessions, children and parents displayed behaviors that suggest acquisition of science knowledge. Table 4 is a set of vignettes showcasing select instances where researchers observed participant use of science knowledge.

Table 4. Example observations of parents and children displaying science knowledge

Some children were able to identify the science problem. In one session, the educator asked children to summarize what happened in the video. One child responded that the characters wanted "to test if the car would go farther." The educator probed a bit more to have children recognize that the heavier car was expected to go farther than the lighter car.
Some children were able to properly define scientific terms. During the introduction of the science concepts, facilitators often asked families to define "prediction." In one case, a child volunteered that prediction was "kind of like guessing but using all your information from your text or this video." A child in a different session offered that a prediction was "kind of guessing but it's based on what you know."
Parents were often observed providing child-directed prompts similar to the ones modeled by educators during hands-on activities. Parents asked questions like "What is your prediction? How are you going to make the car move? How far will your bottle roll?" and modeled statements like "My prediction is __ inches."
Some children remembered lessons learned in previous sessions. When educators asked during wrap-up discussions what words the class had learned the prior week, child responses often included the following science vocabulary: force, pull, and push.
Families were often engaged with the concept of fair tests. Across sail car sessions, when a car was placed farther than the rest, families were quick to label that as cheating, and efforts were made to place cars aligned along an imaginary start line. In one water bottle session, an educator asked families to judge purportedly incorrect demonstrations of fair tests. Then she asked a child to show what a fair test looked like, and the child placed all bottles alongside one another.
Some children made connections between the science concepts and observations they

made during the hands-on activities. At the end of one sail car session, one boy noted, "I didn't want to blow so hard because I didn't want [the car] to fall." Another child added, "We need to go outside because the [wind] force is the greatest there." In a separate water bottle session, a child explained his observation: "What happened to my prediction—I put less water and I almost made it, and then I took a little water out and then I met my goal." When the educator asked what was pulling it, the child responded "gravity."

Some children were able to iterate through the measuring and testing phases of their work. During a water bottle activity, one group of children renegotiated their tape marks after having rolled their bottles down the ramp. Then they rolled again and measured. To improve their results, they transferred water from one bottle to the other and compared results. They tried to move their marks at the end, but the mother encouraged them to add separate marks for their second prediction.

Families were also observed adjusting their sail cars to make them go farther. Two popular strategies that were used included reducing the friction between the wheels and their axis, making a larger sail, and repositioning the sail along the post to improve stability (i.e., either higher or lower along the sail post).

Parents benefited from the program's model, which allowed them to practice science in enjoyable ways. Below are several themes gathered from parents' feedback:

- ***Repetition.*** Parents benefited from the opportunity to repeatedly explore key science concepts and vocabulary. The value of this feedback was confirmed during phone interviews, where researchers observed parents using words such as "force," "gravity," and "prediction" to illustrate at-home learning experiences that had happened several weeks after the facilitated sessions had been conducted. This ability to use science vocabulary across settings might signal the program's success in promoting parents' science knowledge and children's exposure to scientific vocabulary.
- ***Hands-on learning.*** Parents also consistently emphasized how much they liked the program's hands-on approach for facilitating science knowledge acquisition. The opportunity to interact with science learning materials and to practice doing science increased their understanding of scientific practices and principles.

> *"It helped [me] learn about the force and gravity. Kind of like doing the project explained it better than just watching the teacher explain."*
> *– Parent interview participant*

- ***Interactive engagement.*** Parents valued the opportunity to work alongside peers and their educators. This collaborative working time allowed them to practice and discuss scientific principles in ways that supported engagement and learning.

Educators in all partner program sites reported that the Activity Sets promoted the development of science knowledge in parents and their children. Educators heard their learners using scientific terms correctly and observed families working together to test scientific concepts in hands-on activities.

Consistent with the sentiments reported by parents, hands-on learning and collaboration were two of the most highly valued features of RUFF FAMILY SCIENCE by educators.

> *"So normally we have them make the car, but then we had them race. So they all got on the floor. They were blowing together, and they raced for an incentive. So each got an award, and just seeing the parents and the kids working together and seeing really, really small kids trying to work with their parents and understanding that, 'Okay, we're going to count to three, blow, and everybody's going to blow.' And just seeing that work was just awesome. It was great to see. It was a great experience."*
> *– Program educator*

Additionally, parents' observed ability to diagnose problems with sail car models and with unexpected water bottle trajectories (e.g., when water bottles would roll down the ramp in an unanticipated or unpredictable way) demonstrates their understanding of the Big Ideas.

Promoting Engagement in Science Practices among Parents and Children

During adult sessions, parents consistently engaged in the science practices of making observations, making predictions, carrying out investigations, and using science vocabulary. Across locations, observers noted that parents used "if" statements while engaging in the science activities to state their predictions. For example: "If the empty bottle rolled this way, the heavy bottle will roll that way." Some of them were also observed drawing conclusions, such as "the more the weight, the further the bottle travels." Additionally and as noted before, the concept of fair tests was popular with adult and child learners. Both groups referred to it numerous times while engaging in observations and competitions during family sessions.

Table 4 offers a summary of the science practices most commonly observed among parents or families across sessions. The practices that were less frequently observed are believed to reflect site-level modifications to the activities.

Table 4. Frequency of how often target science practices were observed across adult and family sessions

Science Practices	Adult Sessions (*N* = 10)	Family Sessions (*N* = 8)
Built models to test a science concept or Big Idea	8	8
Made predictions based on knowledge	8	7
Observed and described what happened during tests	7	7
Measured, organized, and recorded information	7	7
Compared predictions to data and drew conclusions	4	5
Summarized and communicated results	5	6

As noted above, the downward trend in science practices observed is likely explained by educators' intentional skips of components at the end of the sessions due to time constraints. However, observations revealed that families had some difficulties using the prediction charts and engaging in comparisons between predictions and results to draw conclusions, which may also have played a role in educators' assessments of what activities to skip.

Parents valued learning about science practices in accessible ways. As noted in previous sections, one of the features of the Activity Sets most valued by parents and educators was the intentional "hands-on nature" of the activities. Although some parents were initially hesitant to get up and move around the room, participants consistently came out of the sessions with a full appreciation for the practical knowledge gained through the active use of science practices in the classroom. This active engagement with science played a significant role in offsetting parents' initial concerns about "not being the science type."

Educators also agreed that the Activity Set prototypes promote engagement with the science practices. Educators consistently described the power of showing versus telling when teaching learners about science. Educators liked that learners were actively moving around and in charge of their own data collection. One educator described how talking about making predictions is not nearly as powerful as making them firsthand:

> *"If somebody doesn't know what prediction is, then you're just teaching 'This is prediction,' but they don't really know what it is. . . . If they can learn it and do it, I think that's helpful for them." – Program educator*

Other educators discussed the value of using active hands-on experiences that allowed adults to use their own prior knowledge to inform their learning. One educator described how she connected the act of making predictions to the scenarios where adults may already engage in that activity. She noted that in a football game, for example, her learners are already accustomed to predicting who will win and using what they know about the teams and the game to create a hypothesis. She thought that the ways the Activity Sets presented science practices would allow students to see real-life connections to their own prior knowledge.

Parents reported occasional challenges as they tested predictions, built models with young children, and measured distances. The situations illustrated below present some of the most common difficulties families faced during the activities:

- ***Testing predictions using variable materials.*** Although most parents thought the Activity Sets properly addressed the learning goals, some expressed considerable frustration about the lack of standardized materials. Specifically, parents who were unable to replicate the prescribed results from the water bottle session stated that, although it is great that the materials that are needed are easily accessible, the use of different materials (e.g., different-shaped water bottles) might have produced results that ran contrary to the scientific principles being tested.
- ***Building models with young children.*** Setting up the experiments without standardized materials was also challenging for children. For example, some children found it difficult to build ramps with appropriate inclines using the materials provided. This was especially difficult for younger children, who were often forced into limited roles while engaging in activities where adult leadership was necessary to work with the activity materials. In the

focus groups, some parents suggested that the water bottle activity was more appropriate for older children than younger ones.

- ***Measuring distances.*** The act of measurement presented challenges for parents who either had to come up with creative ways to measure distances without a measuring stick (i.e., by measuring in footstep units or with paper sheets) or had questions about measuring conventions. Some of the dilemmas that arose include (a) using metric or U.S. customary units, (b) using decimals and how many, and (c) where to start measuring travel distances: at the back end of the models or at the front tip.

Enhancing Adult and Family Educators' Ability to Engage Families in Science Learning

Educators were very positive about RUFF FAMILY SCIENCE and the ways in which the Activity Sets helped them promote knowledge and skills in parents and children. Educators felt the model and materials supported their abilities to promote scientific concept knowledge by fostering collaborative learning and presenting science in accessible, concrete ways. Educators thought that the videos were excellent demonstrations of how families can work together when doing science explorations. The activity handouts were clear illustrations of what parents and children would be doing.

> *"I loved everything. I loved the fact that they didn't do it in a studio, that they did each one of them in a home. They showed, like, backyard usage and things that people can do and they use real-life folks because you can tell, too, that they used whole families because everybody looked alike, which made a lot more sense. And they used young people and they used older people. And that also definitely made me feel like, 'Okay, I can do what they're doing because this is what my family looks like.'"*
> *– Program educator*

Educators were also very positive about the training materials and educator supports. They felt these materials prepared them to engage parents and children in science learning. Educators felt that the educator guides were comprehensive and well-organized to guide them through the activity sessions.

> *" . . . I never felt like I was on my own. 'Oh, my God, what am I going to do?' It was pretty specific. The instructions were good. And then they had (the at-a) glance so you could just look through and make sure you didn't forget anything." – Program educator*

Educators described making some modifications to the ways in which activities were implemented in their class environments. Some made modifications directly to the materials. For example, one educator created a PowerPoint presentation to use in her class to keep the session on track; others modified some of the activities to make better use of materials that they had on hand. Because the program model does not provide standardized Activity Set materials—such as ramps, water bottles, and straws—the most common variation was observed in the kinds of materials that the programs introduced. Educators across sites devised inventive ways to provide learners with the necessary materials, some of which included utilizing:

- A variety of materials to create ramps with, including tilting tables on a sharp angle, placing whiteboards on a stack of books, placing cardboard over water bottles, and holding cardboard at an angle
- Funnels to aid in water bottle refills
- Wooden blocks to ensure safe hammering for young children
- Plastic buckets to collect liquids that were no longer needed

Observers documented how the variation in materials may have led to differences in families' experiences. For example, the use of different sizes and styles of water bottles led to differences in how bottles rolled down ramps with varying levels of predictability.

Educators appeared to modify activities based on their own assessments of their learners' needs and interests. Several educators added a second co-facilitator to ensure that there were enough guiding hands to support their learners. Others were observed modifying the discussion of certain aspects of the activities to support and enhance the learning process. For example, one educator described how her parents have been learning about measurement. She described some modifications to continue their learning process with one of the RUFF FAMILY SCIENCE activities: "With my students right now, we're doing a whole measurement unit, so I was trying to just push them on it a little bit." She described how students attended to the activity handout, noticing how the table for recording data asked for measurements in either inches or centimeters. She spent time talking to students about their yardstick and how it only had measurements in inches, so they discussed how centimeters are different and how they would need a different tool to use that metric.

Other variations that were not related to the use of specific materials, some of which have already been mentioned above, included these:

- In one location, the educator of a family session selected a small number of children to model hands-on activities in front of the class, since space was limited.
- Another educator used storytelling techniques to share RUFF FAMILY SCIENCE plots when she struggled to screen the videos because of unexpected technology difficulties.
- One program offered additional gift cards to incentivize spirited competition among participants.

Educators provided recommendations for the development of future educator support resources. The following is a list of educator-generated recommendations to consider for the continued development of RUFF FAMILY SCIENCE resources:

- Create materials in other languages to support the facilitation of the workshop in the native languages of participating families.
- Provide guidance for educators on how to introduce Ruff Ruffman as a character in the context of specific classes or programs.

- Provide supports for educators on how to create additional curricular connections to increase the relevance of science for a variety of students, including those in adult education programs; this will help them to make science more relevant to the learners in their programs.
- Emphasize important issues related to science learning (e.g., science is not a one-and-done type of learning experience. Instead, science inquiry is related to continual exploration).

Factors That Support or Impede Effective Use of the Prototype Materials in Adult and Family Education Programs

Educators from both types of programs identified numerous ways in which RUFF FAMILY SCIENCE supports their organizational goals. They reported that RUFF FAMILY SCIENCE is "packed" with the types of hands-on activities that support a family learning model and parent/child time. Some educators discussed how the materials allow English learners to practice language and literacy skills in a fun, engaging way. Educators also liked how RUFF FAMILY SCIENCE introduces science in a friendly, low-cost approach.

Educators from family education programs identified several ways in which RUFF FAMILY SCIENCE clearly aligned with their program goals and infrastructure. During educator interviews, the following traits were mentioned:

- Educators in family education programs reported that their programs already have a deep sensibility to individual family needs, making it easy to implement RUFF FAMILY SCIENCE. For example, educators knew that it would be best to schedule sessions right after drop-off.
- These educators believed that it was easy to include young children in family sessions because of their existing focus on intergenerational engagement.
- These educators also believed that their programs' long history of promoting sound parenting practices as a tool to support children's academic learning made the focus of RUFF FAMILY SCIENCE consistent with their program practices. In general, family education programs have already made a commitment to fostering intergenerational learning, and in this sense were already moving toward the program's goal of promoting science learning among parents and their children.

> *"Our goal is that the parents are the first teachers. We're teaching them 'You guys can be supportive. You can help. Forget about the barriers—because a lot of times families come from other countries and they see a lot of barriers. They don't think they can help their kids. So we try to take that away from them and instead, you know, help them see that they can support in many ways, I mean even if you don't speak the language." – Family education program educator*

Educators from adult education programs also identified ways in which RUFF FAMILY SCIENCE aligned with their program goals and infrastructure. In most situations, researchers observed that the adult education programs possessed the following traits that facilitate RUFF FAMILY SCIENCE implementation:

- Educators in adult education programs thought that their program infrastructure was conducive to focused learning and supportive of deep engagement with the science concepts.
- These programs tend to meet in spacious and well-lit rooms that are equipped with the necessary technologies. This was helpful for engaging learners with the RUFF FAMILY SCIENCE media.
- Many educators serving these programs have solid background knowledge of GED math and science; therefore, they felt very capable of addressing parents' science-related questions.

Many educators concluded that RUFF FAMILY SCIENCE brings something new and welcome to their learners' experiences. All five educators identified ways in which the program misaligns with course or program goals; however, most of these misalignments were brought up as positives or new, welcome additions for their programs. One of the most common comments was that "the whole idea of playing" is not something that is a current component of program goals; however, educators liked how the RUFF FAMILY SCIENCE experience made parents feel like children again.

Educators also frequently reported that science is not a normal part of their program or course content but that these resources served as an entry point to support other programmatic goals. Many family education programs have more of a literacy focus or emphasize general education supports.

Educators from adult education programs also discussed how the presence of children often seemed at odds with their program goals of building the adult learners' skills. However, these educators felt that the incorporation of children into their programming is something that their participants enjoyed. Additional logistics and permissions would be required to do this on a more frequent basis.

> *"It would be nice if we had a little bit more flexibility with that. I know both of us would love to have, like, family homework time where anyone can come in and do work together, but at least it starts a conversation about working with your kids at home and, like, family education." – Adult educator program educator*

Despite strong support for the RUFF FAMILY SCIENCE program model, educators from both kinds of programs cited a lack of certain kinds of training, which made some parts of implementation challenging for them. Educators in family education programs, for example, do not normally teach science and therefore found it more challenging to implement RUFF FAMILY SCIENCE. During interviews, these educators often reported a lack of familiarity and fluency with science concepts that limited their capacity to build learners' confidence and comfort with science. This was most strongly felt when educators were put on the spot for not being able to address learners' science-related questions.

In adult education contexts, some educators reported a lack of experience in leading programming that includes children and thus found it challenging to implement RUFF FAMILY SCIENCE. Although most of these educators were excited to bring families together into what was conceived as a "family night" programming, their lack of experience working with parents and their children sometimes interfered with the successful integration of a family component. Examples of this included miscalculations about the effort it would take to secure approval for children to attend events on community college campuses where adult education classes are offered, misunderstandings about learners' family composition and the activities that are relevant to them, and uninformed decisions about the times of the day that are the most conducive for child participation.

Some adult education program educators also felt consistent pressure to focus on the specific learning goals of their program because of testing requirements. Although some RUFF FAMILY SCIENCE activities at certain times of the year may provide a welcome break, most of the adult learning program year gets planned out in advance with curriculum-based lessons. For many of the adults enrolled in basic education classes (test-focused or not), science learning is not their primary goal. These learners may be willing to engage in activities like those from RUFF FAMILY SCIENCE occasionally, but educators recognized that this is not their driving purpose in attending their class.

Educators from family and adult education settings also described some programmatic or participant characteristics that pose challenges to scientific concept learning.

- ***Program materials and supplies.*** Several educators discussed technology issues such as the inability to rely on Internet connectivity or technical issues with computers that got in the way of watching the RUFF FAMILY SCIENCE videos. Others described how they did not always have enough supplies on hand, although the activities required common materials.

  > *"We didn't have a yard stick . . . So one of the parents found on their cell phone, was able to measure something using their cell phone. Another parent used the [box/blocks] on the towels to figure out how far stuff was. So that was probably the most difficult in looking back . . . And so last week we ran out of tops . . . when you're talking about a group of 26 and you need like 126 bottle tops, that became difficult. So it's something to think about." – Adult education program educator*

- ***Participant-related learning challenges.*** Educators reported that, during RUFF FAMILY SCIENCE, they thought about the supports that English language learners would need as they struggled with the pace of the videos. Also, some educators thought that not all learners had enough background knowledge to fully engage in some of the science practices. For example, two educators mentioned specific examples of their students' lack of familiarity with tools of measurement. Another one discussed how the act of recording data in tables might have tripped up their learners. In all of these instances, the educators talked about how they had to augment the activity with additional instruction on how to engage with the science practice (e.g., utilize and read the measurement tool, and read the data table and figure out what pieces of information to record). Educators were good at recognizing where parents lacked this comfort, and they provided support to parents, but this made them feel as if they had to speed up or cut short other aspects of the activity to finish in time.
- ***Parent-child interactions.*** They also observed that parents were managing parent-child frustration during activities and the shyness of children, which may hold them back from deeper engagement. Educators also had to encourage parents to inhibit the instinct to overthink an activity or avoid making mistakes. Parents frequently reported that they have fears that activities would go wrong when they were working with their child; educators said that it is a process to cultivate this mindset shift in their learners.

Despite the observed challenges with implementation fidelity, educators were positive about the at-home elements of the program. All educators were enthusiastic about the idea of supplying parents with materials to explore as a family at home. As noted before, it is not clear why some educators did not promote the at-home resources with their learners as thoroughly as others, but based on observation reports, it appears that the family educators did so with the highest level of fidelity. This suggests that the distribution and discussion of these at-home resources occurs more naturally for educators who frequently discuss at-home learning.

Other Interesting Findings

Several other interesting findings emerged as part of our research, which reinforce many of the findings presented above. These are discussed briefly below.

Science learning is important to these parents. When surveyed after the second Activity Set implementation, 91% (n = 53) agreed or strongly agreed that learning science is important to them. Eighty-eight percent of parents (n = 51) agreed or strongly agreed that they play an important role in helping their children learn science.

RUFF FAMILY SCIENCE appeared to establish new real-world connections to science for parents. During focus groups, parents highlighted examples of science in everyday life that they had not recognized prior to their participation; they talked about how they could now see science in action while driving, playing sports, cooking, housecleaning, and while their kids are playing on the playground.

Our follow-up interviews reveal myriad ways in which parents incorporated RUFF FAMILY SCIENCE practices into their daily lives. Inspired by the implementation, parents often took it upon themselves to extend their children's engagement by integrating science lessons with their family routines. Common activities, such as taking a bath, collecting items, riding bikes, and grocery shopping, offered parents exciting new ways to reinforce science learning outside of school.

> *"[My child] wants to now ride a bike, and I'm trying to teach him how he has to keep himself up . . . but I'm leading it all back to the gravity . . . So if he balances himself, he'll be able to stay on the bike and that's all a matter of gravity and balance . . . but it's kind of hard for him to learn it, because it's more of a him doing it thing instead of me helping him do it type of thing . . . It's worthwhile because he already has the knowledge from the gravity experiment that we did." – Parent interview participant*

In sum, these findings suggest that RUFF FAMILY SCIENCE is a valuable opportunity for parents participating in both adult and family education environments. Engaging in hands-on learning opportunities helped to support the development of new connections to science. In turn, these new connections helped parents to transform everyday activities into science learning opportunities.

Conclusions

The research team has assembled five overarching takeaways from the Prototype Testing Phase based on the findings presented above.

1. The RUFF FAMILY SCIENCE Activity Set materials were well-received by educators, adult participants, and children. Adult learners thought the program was a fun way to explore science concepts in a hands-on, interactive way and that it offered an opportunity to introduce science to their children by allowing them to practice science on their own before repeating it with children. Educators thought that the materials were comprehensive and well-designed to support instruction.
2. The Activity Set experiences, particularly the program's model for providing parents with dedicated instruction before engaging with children, can support the development of comfort and confidence with science learning. Allowing parents to try out the activities prior to doing them with their children was critical in providing parents the comfort and confidence that come with knowing what to expect and with acquiring the science vocabulary, content knowledge, and the practices necessary to scaffold their children's experiences.
3. Parents and their children were both observed utilizing the target science practices and discussing science content knowledge. The hands-on activity experiences fostered discussions about force, gravity, and motion among adults as well as between parents and their children. Participants in both adult and family sessions were regularly observed successfully engaging in the science practices of conducting observations, making predictions, and recording data, and utilizing the scientific vocabulary featured in the Activity Sets.
4. The Activity Sets fit well within the family literacy and adult education settings, even when they did not conform with how classes have traditionally been taught. Educators in both family education and adult education programs thought the Activity Sets helped them meet their organizational goals (even those not related to science) and integrated well into their program infrastructure.
5. More research is needed to understand how best to extend the learning experience at home. As previously reported, several parents replicated the facilitated experiences at home, but only a small number of parents reported doing the new activities in the extended at-home materials. Although this may be partly explained by the variability around the distribution of the materials by program educators, the reasons most cited by parents included time, confidence, and comfort with the English language. Some parents were vocal about the potential usefulness of having resources translated to their home languages and about having facilitated instruction for support. They also noted that in spite of their best intentions to participate in extended activities and to use the digital game, time was a big constraint for their families. However, many parents reported talking about science with their children during everyday activities such as driving, shopping, cooking, and during bath time.

Recommendations

As one of the project's aims was to build new knowledge about how digital media can support intergenerational science learning, we have created a set of recommendations for the continued development of learning resources:

- Continue capitalizing on the playful nature of these experiences. RUFF FAMILY SCIENCE makes science fun, hands-on, and active for children and adults.
- Continue providing adult-only experiences prior to family events to build parents' confidence and comfort as they lead activities for their children.
- Identify ways that educators can support the development of essential background knowledge that parents might need to fully engage with the science concepts and practices.
- Recognize that for family education and adult education programs, there is no "one size fits all" model. Find ways to illustrate how the RUFF FAMILY SCIENCE materials can be utilized in different program contexts to address different adult and child science learning goals.
- Consider how to prepare learners for the variation that can occur when science experiments use nonstandardized, everyday materials. Preparing parents to discuss the differences in results based on their materials will help avoid frustration of obtaining a different or unexpected result due to the variation in materials.
- Further, find ways to reduce parent apprehension about science going wrong, which will support more inquisitive investigations and lessen anxiety about achieving the correct outcomes when doing the activity with their child.
- Explore what types of professional development will best support educators in different teaching contexts. The data suggest that professional development might be helpful to support family educators in teaching science and adult educators on how to offer intergenerational programming while meeting the goals of adult education programs.
- Discuss how best to provide supports for English language learners. From prior rounds of research, we know that second-language materials may be a valuable support for some but not all programs. Findings from this phase of work indicate that some parents would feel more comfortable reviewing materials in their native language. Exactly how useful second-language materials are will likely be dependent on program learning goals and how educators typically provide supports for English language learners, and if translated materials would enhance parent comfort when facilitating experiences independently at home.
- Further explore the at-home component as a way to extend the conversation and commitment to learning at home. Attempt to identify ways to offset the well-known pressures of time on parents.

Limitations

There are several limitations with this study to consider when interpreting its findings. First, this study utilized an exploratory approach to design-based research for the development of intergenerational science learning resources. As such, the small sample sizes used for this study limit generalizability. Second, the methodology used throughout this study relies on researcher observations and self-reporting from parents and educators. As such, the study does not provide correlational or causal evidence for how the use of digital and nondigital science learning resources significantly changed parents' and children's learning outcomes.

Implications

Very few studies have focused on how to support intergenerational science learning in adult education environments. This study provides foundational research suggesting that adult education programs, as well as family education programs that support adult learning, can also foster positive intergenerational science learning experiences. The evidence from classroom observations shows that parents appreciate the opportunity to explore science concepts and practices in adult-only settings prior to facilitating activities for their children. Feedback from parents also suggests that this prior experience supports their comfort and confidence when guiding their children through science explorations and answering their children’s questions. Adult and family educators believe that science is relevant to the lives of their students and support the notion of integrating intergenerational science learning into their programming.

APPENDIX A: Activity Set Prototypes

Two prototype Activity Sets were tested during this study. Below is a brief description of each Activity Set. Both targeted the scientific concepts (or Big Ideas) of force and motion.

Activity Set 1: Windy Wheels

This Activity Set starts with a video that pairs animated characters with live-action footage of families as they find a solution for a problem: Ruff and Furlicity need to transport rabbits for a photo shoot but need a mode of transportation. They need help building a car that utilizes wind energy. The live action segments of families demonstrate the process for building and testing a sail car. After watching the video, adults and families engage in a hands-on process for building a sail car and discuss how to use wind to push the car different distances. After the car is built, participants test propelling their car using wind sources such as breath, a fan, and other kinds of wind. They are asked to predict how far the car will go and then to measure the actual distance. The *Explore More* video encourages families to think about different kinds of designs that could be used to create a wind car. An educator's guide supports facilitation and instruction for adults and families.

Activity Set 2: Roll It

This Activity Set begins with a video framed by the fact that Ruff and Furlicity want to figure out if empty or full shopping carts roll faster downhill. Because they cannot agree, they need help collecting data to answer their question. The live-action footage shows families testing light and heavy carts to identify which roll farther. After watching the video, adults and families engage in a process of rolling weighted water bottles down a ramp to explore how weight affects the distance that an object traveled. Participants are asked to predict how far the bottles will roll and then measure the actual distance. The *Explore More* video shows a family engaged in the hands-on activity and shows how parents can model discussions about scientific exploration. An educator's guide supports facilitation and instruction for adults and families.

Digital Game

Both Activity Sets are supported by a digital game: *Cart Fun with Ruff Ruffman*. The object of the game is to push Ruff's cart downhill and to predict how far it will travel with the effect of gravity pulling it downhill and the air pushing against it. Ruff's cart can be rounded, squared, or wedge-shaped. Participants get to use their knowledge of the target scientific concepts to predict how far the carts will travel.