The efficacy of digital media resources in improving children's ability to use informational text:

An evaluation of *Molly of Denali* from PBS KIDS

Ready To Learn **Research**
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EDC Education Development Center

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Abstract

Informational text—oral or written text designed to inform—is essential to daily life and fundamental to literacy. Unfortunately, children typically have limited exposure to informational text. Two nine-week randomized controlled trials with a national sample of 263 first-graders examined whether free educational videos and digital games supported children's ability to use informational text to answer real-world questions. Participants received data-enabled tablets and were randomly assigned to condition. Study 1 found significant positive intervention impacts on child outcomes; Study 2 replicated these findings. Combined analyses demonstrated primary impact on children's ability to identify and use structural and graphical features of informational text. Results are discussed in the context of the scalability of educational media to support informational text learning.

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Contents

Introduction

As young children develop literacy skills, the type and variety of content they encounter is as important as letter recognition and phonemic awareness. **Gaining exposure to and learning the hallmarks of a wide range of genres** is an essential component of being able to access and use each type.

(Jeong et al., 2010; Price et al., 2009)

However, many children have disproportionately less exposure to informational text throughout elementary school as compared to other genres, such as narrative text (Duke, 2000; Yopp & Yopp, 2012). This is a critical gap, as children—and adults—use informational text every day, whether in referencing a textbook, using a diagram, looking up a fact online, consulting an expert, or following a recipe. Informational text is not limited to nonfiction books. The genre includes both oral and written texts whose primary function is to convey information, and it has a set of characteristics that distinguishes it from narrative text (Duke, 2000). Typically, informational text features timeless verb constructions rather than past tense; includes a wider diversity of technical vocabulary; and uses a variety of structural and graphical features, such as topic headings, captions, and indexes (Jeong et al., 2010; Jones et al., 2016; Young & Goering, 2018). Informational text also often organizes information into figures, maps, and tables that support learning from the text (Duke & Kays, 1998). Lack of exposure to informational text thus means children are less familiar with these features.

This lack of exposure limits children's ability to function well academically, as well as later on in adulthood. Informational text is the format in which a substantial amount of academic content, especially science and social studies, is transmitted to students and is a component of standardized tests beginning in fourth grade (Duke & Barnett-Armistead, 2003; Jeong et al., 2010). Children who lack sufficient exposure to informational text are therefore at an academic disadvantage, both in learning from texts and in testing. Thus what is often thought of as an indicator of student skills regression may actually be a reflection of inadequate exposure to informational text material that is revealed only by testing (Duke, 2000; Duke & Barnett-Armistead, 2003; Jeong et al., 2010). These academic challenges then compound, as the ability to read and critically process informational text remains a cornerstone of secondary education and beyond, as well as of nonacademic adult literacy (Moss, 2008; National Governors Association Center for Best Practices & Council of Chief State School Officers [NGAC & CCSSO], 2010).

Although empirical evidence has led to federal mandates that 50% of elementary school texts should be informational, systemic changes have proven difficult to implement, especially when addressing beliefs that have taken root over decades of teaching experience (Moss, 2008). Over the course of the 1996-97 school year, only 9.8% of first-grade classrooms' library material could be classified as informational text of any type, and only 3.6 minutes per day on average were spent using informational text in written language activities; in school districts with greater proportions of students who qualify for free and reduced-price lunch, this dropped even lower to 1.4 minutes per day (Duke, 2000). A decade later, only 20.2% of the material found in second-, third-, and fourth-grade classrooms' libraries could be classified as informational text, compared to 70.9% narrative text (Jeong et al., 2010)[1]. While minutes spent with informational text rose from an average of one minute during teacher read-alouds in second grade to an average of 16 minutes in third and fourth grades, the majority of time these older students spent with written informational text was spent filling out worksheets (Jeong et al., 2010). Teachers in kindergarten through second grade, particularly those with more than 20 years of experience, were resistant to curricular changes necessitated by the inclusion of informational text in the Common Core State Standard (CCSS), as they feared that children would not like informational text and would not be able to handle the material (Young & Goering, 2018).

1 Jeong et al. (2010) classified "[t]exts that do not meet the criteria of either informational or narrative categories, such as biographies, autobiographies, and procedure books, … as "other" (p. 40). However, these types of books do meet the definition of "informational text" used here. Collapsing "informational text" and "other," however, assumes that no other types of books were included in the "other" category, which might not be accurate. If combined, 29.1% of material would qualify as informational text, still much less than narrative.

However, there is ample empirical evidence that children can gain both content knowledge and literacy skills from informational text, as well as enjoy the material. Children can detect the differences between textual styles as early as kindergarten, as long as they have had access to these styles (Donovan & Smolkin, 2002; Duke & Kays, 1998). Many children enjoy reading informational text even more than reading narrative fiction (Caswell & Duke, 1998; Robertson & Reese, 2017). Exposure to informational text may result in students reading more because it gives them more opportunity to read about their personal interests (Caswell & Duke, 1998; Duke & Bennett-Armistead, 2003). Research has demonstrated that engaging in informational text with an authentic purpose—for example, to pursue an interest or solve a problem—increases engagement as well as comprehension (Guthrie, 2003; Purcell-Gates et al., 2002). Informational text often combines areas of interest and helps build children's background knowledge, vocabulary, and comprehension on specific subjects (Caswell & Duke, 1998; Duke & Bennett-Armistead, 2003). Additionally, more and earlier exposure to informational text also builds children's ability to reproduce key features of informational text in their own writing (Donovan & Smolkin, 2002; Duke & Kays, 1998). Teachers who have incorporated additional informational text into their classroom environments and curricula have found that their students gravitate toward informational text content, even in their free reading time (Young & Goering, 2018).

The benefits of exposure to informational text—and the relative lack of it—are similar in the home context. Informational texts are not well represented in homes. One study found that only 12% of the books parents reported reading with their preschool children classified as informational text (Roberston & Reese, 2017), while another found that parents reported that an average of 14% of their books at home were informational text (Price et al., 2009). There is evidence that sharing informational text with children at home supports language development. Parents and children naturally engage in remarks and conversations, termed "extratextual utterances," that are related to but outside of the text they are reading together, often sparked by the text itself. Parents who read both informational text and storybooks with their preschool-aged children made extratextual utterances more frequently, at longer lengths, and at higher levels of complexity in terms of content when reading the informational text (Mol & Neuman, 2014; Price et al., 2009), thus contributing to overall language development (Neuman et al., 2000; Weisleder & Fernald, 2013). Their utterances also featured greater diversity of vocabulary while reading informational text (Price et al., 2009).

One solution to the lack of informational text across contexts is to reach children directly, outside of school and family reading time; educational media provide one such route. Young children under the age of eight across the socioeconomic spectrum spend an average of about two and a half hours a day using or watching onscreen media, including television, movies, and apps (Rideout & Robb, 2020). Educational media, especially public media, are a low- to no-cost tool for parents, caregivers, and educators to explain, model, and explore new and complex information with children (McClure et al., 2017; Silander et al., 2018; Troseth et al., 2006). The time children already spend with screens thus provides a prime opportunity to meet children where they are with engaging, intentionally designed educational media focused on informational text.

There is a large body of research supporting the effectiveness of media in teaching literacy to young children (e.g., Anderson et al., 2001; Fisch et al., 1999; Fisch et al., 2005; Grindal et al., 2019; Hurwitz, 2019; Linebarger et al., 2017 Pasnik et al., 2015; Pasnik, 2019; Schmitt et al., 2018). Media that successfully support learning and development include relatable characters and stories (Bandura, 1965; Lauricella et al., 2011; Linebarger et al., 2017), are cognitively engaging, support meaningful and socially interactive learning experiences, feature meaningful repetition of key concepts across multiple contexts, and are guided by specific learning goals (Hirsh-Pasek et al., 2015; Kirkorian et al., 2008; Schmitt et al., 2018). Like informational text, educational media are particularly effective when parents and children jointly engage with the content. Co-viewing and joint media engagement have been shown to support literacy (Strouse et al., 2013), math (Pasnik et al., 2015), and science learning (Pasnik, 2019). Educational media can consistently deliver learning content to a wide and varied audience across large geographical areas, making educational media interventions highly scalable at low cost relative to other person-to-person early childhood interventions (Kearney & Levine, 2019). To our knowledge, however, no rigorous experimental studies have examined the effectiveness on children's learning of educational media focused on informational text.[2]

2 Kim et al. (2019) investigated an app using informational text, but the focus was on developing an adaptive intervention and increasing the response rate, rather than learning. Some studies have included digital media, but only to support the primary intervention (e.g., Neuman et al., 2021 and Silverman & Hines, 2009, both targeting vocabulary).

The present research focused on the first season of *Molly of Denali*, which is a PBS KIDS multi-platform media program created to help children ages 4–8 develop the skills to use informational text through videos, interactive games, and hands-on, real-world activities. Molly is an adventurous 10-year-old Alaska Native girl who uses informational text to explore the world around her, solve problems, and help her community. Molly and her friends explore their world using field guides, maps, instruction manuals, informational websites, weather reports, and more. In each episode, Molly's adventures are enhanced by using and creating a variety of informational text materials, including books (such as field guides and how-to manuals), online resources, historical archives, information from knowledgeable people, maps, charts, tables, and photos (Timcheck, 2018). A mobile app features digital games based in Molly's world that are designed to provide opportunities for children to engage with and explore informational text. Resources also include hands-on activities that provide an opportunity for children to engage in related real-world informational text activities, ideally with older family members.

The *Molly of Denali* animated series was developed and produced by GBH in partnership with Public Broadcasting Service (PBS) and the Corporation for Public Broadcasting (CPB) as part of the CPB and PBS 2015–2020 Ready To Learn Initiative, funded by the U.S. Department of Education. The Ready To Learn Initiative brings free educational television and digital media resources to children ages 2–8, promoting early learning and school readiness at scale, with an emphasis on supporting children from low-income, underserved communities. The content of all *Molly of Denali* materials is aligned with 15 informational text learning goals adapted and expanded from the PBS KIDS Literacy-English Language Arts Learning Framework Version 4.0 (PBS KIDS, 2016). The PBS KIDS Framework is aligned with the Common Core Standards for English Language Arts (NGAC & CCSSO, 2010) and with the *Head Start Early Learning Outcomes Framework: Ages Birth to Five* (U.S. Department of Health and Human Services, 2015). Additional details about the *Molly of Denali* resources included in the study intervention are listed in the "Study Materials" section.

The study team reports here on the individual results of two randomized controlled trials (RCTs), as well as the combined results from both studies. The study team initially intended to conduct a single RCT on the impact of access to the *Molly of Denali* resources with 500 families across the United States. However, the COVID-19 pandemic halted study activities after baseline data collection had been completed in person at two locations (Birmingham, Alabama and Phoenix, Arizona); the study team completed data collection with the 127 families already enrolled (Study 1) using video conferencing for the post-intervention assessment. The study team then replicated the same intervention in a fully online RCT (Study 2) with new participants from across the United States. Because recruitment criteria and the intervention itself were identical in the two studies, the study team combined data across the two studies and completed analyses with the full sample ("Full Sample Analyses"). Thus, in addition to examining how exposure to the *Molly of Denali* videos, digital games, and hands-on activities affects children's understanding of concepts and practices related to informational text, this research also provides a unique window into research that was planned before the COVID-19 pandemic, continued through online administration in the midst of it, and adapted into a fully remote replication study. All analyses addressed the following confirmatory research question:

CQ1: **Does providing 9 weeks of access to *Molly of Denali* resources via an Internet-enabled tablet improve low-income first-grade children's ability to use informational text skills to answer questions or solve real-world problems, as compared to providing an Internet-enabled tablet that cannot access *Molly of Denali* resources?**

Because the combined sample increased our statistical power to detect effects, the study team also examined impacts on specific informational text skills and dispositions, and whether treatment impacts differed by demographic variables, child engagement, and parent-child co-engagement. Specific research questions guiding these exploratory analyses are reported in the "Full Sample Analyses" section, and a full discussion follows the presentation of results from all analyses.

Study 1

Participants

The study team recruited 127 children from families from Birmingham, Alabama (59.1%), and Phoenix, Arizona (40.9%), before the COVID-19 pandemic halted research efforts.[3] Participants received $125 in incentives ($25 after the first meeting and $100 after the final meeting). All participating families met the following eligibility requirements:

- **Families were low-income.** A family qualified as low-income if they received free or reduced-priced lunch (FRPL); if their income was determined to be equal to or less than 125% of the income requirement for FRPL, regardless of whether or not they indicated such a qualification; or if they participated in other government assistance programs, including the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), the Supplemental Nutrition Assistance Program (SNAP), or Temporary Assistance for Needy Families (TANF).

- **Only one child per household could participate.** The participating child had to be enrolled in first grade as of March 1, 2020, fluent in English, able to participate in game-like activities for up to 45 minutes at a time, and had not had heavy prior exposure to *Molly of Denali* (defined as having watched or played four or more hours of *Molly of Denali* content in the prior seven days by parent report).

- **At least one parent was proficient in either English or Spanish.**

The sample included neurodiverse children, with 16.8% having some form of an individualized education program (IEP) or therapy reported. However, one child was excluded prior to randomization because he was non-verbal and valid one-on-one assessment was impossible.

3 Although we conducted a power analysis prior to the study, its results became moot given the pandemic-related restrictions on our sample size.

The study team randomized children to condition based on the order in which they completed the baseline assessments, which depended both upon the timing of their research appointment and the duration of their baseline assessment. Once assigned to their condition, the family received either a treatment- or control-provisioned tablet and an orientation to the study. The study team kept families blind to the condition to which they were assigned, informing all participants that they were in a study of educational media use for young children. Procedures throughout the study also ensured that assessors were blind to the study participants' assigned condition. Overall attrition for Study 1 was low at 3.94% (2.99% for the treatment group; 5.00% for the control group; 2.01% differential attrition). According to What Works Clearinghouse (WWC) standards (U.S. Department of Education, 2017), this combination of overall and differential attrition represents a tolerable threat of bias under both optimistic and cautious assumptions. Descriptives for the sample are listed in Table 1. There were no significant baseline treatment/control group differences.

Table 1. Study 1 Child Baseline Literacy Knowledge and Demographic Characteristics, Overall and by Condition

	Control Group (n = 60)		Treatment Group (n = 67)		Total Study 1 Sample (n = 127)	
	n	% or mean *(SD)*	*n*	% or mean *(SD)*	*n*	% or mean *(SD)*
Urbanicity (%)						
» Urban	25	43.86	26	40.00	51	41.80
» Suburban	15	26.32	13	20.00	28	22.95
» Rural	17	29.82	26	40.00	43	35.25
Baseline EVT score	60	89.67 (12.86)	67	86.45 (15.35)	127	87.97 (14.26)
Baseline DIBELS score	60	476.18 (58.79)	66	471.94 (56.21)	126	473.96 (57.26)
Child is female (%)	29	48.33	28	41.79	57	44.88
Child age in months	60	85.25 (5.60)	67	83.59 (6.84)	127	84.38 (6.32)
Child race or ethnicity (%)						
» White	23	38.33	24	35.82	47	37.01
» Hispanic/Latinx	7	11.66	5	7.46	12	9.45
» Black or African American	20	33.33	29	43.28	49	38.58
» Indigenous Peoples	0	0.0	0	0.0	0	0.0
» Multiracial	10	16.66	8	11.94	18	14.17
» Other	0	0.00	1	1.49	1	0.79
Child's primary language is English (%)	53	88.33	61	91.04	114	89.76
Child has an IEP or 505 plan (%)	8	13.33	12	17.91	20	15.75
Child attended preschool (%)	50	83.33	54	80.60	104	81.89
Family annual income is less than $50K (%)	45	77.59	45	72.58	90	75.00
Responding parent education (%)						
» Less than HS	0	0.00	1	1.49	1	0.79
» HS diploma or GED	14	23.73	12	17.91	26	20.63
» Some college or AA	29	49.15	25	37.31	54	42.86
» BA or higher	16	27.12	29	43.28	45	35.71
Prior exposure to *Molly* (in mins)	58	39.12 (70.01)	67	38.52 (69.85)	125	38.80 (69.64)

Note. Parents reported child gender on the parent pre-survey. Response options were male, female, and other (please specify). All parents selected either male or female. There were no statistically significant treatment/control differences. *Molly* = *Molly of Denali*.

Methods

The study team designed this study to meet WWC Standards (Version 4.0) *without reservations* and preregistered the study with the Society for Research on Educational Effectiveness. Researchers provided all participating children with a internet-enabled tablet, loaded with software that tracked Web and app usage during the nine-week study period. Researchers instructed families in the control group to use the tablet for educational purposes for at least one hour per week, and blocked access on the control tablets to PBS KIDS, 14 other apps with strong informational text content,[4] and all *Molly of Denali* materials. Blocking was designed to ensure a more robust treatment/control contrast. These restrictions applied only to the study tablet; children in the control group could access any materials—including *Molly of Denali*—on any other devices in the home. Three tablets in the control group bypassed the blocking software:

- One tablet showed use of the PBSKIDS Games app for 71 minutes, Amazing Amphibians for 8 minutes, and Starfall Learn to Read for 53 minutes.
- A second tablet showed use of the PBSKIDS Games app for 44 minutes.
- A third tablet showed use of the PBSKIDS Games app for 11 hours.

No tablets in the treatment group accessed any of the apps that were blocked on the control group tablets. Any back-door access by children in the control group would serve to dilute any observed impacts.

Families in the treatment group received a tablet loaded with intervention materials, described below, and researchers also instructed these families to use the materials for at least one hour per week. Researchers sent weekly text messages to families in both groups, asking them to complete a log of their past week's media-related activities; messages also reminded families in the treatment group that new videos were available on their tablet each week. The study team successfully tested these procedures, including randomization, during a four-week pilot study with 71 families in Indianapolis, Indiana, and Anchorage, Alaska, in the fall of 2019.

4 *PBS KIDS Games, PBS KIDS Video, Splash and Bubbles for Parents, Daniel Tiger for Parents, Play and Learn, Nature Cat's Great Outdoors, Outdoor Family Fun with Plum, Kids A-Z, Ocean Forests, Amazing Amphibians, Starfall Learn to Read, Starfall I'm Reading, Starfall It's Fun to Read,* and *Starfall Free & Member*.

Intervention Materials

The study team designed the intervention to provide a more structured version of how children would encounter the publicly available *Molly of Denali* resources in everyday life. Families accessed all intervention materials through a researcher-developed app available on the tablet home screen; game content could also be accessed through a separate game app, also on the home screen. The intervention focused on two types of informational text: informative/explanatory and procedural. Given the short duration of the intervention and the home context, the intervention targeted skills and knowledge that did not require extensive adult mediation. In all materials for parents, the study team emphasized the importance of repetition for young children's learning, as well as parent co-engagement with the intervention resources.

***Molly of Denali* Videos.** Each *Molly of Denali* video episode consists of two animated stories, separated by a two-minute live-action video that builds on the skill presented in the first story. To sustain children's engagement with the intervention resources[5] the study team organized videos into weekly bundles of content based on the focal learning goal identified by PBS: captions, procedural text, search boxes, indexes, flow diagrams, and evaluating sources. At least two researchers reviewed and cross-coded videos for content (both focal and incidental) to confirm PBS' learning goals classifications. The first week of videos provided an overview, with one video from each focal skill area; the final two weeks were review weeks, with bundles that included some repeat videos. The order in which bundles were released was static across participants: many stories address more than one skill, so bundles were ordered to present stories foregrounding the focal content before those containing background mention. Each bundle contained approximately 70 minutes of content targeting the focal skill.

***Molly of Denali* Games.** The intervention included an app with three digital games focused on informational text, accessed through an interactive map-style representation of Molly's home village; two games targeted multiple skills across content bundles and one targeted procedural text.. The map also included mini-activities (e.g., tossing a basketball) and a game intended for

5 Prior evaluation studies (e.g., Pasnik et al., 2015) have shown that initial high levels of resource use drop sharply after the first week. This pattern was also demonstrated in this study; see Figure 2.

younger children that did not have informational text content; however, the study team did not consider these to be part of the intervention. Due to software constraints, it was not possible to stagger the release of the games, so all games were available at start of the study and then throughout the study. However, the study calendar provided to treatment families did show the alignment of each game with the specific skill(s) targeted each week. Three hands-on, real-world activities also were available, in English and Spanish, in printed form and as PDFs in the tablet app.

Instructional Videos for Parents. To support parent co-engagement, PBS developed seven short videos to orient caregivers to informational text, to introduce the *Molly of Denali* learning goals, and to support families' use of the intervention resources; these videos were available on the **PBSLearningMedia.org** website. Parents watched the introductory video during orientation at the first meeting with researchers. Each subsequent video focused on a particular informational text concept or skill, aligned with the bundles, and modeled parents engaging their children around informational text. All videos were available through the tablet app, in both English and Spanish.

Orientation Materials. At the first meeting, researchers gave all parents a folder containing a written orientation to the study and instructions about how to use the tablet. Families in the treatment condition also received an overview about informational text—emphasizing the importance of repetition for learning—as well as a study calendar and the printed hands-on activities. The calendar detailed the timing of bundle releases, explained the skills targeted each week, and listed the resources available to support the target skill.

Measures

For Study 1, researchers collected pre-test measures in person, and families completed all post-test child assessments on the study tablet provided to the family.

Baseline Measures. Researchers measured expressive language and reading ability at baseline to establish treatment/control equivalence on constructs that might affect performance on the informational text measure regardless of informational text knowledge. Children's expressive language ability was estimated using the Expressive Vocabulary Test (3rd Edition; EVT-3), and their reading ability was estimated using the Dynamic Indicators of Basic Early Literacy Skills (8th Edition; DIBELS-8). For the DIBELS-8, the study team included four measures recommended for first grade: letter-naming fluency, phoneme segmentation fluency, nonsense word fluency, and word reading fluency.[6]

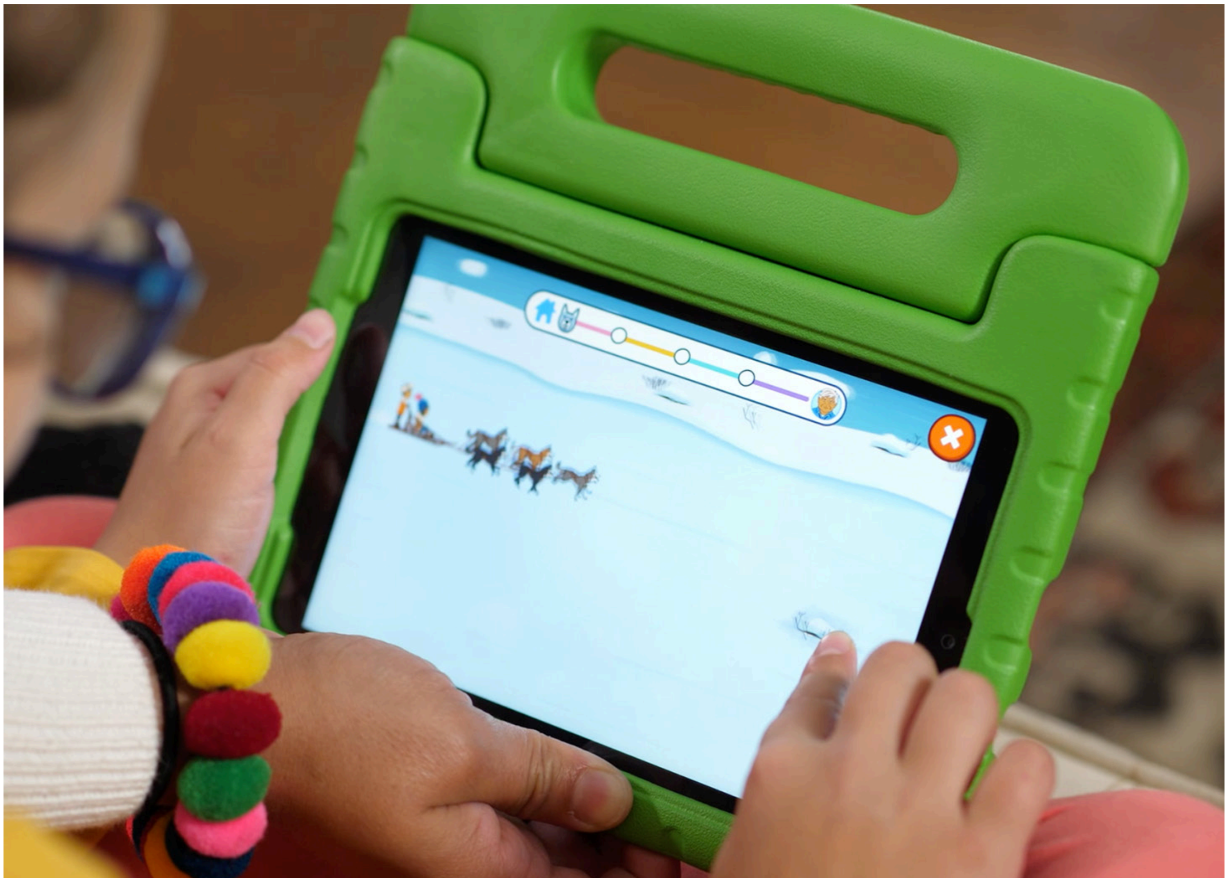
Informational Text Assessment. Existing measures of children's informational text knowledge and skills either relied on open-ended questions that required too much subjective coding for a large-scale RCT (Billman et al., 2008; Witmer et al., 2014), or were designed for older children (Duke et al., 2021). Thus, the study team designed a measure, the Informational Text Skills Instrument (ITSI), to assess children's disposition and ability to use informational text. The ITSI primarily focuses on the Common Core State Standard (CCSS.ELA-LITERACY.RI.1.5): *Know and use various text features (e.g., headings, tables of contents, glossaries, electronic menus, icons) to locate key facts or information in a text.* (NGAC & CCSSO, 2010). The ITSI consists of 37 items: 23 closed-ended items use a flipbook format (see Figure 1 for an example), and the remaining 14 items ask the child to use an informational text to answer practical and authentic questions (e.g., how to find a specific topic using the index). Eleven items are open-ended but require very brief answers that are either right or wrong (e.g., Q: *What is this called*? A: *A search box.*). To address variations in reading ability, assessors read all key pieces of text aloud. The ITSI takes approximately 15 minutes to administer. To avoid over-alignment with the intervention, researchers included several distractor response options, as well as sections that measure components of informational text that were not targeted by the intervention; there were no text or graphics similar to those used in *Molly of Denali*. Researchers developed three equivalent forms of the ITSI, of equal difficulty level and targeting the same skills but using different books and stimuli. After minor modifications following expert review, the study team piloted the instrument with a sample of 71 children, and a confirmatory factor analysis showed a single scale with a Cronbach's alpha of .80. Based on the results from the pilot, the study team selected the two most equivalent forms for use in the RCT. Researchers randomly assigned children to receive one form at pre-test and the alternate form at post-test to mitigate the potential for learning effects or priming.

6 Oral reading fluency also is recommended, but during the pilot most children struggled on this task, and no child reached the ceiling on the other measures. It was thus eliminated.

Figure 1: *Sample Closed-Response Item from the Informational Text Skills Assessment (ITSI)*

A3. My friend and I saw a strange animal. She thinks it's a frog, but I think it's a toad. What should we do – play jump rope, use an animal book, pet the animal, or use a telescope?

Due to the COVID-19 pandemic, the study team adapted the ITSI to be administered via video conference at post-test, using an animated PowerPoint. Researchers used screen share to present the stimuli, asked the questions orally, and recorded children's responses on paper scoresheets. While most items remained identical, researchers converted five items that had been open-ended and that had permitted non-verbal responses (e.g., "Point to the caption") in the in-person format to closed-ended responses. For these items, researchers enclosed key elements of the page in boxes and labeled the boxes with both colors and numbers to give children multiple ways to respond. Researchers chose colors that are readily distinguishable by colorblind children according to universal design standards. Researchers read the questions out loud as they had in person and recorded children's responses on paper scoresheets. The remote assessment required more verbal expression from children. Correlations between pre- and post-test scores were higher for Study 2 (Control = .84; Treatment = .75; All = .78), where both assessments were remote, than for Study 1 (Control = .63; Treatment = .74; All = .68), where the pre-test was in person and the post-test was remote.



Psychometric analyses of children's performance on both the in-person and remote assessments from Study 1 and Study 2 resulted in elimination of 11 items after examination of the item-total correlations. These items had item-total correlations less than 0.20 and in general were far too easy, with 80%–90% of children getting them correct even on the pre-test. Factor analysis of the resulting reduced instrument showed two factors: The first (7 items) related to the disposition to use informational text to solve a problem, and the second (19 items) assessed the ability to identify and use different structural and graphical features of informational text. The final instrument contains 26 items and yields one total score and two subscores (one for each factor). Psychometrics for each score are reported in Table A1 in the appendix.

Parent Survey. Parents in both the treatment and control groups completed digital pre- and post-intervention surveys using Qualtrics. All surveys were written at approximately a fourth-grade reading level and were available in English and Spanish. Parents completed the pre-study survey before assignment to condition. The parent survey included demographic questions regarding parent and child backgrounds as well as questions regarding child engagement with the intervention materials (in the treatment group only).

Media Log. The media log was a brief (five-minute) weekly survey that asked parents about the duration of the parent-child co-engagement with the study materials over the prior week.

Data Analysis

The study team conducted linear regression analyses to address the confirmatory research question on the impact of *Molly of Denali* resources on children's ability to use informational text to answer questions or solve real-world problems. First, the study team examined bivariate correlations between the ITSI total score and family background characteristics in the full sample (Study 1 and Study 2) to identify a consistent set of child and family characteristics to include in all regression models across studies (see Table 2). Researchers selected variables for inclusion if they were correlated at $p < .10$ with the ITSI total score at post-test. The final set of covariates that met these criteria were child gender, child age in months (continuous), child ethnicity (dichotomized to White or non-White), family income (dichotomized to less than $50,000 per year versus more), responding parents' education (dichotomized to high school diploma or less versus some college or higher), child's IEP status, and urbanicity (suburban and rural versus urban). The study team dichotomized multi-categorical variables (e.g., parent education) for ease of interpretation.

Table 2. Bivariate Correlations between Study Variables in the Full Sample (Study 1 and Study 2; N =263)

		1 ITSI Total Pre-test	2 ITSI Total Post-test	3 ITSI Features Pre-test	4 ITSI Features Post-test	5 ITSI Disp. Pre-test	6 ITSI Disp. Post-test	7 EVT Pre-test
1	ITSI Total Pre-test	--	0.72***	0.91***	0.65***	0.71***	0.55***	0.63***
2	ITSI Total Post-test		--	0.69***	0.94***	0.46***	0.70***	0.63***
3	ITSI Features Pre-test			--	0.69***	0.37***	0.40***	0.56***
4	ITSI Features Post-test				--	0.30***	0.42***	0.56***
5	ITSI Disp. Pre-test					--	0.58***	0.47***
6	ITSI Disp. Post-test						--	0.52***
8	Child female	0.10	0.18**	0.12+	0.17**	0.02	0.13*	0.08
9	Child age in months	0.09	0.10	0.07	0.07	0.09	0.10	0.08
10	Family income <$50K	-0.13*	-0.18**	-0.14*	-0.19**	-0.05	-0.08	-0.06
11	Parent ed. HS or less	-0.20**	-0.15	-0.21***	-0.18**	-0.09	-0.03	-0.27***
12	Child is white	0.17**	0.20**	0.12+	0.15*	0.18**	0.24***	0.20**
13	Attended pre-K	0.00	0.05	0.01	0.05	-0.03	0.02	0.01
14	English only at home	0.08	0.06	0.10+	0.07	0.00	0.02	0.06
15	Has IEP	-0.15*	-0.18**	-0.14*	-0.18**	-0.09	-0.10	-0.18**
16	Prior *Molly* minutes	0.11+	0.04	0.13*	0.08	0.03	-0.06	-0.05
17	Urban	-0.09	-0.11+	-0.07	-0.07	-0.08	-0.14*	-0.07
18	Rural	0.15*	0.20**	0.17**	0.17**	0.06	0.19**	0.14*

Note. ITSI Features = Subscore for ability to understand the purpose of and use structural features of informational text. ITSI Disp. = Subscore for disposition to use informational texts. EVT = Expressive Vocabulary Test. IEP = individualized education plan. Prior *Molly* minutes = parent-reported minutes of exposure to *Molly of Denali* in the seven days prior to the parent pre-survey.
+ $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$.

The study team then estimated stepwise regression models to determine which model best predicted the informational text assessment total score (i.e., explained the highest variance in the outcome). Model 1 included only the baseline informational text assessment total score; Model 2 added baseline EVT and DIBELS total scores; Model 3 added child and family covariates; and Model 4 added indicators for the study site (i.e., Arizona or Alabama). Model 4 explained significantly more variance in the outcome than did the other models and was selected as the final model. Model 4 is given by the following equation:

$$y = ß_0 + ß_1 TRT + ß_2 PRE + \lambda + \alpha + \varepsilon$$

where y is the outcome of interest; $ß_0$ is the intercept; $ß_1$ is the expected change associated with the treatment indicator; $ß_2$ represents the expected change associated with a 1-unit change in the child's baseline score; λ is a set of child and family covariates; α is an indicator for study site; and ε is the error term. The study team estimated this model to examine the impact of *Molly of Denali* resources on children's ability to use informational text in the Study 1 sample, with the outcome variable as the total score on the ITSI. In addition, to report the magnitude of the effect in a standardized metric that can be understood relative to other findings, the study team calculated an effect size, Hedge's *g* (U.S. Department of Education, 2017), by dividing the treatment coefficient by the pooled standard deviation.

Results

In Study 1, children in the treatment group showed significantly greater ability to use informational text to answer questions or solve real-world problems than did children in the control group, controlling for baseline ITSI score, EVT, and DIBELS scores; demographics (child gender, child age in months, child race, family income, parental education, and urbanicity); and site, $b = 1.47$, $p < .05$, $g = .27$. (See Table A2 in appendix for complete models.) Sensitivity analyses were run excluding the three control children who had accessed informational text resources, and overall findings remained unchanged, $b = 1.40$, $p < .05$. For this sample, the intervention led to improved informational text outcomes. Given the difference in mode of assessment (in-person for pre-test and remote for post-test), these results are particularly promising as remote assessment is less personal and lower child engagement with the assessment might be expected.

Study 2

The study team designed Study 2 to replicate the findings of Study 1, with a new—and more national—sample. Researchers again designed this study to meet WWC Standards (Version 4.0; 2017) *without reservations* and preregistered the study with the Society for Research on Educational Effectiveness.

Participants

Recruitment procedures were identical to those of Study 1, except that the study team first re-contacted families who had already been recruited as part of Study 1 but who were not enrolled due to curtailment of Study 1. The study team then expanded recruitment to families across the United States. Study 2 participants lived in the following locations: Oklahoma (34.6%), Illinois (20.6%), New York (11%), and other locations that were not part of Study 1 recruitment efforts (33.8%). Inclusion criteria were the same as for Study 1, but remote data collection required the addition of two more criteria:

1. **Participants must have access to Wi-Fi** or cellular signal strong enough to hold an hour-long video call.[7]
2. **Participants must be able to safely receive packages** (or live near a business accepting FedEx shipments), as the tablet was shipped to their residence.

Table 3 presents sample descriptives for Study 2. As with Study 1, there were no significant treatment/control differences at baseline. Overall attrition was low at 4.41% (3.90% for the treatment group; 5.08% for the control group; 1.18% differential attrition). As in Study 1, this combination of overall and differential attrition represents a tolerable threat of bias under both optimistic and cautious assumptions (U.S. Department of Education, 2017).

7 Each tablet was provisioned with a Verizon cellular data plan for the duration of the study. The participants' cellular plan did not need to include enough data to support the hour-long video call. However, if participants did not have Wi-Fi access, they needed to live within Verizon's coverage plan in order to have a strong enough signal to support the call. The Study 1 post-test demonstrated that this coverage was variable.

Table 3. Study 2 Child Baseline Literacy Knowledge and Demographic Characteristics, Overall and by Condition

	Control Group (*n* = 60)		Treatment Group (*n* = 67)		Total Study 1 Sample (*n* = 127)	
	n	% or mean *(SD)*	*n*	% or mean *(SD)*	*n*	% or mean *(SD)*
Urbanicity (%)						
» Urban	33	56.90	45	58.44	78	57.78
» Suburban	15	25.86	13	16.88	28	20.74
» Rural	10	17.24	19	24.68	29	21.48
Baseline EVT score	56	88.55 (16.26)	76	88.14 (12.73)	132	88.32 (14.28)
Baseline DIBELS score	--		--		--	
Child is female (%)	31	52.54	39	50.65	70	51.47
Child age in months	59	88.80 (5.17)	77	88.43 (4.85)	136	88.59 (4.98)
Child race or ethnicity (%)						
» White	9	15.25	18	23.38	27	19.85
» Hispanic/Latinx	12	20.34	12	15.58	24	17.65
» Black or African American	17	28.81	18	23.38	35	25.74
» Indigenous Peoples	1	1.69	3	3.90	4	2.94
» Multiracial	19	32.20	26	33.77	45	33.09
» Other	1	1.69	0	0.00	1	0.74
Child's primary language is English (%)	43	72.88	63	81.82	106	77.94
Child has an IEP or 505 plan (%)	9	15.52	15	19.48	24	17.78
Child attended preschool (%)	51	86.44	69	89.61	120	88.24
Family annual income is less than $50K (%)	39	67.24	45	60.00	84	63.16
Responding parent education (%)						
» Less than HS	0	0.00	2	2.63	2	1.48
» HS diploma or GED	15	25.42	15	19.74	30	22.22
» Some college or AA	35	59.32	31	40.79	66	48.89
» BA or higher	9	15.25	28	36.84	37	27.41
Prior exposure to *Molly* (in mins)	59	49.07 (69.40)	74	48.65 (78.17)	133	48.83 (74.13)

Note: Parents reported child gender on the parent pre-survey. Response options were male, female, and other (please specify). All parents selected either male or female. There were no statistically significant treatment/control differences. MoD = *Molly of Denali*.

Methods

The study team conducted the entire study, from consent through post-test assessment, remotely via video conferencing. All aspects of the intervention were identical. Most procedures were identical, although the remote format required some logistical shifts. Participants met virtually with researchers three times instead of two: (1) consent, (2) pre-test and orientation to the study, and (3) post-test. Randomization also varied slightly. Rather than assignment to condition after pre-test, researchers assigned Study 2 participants to condition (using the same pre-randomized sequence of treatment- and control-assigned ID numbers used in Study 1), based on the time-stamped order in which parents completed the pre-study survey after their one-on-one consent meeting. Researchers excluded parents who consented but did not complete the parent pre-survey within 24 hours of receipt from the study prior to randomization, and they did not receive a tablet. The study team shipped participants either a treatment- or control-provisioned tablet according to their random assignment. Researchers again ensured that participants were blind to the condition to which they were assigned, and procedures throughout the study ensured that assessors were not aware of the study participants' assignment to condition. In Study 2, neither children in the treatment group nor those in the control group used any of the apps that were blocked on the control group tablets.

Intervention Materials

The study materials in Study 2 were identical to those in Study 1. Upon completion of the parent survey, the study team shipped all participating families the same data-enabled tablets, provisioned in the same manner as in Study 1, along with the orientation materials. The study team oriented parents to the study during the online Meeting 2, immediately after children completed the pre-test.

Measures

The child measures used in Study 2 were similar to those used in Study 1, although assessors administered both pre- and post-tests via video conferencing on the study tablet.

Baseline Measures. For Study 2, the study team administered a digital version of the EVT-3, provided by the publisher, via screen share. Assessors provided prompts orally and recorded children's responses on paper scoresheets. Both the prompts and the scoresheets were identical to the in-person version. The study team eliminated the DIBELS-8 as a baseline measure for Study 2 because a digital version was difficult to see, particularly for children with visual disabilities, and stimuli were easily obscured on the tablet screen. In addition, in Study 1, the amount of variance accounted for by the DIBELS-8 and the EVT-3 overlapped; including the DIBELS-8 explained only an additional 2.7% of variance beyond that explained by the EVT-3 and other covariates. In other words, the EVT-3 alone provided a good measure of children's baseline abilities unrelated to informational text.

Informational Text Assessment. Assessors administered the ITSI at pre- and post-test using the same remote format as used at Study 1 post-test.

Parent Survey and Media Log. The parent pre- and post-surveys were similar to those used in Study 1. The post-intervention survey in Study 1 included sections on COVID-related changes in the home that were moved to the pre-survey for Study 2. This section was intended to provide information about family context in the event of any significant demographic differences between the two samples. The Study 1 and 2 media logs were identical.

Data Analysis

The study team followed the same analytic procedure for Study 2 as described for Study 1, with two exceptions: (1) because the DIBELS was not administered in Study 2, it was not included as a covariate and (2) the indicators for the study sites were Illinois, New York, Oklahoma, and other sites versus Arizona.

Results

Study 2 findings replicated Study 1 findings. Children in the treatment group showed significantly greater ability to use informational text to answer questions or solve real-world problems than did children in the control group, controlling for baseline EVT score; demographics (child gender, child age in months, child race, family income, parental education, and urbanicity); and site, $b = 1.30$, $p < .05$, $g = .25$. (See Table A3 in the appendix for final model.) For this sample, as with Study 1, the intervention led to improved informational text outcomes.

Full Sample Analyses

Because the intervention and outcome measures in Study 1 and Study 2 were identical, the study team combined the samples from the two studies to increase power for more fine-grained analyses, including examination of differences in subscores by treatment condition and impact differences by demographic characteristics, resource usage, and co-engagement with the resources. These analyses were guided by the following exploratory research questions.

Compared to providing an Internet-enabled tablet that cannot access *Molly of Denali* resources, does providing nine weeks of access to *Molly of Denali* resources via an Internet-enabled tablet improve low-income first-grade children's:

- Disposition to use informational texts? **(EQ1)**
- Ability to understand the purpose and use of structural features of informational text? **(EQ2)**

How does the impact of providing nine weeks of access to *Molly of Denali* resources on low-income first-grade children's informational text skills vary by:

- Demographic variables? **(EQ3)**
- Duration of engagement and number of times *Molly of Denali* resources were accessed? **(EQ4)**
- Parent-reported child interest in *Molly of Denali* resources? **(EQ5)**
- Parent-reported co-engagement with *Molly of Denali* resources? **(EQ6)**

Participants

There were no significant baseline treatment/control differences in the combined sample of 263 children (see Table 4). Study 2 participants were statistically significantly older than Study 1 participants, $b = 4.22$, $p < .001$, $g = .74$; this was expected given that Study 2 began two months after Study 1 concluded and continued to enroll first-graders. Compared to Study 2 participants, Study 1 participants were significantly more likely to be White, $b = -0.17$, $p < .01$, $g = -.39$; to speak English as their primary language, $b = -0.12$, $p < .01$, $g = -.33$; and to have a family annual income of less than $50,000, $b = -0.12$, $p < .05$, $g = -.26$. Overall attrition for the full sample was low at 4.18% (3.47% for the treatment group, 5.04% for the control group, 1.57% differential attrition). As with Studies 1 and 2, this combination of overall and differential attrition represents a tolerable threat of bias under both optimistic and cautious assumptions (U.S. Department of Education, 2017).

Data Analysis

For the full sample impact analyses, the study team followed the same analytic procedures as for Studies 1 and 2 and estimated an additional model (Model 5) that included an indicator for Study 1 versus Study 2. This variable was included to account for significant differences between the study samples at baseline and to account for any unmeasured differences between the two samples related to time of year, COVID-19, or other unanticipated factors. Model 5 explained significantly more variance than did Model 4 and was used for all analyses of the full sample.

To answer EQ1 and EQ2, the study team estimated the same regression model that was used for the impact analyses (Model 5). The outcomes were the two subscales of the ITSI (structural features of informational text and disposition to use informational text). In addition to examining the overall treatment impact of *Molly of Denali* resources on children's informational text skills, the study team examined whether the impact varied by children's baseline literacy scores, gender, age, ethnicity, and the parents' education level or income (EQ3). The study team created interaction terms by multiplying the treatment status by each of these characteristics; these interaction terms were entered as additional predictors in Model 5.

Table 4. Full Sample Child Literacy Knowledge and Demographic Characteristics, Overall and by Condition

	Total Study 1 Sample (n = 127)		Total Study 2 Sample (n = 136)		Total Control Group (n = 144)		Total Treatment Group (n = 119)		Total Sample (n = 263)	
	n	% or mean *(SD)*	*n*	% or mean *(SD)*	*n*	% or mean *(SD)*	*n*	% or mean *(SD)*	*n*	% or mean *(SD)*
Urbanicity (%)										
» Urban	51	41.80	78	57.78	58	50.43	71	50.00	129	50.19
» Suburban	28	22.95	28	20.74	30	26.09	26	18.31	56	21.79
» Rural	43	35.25	29	21.48	27	23.48	45	31.69	72	28.02
Baseline EVT score	127	87.97 (14.26)	132	88.32 (14.28)	116	89.13 (14.55)	143	87.35 (14.00)	259	88.15 (14.25)
Baseline DIBELS score	126	473.96 (57.26)	--		--		--		--	
Child is female (%)	57	44.88	70	51.47	60	50.42	67	46.53	127	48.29
Child age in months	127	84.38 (6.32)	136	88.59 (4.98)***	119	87.01 (5.66)	144	86.18 (6.32)	263	86.56 (6.03)
Child race or ethnicity (%)										
» White	47	37.01	27	19.85**	32	26.89	42	29.17	74	28.14
» Hispanic/Latinx	12	9.45	24	17.65	19	15.97	17	11.81	36	13.69
» Black or African American	49	38.58	35	25.74	37	31.09	47	32.64	84	31.94
» Indigenous Peoples	0	0.00	4	2.94	1	0.84	3	2.08	4	1.52
» Multiracial	18	14.17	45	33.09	29	24.37	34	23.61	63	23.95
» Other	1	0.79	1	0.74	1	0.84	1	0.69	2	0.76
Child's primary language is English (%)	114	89.76	106	77.94**	96	80.67	124	86.11	220	83.65
Family annual income is less than $50K (%)	90	75.00	84	63.16*	84	72.41	90	65.69	174	68.77
Responding parent education (%)										
» Less than HS	1	0.79	2	1.48	0	0.0	3	2.10	3	1.15
» HS diploma or GED	26	20.63	30	22.22	29	24.58	27	18.88	56	21.46
» Some college or AA	54	42.86	66	48.89	64	54.24	56	39.16	120	46.98
» BA or higher	45	35.71	37	27.41	25	21.19	57	39.86	82	31.42

Note. Asterisks represent comparisons between Study 1 and Study 2. The treatment and control group do not differ significantly in the combined sample.
* $p < .05$, ** $p < .01$, * $p < .001$

To answer EQ4, the study team estimated the association between usage of *Molly of Denali* resources and ITSI total scores. Researchers estimated the same regression model (Model 5) but entered resource usage as a predictor instead of study condition and limited the sample to the treatment group. Using back-end data from study tablets, the study team calculated the total hours that each child in the treatment group spent watching *Molly of Denali* videos and the total hours spent playing *Molly of Denali* games. For the purposes of these analyses, video usage totals include all videos; game usage totals include only games that had informational text content, as noted in the intervention description. Researchers excluded children with extreme values of usage (more than three standard deviations above the mean) from analyses. The number of times children accessed the *Molly of Denali* resources was operationalized as a count of the number of days on which children used either games, videos, or both.

To answer EQ5, researchers estimated the association between parent-reported interest in *Molly of Denali* videos and games and ITSI total scores. Parents rated their child's interest in *Molly of Denali* videos and games on a scale from 1 (low interest) to 10 (high interest). Researchers estimated the same regression model (Model 5) but entered parent-reported interest as a continuous predictor instead of study condition and limited the sample to the treatment group.

Finally, for EQ6, researchers estimated the association of parent-reported parent-child co-engagement with *Molly of Denali* resources with children's total scores on the ITSI. Parent reports of co-engagement were drawn from the weekly media logs sent to parents. Parents reported the number of minutes they spent using *Molly of Denali* resources with their child over the past week. Their reports were averaged across the weeks that they responded to the media log. Researchers estimated the same regression model (Model 5) but entered parent-reported co-engagement as a continuous predictor instead of study condition and limited the sample to the treatment group.

Results

Consistent with the findings from the separate analyses of Studies 1 and 2, in the full sample, the treatment group outperformed the control group on ability to use informational text to answer questions or solve real-world problems, controlling for baseline EVT scores; demographics (child gender, child age in months, child race, family income, parental education, and urbanicity); site; and study, $b = 1.31$, $p < .01$, $g = .25$. (See Table A4 in the appendix for final model.)

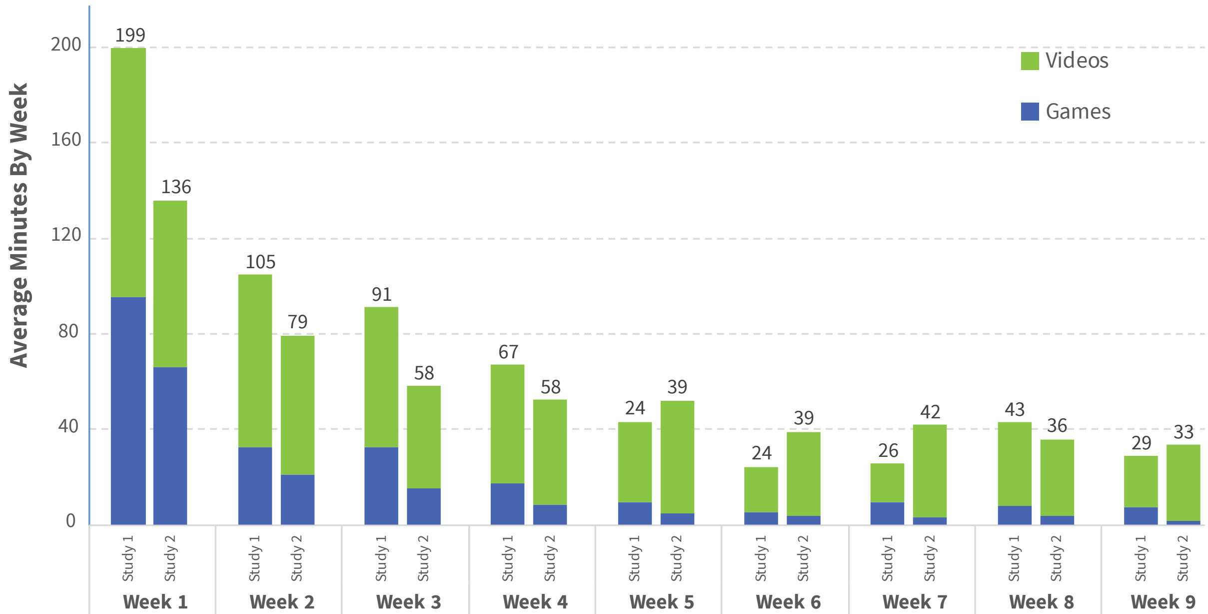
EQ1 and EQ2 examined the impact of access to the *Molly of Denali* resources on assessment subscores. There was no significant treatment impact on disposition to use informational text, $b = 0.06$, ns, $g = .03$. However, children in the treatment group scored higher than did children in the control group on ability to understand the purpose of and use structural features of informational text, $b = 1.23$, $p < .01$, $g = .30$.

EQ3 examined the extent to which the impact of providing access to the *Molly of Denali* resources varied by demographic characteristics. There were no significant treatment x demographic interactions for EVT score, gender, parent income, or parent education. Older children benefited less from access to the resources than did younger children, $b = -0.16$, $p < .05$. Children who identified as an "other" ethnicity ($b = -2.09$, $p < .10$) benefited marginally less from access to the resources than did White children, but this difference was not statistically significant at the $p < .05$ level.

Analyses within the treatment group to address EQ4 showed that more combined hours spent watching the *Molly of Denali* videos and playing the focal *Molly of Denali* games ($M = 10.32$, $SD = 8.11$) was predictive of higher post-test scores, $b = 0.20$, $p < .001$. This means that, for every hour spent on *Molly of Denali* content, children scored 0.20 points higher at post-test (out of 27 possible points). Researchers excluded two children from this analysis based on extreme values, with hours of combined usage (video + game time) more than three standard deviations above the mean. Because children's patterns of interaction with the videos and games varied considerably (see Figure 2), researchers also analyzed video and game usage separately. Hours children spent watching *Molly of Denali* videos was associated with higher post-test scores, $b = 0.21$, $p < .001$, but hours spent playing the focal *Molly of Denali* games was not, $b = 0.18$, $p = .21$. For analyses with video and game usage as separate predictors, researchers excluded six children from the analysis based on extreme values: three children had video usage that was greater than three standard deviations above the mean, and three had game usage that was three standard deviations above the mean. The results using the number of days metric of usage were very similar: an increase in the number of days on which children accessed the *Molly of Denali* resources was also predictive of higher post-test scores, $b = 0.14$, $p < .001$, for videos, $b = 0.11$, $p < .05$, but not for games, $b = 0.07$, $p = .31$. There were no outliers in analyses using the number of days metric.

Children in the treatment group who were more interested in the *Molly of Denali* videos and games, according to parent report, benefited marginally more than did children who were less interested, although this difference was not statistically significant, $b = .18$, $p < .10$ (EQ5). There was no statistically significant association between average duration of parent-reported parent-child co-engagement with the treatment resources and children's post-test scores, $b = .00$, *ns* (EQ6).

Figure 2: *Average Minutes Using Focal Resources (Videos and Games) in Each Study, by Week*



Discussion

This research is the first to show that children can learn informational text skills from educational media. Children's ability to use and learn from informational text is critical to their success in school and later in life. Given the lack of informational text content in elementary school curricula and libraries (Duke, 2000; Jeong et al., 2010), public media offers an inexpensive, scalable method to introduce children to the key features and functions of informational text. Two RCTs investigated the efficacy of *Molly of Denali*, a new PBS KIDS program targeting informational text knowledge in children ages 4–8, in improving children's ability to use informational text to answer questions and solve real-world problems. Although the effect sizes were modest, results of the nine-week intervention demonstrated statistically significant positive impacts in both studies and combined analyses, particularly promising for a short-term, light-touch intervention that imitated children's real-world exposure to *Molly of Denali*. Quite often, educational interventions require longer and more intensive curricula to achieve impacts (e.g., Baker, et al., 2011; see Vaughn et al., 2012, for a comprehensive summary).

Although replication is an essential part of the scientific process to confirm the efficacy of an intervention, it is uncommon in educational research for study findings to be replicated with a second group of participants (Makel & Plucker, 2014). Although the COVID-19 pandemic forced the study team to end enrollment into Study1 well short of the 500 participants originally planned, it presented the opportunity to conduct a fully remote replication study with a new set of participants from across the United States. Moreover, because many of the participants in Study 2 were recruited to be in Study 1 before the pandemic, the two samples were similar in many ways. The successful replication of the Study 1 findings in Study 2, despite the pandemic, speaks to the impact of the *Molly of Denali* resources, but also to the strength of the study design, including intensive logistical planning to ensure proper randomization and preserve assessor blind, successful conversion of the ITSI assessment to a digital format, and provision of adequate support for families to engage in the remote research process.

This study provides further evidence that learning can take place when children engage at home with intentionally developed, high-quality educational media. This is particularly important at a time when millions of children's in-school education has been substantially disrupted, but it is also meaningful for children who lack access to quality early learning opportunities, such as affordable early learning programs, community supports, libraries, and other resources. However, prior research also has demonstrated that parent-child co-engagement around educational media can improve outcomes (Pasnik et al., 2015; Pasnik, 2019; Rasmussen et al., 2016; Strouse et al., 2013), a finding which was not duplicated here. It is possible that the resources included in this research did not require much adult mediation for learning to occur. In fact, because of the short duration of the intervention, the study team purposely selected skills, such as recognizing and using structural features, that require less adult mediation than do other skills, such as comparing and contrasting different texts. It is also possible that parent self-reported weekly co-engagement is too crude a measure of co-engagement to be meaningful, particularly given low response rates on this instrument.

One further contribution of this work to the scientific community relates to how the resources were released during the intervention. Because prior studies (e.g., Grindal et al., 2019) have shown a rapid drop-off in children's usage of intervention media, these studies used a timed release of weekly bundles of video content in an attempt to sustain engagement with the resources over the nine-week intervention. Software restrictions prevented doing the same with the digital games, in essence setting up something of an internal experiment. This approach actually mimics children's real-world access to content: videos on the PBS KIDS website and many other platforms are not all available at once, but they are cycled in and out over time, while the games are typically all available at once. Tracking software on the tablets showed the typical drop in games usage, as well as lower but more sustained engagement with the videos through the duration of the nine weeks (see Figure 2). While it is possible that the videos were just more interesting over time, or contained more instructional material, analyses demonstrated that time spent watching videos—but not time playing games—was related to treatment impacts. This is at least suggestive that sustained engagement over time might lead to better outcomes, a hypothesis that bears further systematic research.

Findings also suggest that the intervention resources were able to produce learning gains even when families were distracted by national hardships. In Study 1, 55.2% of parents said that the pandemic made it harder to engage with the intervention resources, and 47.8% said the pandemic made it harder to attend the study meetings and complete the surveys. To some extent, many families seem to have adjusted to COVID-related restrictions by Study 2, as those numbers dropped to 44.2% and 29.9%, respectively. For such positive impacts to occur during such a stressful and disruptive time for families emphasizes the power of this low-cost and scalable approach.

Finally, these studies provide concrete evidence that education research can continue during a pandemic. The post-test for Study 1 and the entire replication study occurred during the COVID-19 pandemic, requiring a pivot to remote forms of participant contact and assessment. The low attrition observed for both studies suggests that remote research might be easier for families to engage in. It is possible that the study incentive held more significance for families due to pandemic-related financial hardships. While the demands on the study team certainly were no lighter, successful navigation of these demands makes remote research in the future a real and manageable proposition. This possibility is critical, as capacity to perform these kinds of fully remote studies is essential to the continued performance of education research under conditions where in-person meetings are not possible.

Limitations

While replication of the findings from Study 1 with a different and fully national sample suggests that these findings are generalizable to other first graders, these studies nonetheless have some limitations. Although this was a rigorous study design based on randomization and double-blind participants, sample sizes in each study were relatively small. Confirmation of our primary findings with the combined sample does suggest, though, that these findings are robust.

In addition, both studies were conducted during the COVID-19 pandemic, which may affect the generalizability of our findings. Our participant samples may favor those who had the emotional and material resources to participate in a research study during the pandemic. Given that recruitment for Study 2 was conducted in early July 2020, during a time of nationwide protests for racial equality, it is also possible that families impacted by the racial justice movement were less likely to participate in a research study at that time. In the combined sample, a majority of parents (54.9%) reported decreased household income due to the pandemic, suggesting that the sample does include individuals negatively impacted by the pandemic.

In addition, pandemic-related school closures could have increased demand for educational media, including the intervention resources in the treatment group. If so, these findings may be less generalizable to times when school is offered in person. During Study 1, 94.2% of parents reported school closures, and 69.9% did so in Study 2. Most parents in both studies (71.9%–83.9% by study and condition) reported that the pandemic increased the amount of time their child spent with educational technology. If this included abnormally high usage of the intervention materials in the treatment group, it likely resulted in stronger learning outcomes; our findings show that children who spent more time using the intervention resources benefited more. Study 2 school closure rates are lower than in Study 1; the replication of our findings in Study 2 suggests that impacts are still observable in a sample with lower rates of school closures and thus that school closures are not driving these results.

Because existing measures were either designed for older children, relied on open-ended coding, or both, these studies used a researcher-designed measure, the Informational Text Skills Instrument (ITSI). Any study relying on a researcher-derived measure runs the risk of being over-aligned with the intervention. The study team thus aligned the ITSI with the Common Core State Standards and the PBS KIDS literacy-English language arts (ELA) learning framework. In addition, the ITSI included distractor items and assessed content areas that were not part of the intervention (e.g., the glossary). Future research using performance on existing, standardized measures—for example, state ELA testing—is warranted to examine whether the impacts demonstrated here predict future learning outcomes.

Implications for Policy and Practice

The results of this research highlight the efficacy of free public media to improve children's learning outcomes. Public media represent a low-cost, highly scalable means of reaching into the homes of millions of U.S. children and may provide learning opportunities in locations where access to early learning opportunities are limited. Federal programs, such as the Ready To Learn Initiative, that invest in innovative approaches to early learning through media are thus key ingredients in ensuring equitable access to education for young learners. In addition, the content of such media does not need to be explicitly didactic. A rich body of research exists showing the efficacy of innovative media in changing behavior, at least in adults, through non-direct and incidental content (see, for example, using telenovelas, Forster et al., 2016; Rios-Ellis et al., 2010; Singhal, 2007; Wilkin et al., 2007). *Molly of Denali* videos and games foreground an entertaining storyline that highlights Alaska Native cultures and values, while still providing rich opportunities for social-emotional and informational text learning. This research provides further evidence that educational content can be embedded into animated or fictional storylines that are appealing to young children and still result in learning.

These research findings are important as the conversation about children's consumption of media results in worries about children having too much screen time. Not all screen time is the same—media differ both in terms of content and how they are consumed. While limits are important, particularly on purely entertainment media, these findings suggest that stringent limitations on children's time engaging with educational media might be counterproductive to their learning outcomes. Further, adult mediation of children's use is also important to extend learning and to bring media examples into the real world, for example by helping children make the connection between Molly's vlog and an informational video a child creates to share with friends and family.

Finally, our findings suggest that further research is needed into how best to use educational media to support children's learning. For example, parents in our pilot study noted how much their children enjoyed the live-action interstitials, but the role that live action plays in reinforcing concepts is unclear. It is possible that demonstrating the application of concepts in real life makes it easier for young children to make that leap themselves. The target age range for optimal reception of educational media is also unknown; as children's media consumption increases in general with age, it might be that diluting educational media with other forms of entertainment-oriented media correspondingly dilutes impacts. More research is also needed on the structure of learning interventions to disentangle the relative benefits of consistent, measured release of resources as compared to an all-at-once approach. While the findings here showed more benefit from the videos that were released gradually in weekly bundles than from the games that were available from the start of the study, we cannot conclude that the release mechanism was responsible. A rigorous study of learning outcomes with the same intervention materials released in different ways is warranted to ensure that interventions are using the most efficacious ways to reach children.

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Appendix

Table A1 includes details on psychometrics on the study assessment, as well as alignment of the assessment with **Common Core State Standards**.

Table A1. Psychometrics and Alignment of Informational Text Skills Instrument (ITSI) Scores and Subscores

Scale	# of Items	Range	Mean *(SD)*	α *(Form A)*	α *(Form B)*	Associated CCSS-ELA Standard
Overall score	27	2-26	12.75 (5.28)	0.81- 0.84	0.76-0.81	CCSS.ELA-LITERACY.RI.1.2 CCSS.ELA-LITERACY.RI.1.7 CCSS.ELA-LITERACY.RI.1.9
Disposition to use IT	8	0-8	5.85 (1.98)	0.61-0.77	0.64-0.73	CCSS.ELA-LITERACY.RI.1.2 CCSS.ELA-LITERACY.RI.1.7 CCSS.ELA-LITERACY.RI.1.9
Ability to identify and use	19	0-18	6.91 (4.14)	0.77-0.86	0.70-0.80	CCSS.ELA-LITERACY.RI.1.5 CCSS.ELA-LITERACY.RI.1.6 CCSS.ELA-LITERACY.RI.1.7

Note. Ranges and means are based on scores for the combined sample at post-test. Alphas are calculated from the scores from the individual samples from Study 1 and Study 2 for both pre- and post-tests.

Table A2 presents the four regression models tested for Study 1, with unstandardized beta values and Hedge's *g*.

Table A2. Regression Results for Treatment Impact of *Molly of Denali* Resources on ITSI Total Score – Study 1

Variable	Model 1			Model 2			Model 3			Model 4		
	b	SE	*g*	*b*	SE	*g*	*b*	SE	*g*	*b*	SE	*g*
Treatment	1.38	-0.71	0.26	1.63*	0.64	0.3	1.60*	0.68	0.3	1.47*	0.64	0.27
Baseline ITSI Total	0.77***	-0.07		0.44***	0.09		0.36***	0.10		0.40***	0.09	
Baseline EVT				0.10**	0.03		0.11***	0.03		0.10**	0.03	
Baseline DIBELS				0.02***	0.01		0.02**	0.01		0.02*	0.01	
Child is female							1.09	0.68		1.24	0.64	
Child age in months							-0.07	0.06		-0.07	0.06	
Family inc.< $50K/year							-1.35	0.78		-0.80	0.74	
Parent ed. <= some HS							1.14	0.91		1.44	0.86	
Child is white							1.68*	0.76		1.05	0.73	
Child has an IEP							-0.35	1.02		-0.83	0.97	
Suburban (vs. urban)							0.29	0.88		0.91	0.84	
Rural (vs. urban)							0.32	0.83		1.95*	0.89	
Site: AZ (vs. AL)										2.90***	0.77	
Adjusted R^2	0.47			0.58			0.59			0.64		
N	123			122			112			112		

Note. Continuous variables are grand mean centered. Where values are not provided, variables were not included in the model.
* $p < .05$, ** $p < .01$, *** $p < .001$

Table A3 presents the final regression model (Model 4) for Study 2, with unstandardized beta values and Hedge's *g*.

Table A3. Regression Results for Treatment Impact of *Molly of Denali* Resources on ITSI Total Score – Study 2, Model 4

Variable	*b*	SE	*g*
Treatment	1.30*	0.59	0.25
Baseline ITSI Total	0.69***	0.08	
Baseline EVT	0.07*	0.03	
Baseline DIBELS	0.90	0.58	
Child is female	0.01	0.06	
Child age in months	-0.26	0.64	
Family inc.< $50K/year	0.53	0.71	
Parent ed. <= some HS	0.73	0.78	
Child is white	-0.91	0.77	
Child has an IEP	-0.91	0.77	
Suburban (vs. urban)	0.20	0.73	
Rural (vs. urban)	0.73	0.81	
Site: AZ (vs. AL)	-5.83	3.22	
Site: NY (vs. AZ)	-6.55	3.32	
Site: OK (vs. AZ)	-5.86	3.24	
Site: Other (vs. AZ)	-6.30	3.21	
Adjusted R^2	0.64		
N	125		

Note. Continuous variables are grand mean centered.
* $p < .05$, ** $p < .01$, *** $p < .001$

Table A4 presents the final regression model (Model 5) for the combined sample, with unstandardized beta values and Hedge's *g*. Model 5 is the same as Model 4 for Study 1 and Study 2, with the addition of a covariate denoting in which study the child participated.

Table A4. Regression Results for Treatment Impact of *Molly of Denali* Resources on ITSI Total Score – Combined Sample, Model 5

Variable	*b*	SE	*g*
Treatment	1.31**	0.43	0.25
Baseline ITSI Total	0.59***	0.06	
Baseline EVT	0.09***	0.02	
Child is female	1.09*	0.43	
Child age in months	-0.05	0.04	
Family income < $50K/year	-0.46	0.48	
Parent education <= some HS	1.00	0.54	
Child is White	0.89	0.52	
Child has an IEP	-1.23*	0.59	
Suburban (vs. urban)	0.55	0.54	
Rural (vs. urban)	1.71**	0.57	
Site: AZ (vs. AL)	2.88***	0.67	
Site: IL (vs. AL)	-5.85	3.29	
Site: NY (vs. AL)	-6.77*	3.36	
Site: OK (vs. AL)	-6.33	3.28	
Site: Other (vs. AL)	-6.73*	3.27	
Study 2 (vs. Study 1)	9.28**	3.31	
Adjusted R2	0.64		
N	238		

Note. Continuous variables are grand mean centered.
* $p < .05$, ** $p < .01$, *** $p < .001$

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