The Impact of a Media-Rich Science Curriculum on Low-Income Preschoolers' Science Talk at Home

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Abstract: While research suggests that educational television shows can contribute positively to a range of developmental outcomes for preschoolers, few preschool curricula make use of digital content to teach science. This study explored the impact of a curriculum that integrated hands-on activities with digital content from two public television shows aimed at introducing preschoolers to science, *Peep and the Big Wide World* and *Sid the Science Kid.* Impact was measured using parent reports of 398 low-income children's science talk using a random assignment design, where preschool teachers were assigned to implement either the media-rich science curriculum or a literacy curriculum. Results indicated that the science curriculum had a positive impact on caregivers' reports of children's talk about science. Though the study's outcome measure is an indirect measure of learning, the study suggests the potential for this and other media-rich curricula for introducing preschoolers to science.

Context for the Study

Learning scientists are increasingly interested in preschool children's science learning. Learning scientists have examined young children's conceptual development (Gelman & Lucariello, 2002; Gelman & Brennamen, 2004), the roles that caregivers play in encouraging young children's talk about science at home that encourages curiosity and fosters the development of explanations (Crowley et al., 2001), and the effects of specific curricula that target preschoolers in developing children's inquiry skills and conceptual understanding (Clark-Chiarelli, Gropen, Chalufour, Hoisington, & Eggers, 2009). To date, however, there have been few studies exploring the role that digital media can play in supporting young children's science learning or that focus specifically on science learning of low-income children. This gap is noteworthy, since a significant focus of learning sciences research has been on the role technology can play in supporting science learning in K-12 settings (Pea & Collins, 2008) and on the requirements for enacting inquiry approaches to teaching science in low-income communities (Songer, Lee, & Kam, 2002).

There are several obstacles to designing and undertaking such studies in preschool settings. First, the use of technology in preschools has been controversial. Critics have argued that adults should not promote the use of video or computers by young children, arguing that these technologies make children passive and reduce their opportunities to learn from interacting with adults and peers (Healy, 2003). In preschools where staff members believe technology is likely to harm children, it may be difficult to recruit study participants. In addition, curricula that use technology can also be hard for teachers to implement, since many preschools have limited access to technology and teacher training opportunities (Davidson, Fields, & Yang, 2009). Thus, fielding a study of media-rich curriculum materials would require researchers to provide extensive technical and professional support. Third, there are few standards-based outcomes for researchers to use. Those few that have some evidence of validity and reliability are only available to those researchers involved in their development. As a result, researchers wishing to study outcomes will have to develop measures that are instructionally sensitive, yet not so closely aligned to curriculum content as to have limited value in persuading others of the objectivity of the measure.

This study investigates whether low-income preschool-aged children can learn from a media-rich curriculum that combines hands-on investigations with digital content from public television programs and games. Researchers at Education Development Center Inc. designed the curriculum used in the study, which was part of the *Ready to Learn Initiative*, a program to develop educational television programming and outreach activities that increase school readiness for 2- to 8-year-old children living in low-income households. In 2005, the U.S. Department of Education awarded one of two Ready to Learn programming grants to the Corporation for Public Broadcasting (CPB) and PBS. The award required an impact evaluation of the *Ready to Learn* Initiative's target audience of low-income children.

Theoretical Background

The premise behind the curriculum in this study is that preschool teachers can implement a curriculum that integrates digital content from public television preschool science programs with hands-on activities in ways that promote early science learning. The curricular design is grounded in the literature on early science learning and on how and when young children can learn from digital media.

Approaches to Promoting Early Science Learning

As is true for learning across a variety of domains and ages, young children's prior experiences are important for learning. Because children have every day experiences with life science and earth science phenomena, many preschool science curricula draw from these fields. For instance, Rule and Guggenheim's (2007) science curriculum centers on clay partly because young children often have prior experience working with clay. The curriculum progresses from using art clay to experimenting with mud, clay, and sands. Gelman and Brenneman's (2004) curriculum embeds the scientific method and vocabulary into lessons devised with familiar objects like the apples, seeds, baby pictures, and shoes of various sizes, all of which demonstrate the concepts of growth and change. The idea behind both curricula is young children can be introduced to science concepts by using familiar objects and phenomena.

Hands-on investigations of these phenomena enable students to develop critical skills for inquiry, including making observations and predictions. Because hands-on activities make observations concrete and more comprehensible to preschoolers, science curricula routinely call for children to experiment with objects by using the senses to explore and manipulate them. Many preschool science curricula teach students to record observations with drawings and then make predictions based on the observations (e.g., Chalufour & Worth, 2003). Long-term activities also promote deeper exploration of a topic by allowing preschoolers to observe, predict, verify predictions, and reflect on observed changes over time (Gelman & Brenneman, 2004). Such investigations also support the earliest stage of scientific thinking, false belief understanding, which occurs when a child realizes her observations or beliefs may be different from others' and that beliefs may even be false (Wellman, Cross, & Watson, 2001). False belief understanding is the first step towards the ability to falsify a theory (Kuhn & Pearsall, 2000).

In early childhood, encounters with science can help children cultivate students' interest in science and develop ways for talking about science and learn scientific vocabulary, two skills that correspond to important strands of proficiency in science (National Research Council, 2009). According to French (2004), children's interest in science activities can support the formation of mental representations of complex phenomena and promote communication about these phenomena. For example, preschoolers can verbally describe the inside and outside of an apple, describing the apple's color, texture, temperature, and lack of sound while the teacher records the information on a chart (Gelman & Brenneman, 2004).

To date, little research has focused on science learning for low-income preschoolers; an exception is a recent pair of studies focused on children's science learning in Head Start by Greenfield and colleagues (Greenfield et al., 2009). In one study, the researchers compared the developmental scores of Head Start children using the Galileo observational system (which rates children's skills in a range of domains). They found that in a cohort of more than 2,000 children, children's ratings and gains in science were significantly lower than in the other 7 domains measured (e.g., literacy). In another study, they found that many teachers reported low perceived self-efficacy with respect to teaching science and had trouble integrating science into their schedule. A third study was a quasi-experimental study of the ECHOS curriculum, which uses a combination of direct instruction and guided discovery to teach science skills. Relative to a control group, students in classrooms implementing the ECHOS curriculum were rated higher on four of the eight domains of the Galileo observational system.

Young Children's Learning Using Digital Media

Research on young children's learning from digital media has been an area where there is a long history of research, including for low-income students (for a review, see Pasnik, Strother, Shindel, Penuel, & Llorente, 2007). For example, in the earliest days of public television programming for children, producers used research to study children's engagement and learning (Fisch, Truglio, & Cole, 1999; Morrow, 2005). A pair of experimental studies conducted by the Educational Testing Service in the first and second years of production for *Sesame Street* (Ball & Bogatz, 1970; Bogatz & Ball, 1971) found that children encouraged to watch the show grew in skills targeted by the show and were rated as more ready for school by their teachers than students assigned to a control group. A limitation of these and many of the other studies of the effects of educational television, including those that employed random assignment designs, is that they have been conducted in laboratory settings (Thakkar, Garrison, & Christakis, 2006). The lack of field-based studies is significant because achieving similar results in field settings (e.g., homes, day care facilities, or early childhood education centers) requires that a coherent sequence of curricular activities be enacted, something care givers in these settings may find challenging.

With the increasing availability of computers came developments in computer-assisted instruction that targeted young children's learning, primarily in the area of literacy. For this age group that is not yet reading, software programs facilitate the reading process by having the computer speak letter sounds, phonemes, and words to students as they read or interact with the computer. An intervention designed to increase phonological awareness (Olson, Wise, Ring, & Johnson, 1997) is fairly typical of such programs. In their software program, one set of tasks asks children to change the onset or rime of a word presented on a screen to match what the computer says (e.g., if the computer shows "buzz" and the computer says "fuzz," students must replace the "b" with an "f"). Another set of tasks requires children to try spelling words. The computer pronounces students' spellings back to them, providing them with feedback they can use to adjust their spelling. Studies of the effectiveness of these programs (e.g., Foster, et al. 1994; Baker & Torgesen, 1995) have found strong, positive effects on children's phonological awareness.

More recently, a number of interventions have been developed based on the idea that different media can be used *synergistically* (Neuman, 1995) to enhance children's learning. Interventions designed to promote learning from media synergy encourage co-viewing (watching and interacting with the television program with a peer, parent, or teacher) coordinate media viewing with non-media activities such as listening to a story, reading a book with a parent, teacher, or older sibling, or working on a practice activity related to skills targeted in the intervention. An intervention described by Prince and colleagues (Prince et al, 2002) provides a representative example of a media synergy intervention in practice. Teachers in that study were provided with a comprehensive *Between the Lions* curriculum that included whole episodes of the program, books related to themes covered during the program and enrichment activities. Teachers participated in intensive, daylong workshops to familiarize themselves with the resources and learn strategies for using them to supplement the literacy curricula already in place in their schools. During the school year, participating preschool, kindergarten, and first grade children viewed at least two *Between the Lions* episodes, read a book related in some way to the content of the episode viewed, and then participated in a hands-on activity that reinforced the skill or theme stressed in the episode. This and other studies (e.g., Chambers, et al., 2006) have found small, but positive, effects on children's reading skills. Similarly, recent evaluations of preschool math curricula that include computer-based math games revealed significant student math achievement gains (Clements & Sarama, 2008; Starkey, Klein, & Wakeley, 2004).

The Public Media-Produced Science Curriculum

The 10-week media-rich early science curriculum studied integrated video from educational television programs and associated online games with classroom activities to foster skills for later success in science learning. Researchers randomly assigned teachers to the early science or an early literacy condition. Teachers played a leading role in every aspect of the curriculum, guiding students through whole-group hands-on investigations, small-group experiences, and individual exploration, as well as mediating children's experiences with digital content through active co-viewing. The curriculum combined full episodes of *Sid the Science Kid* (produced by KCET/Los Angeles with Jim Henson Productions) and self-contained "focused viewing" segments from *Peep and the Big Wide World* (produced by WGBH Educational Foundation). Over the 10 weeks, the children participated in 25 hours of the science curriculum, including time spent actively watching TV episodes and segments, playing online games, and participating in small and large group activities.

Integration of Different Media and Formats for Learning

Video from *Sid the Science Kid* and *Peep and the Big Wide World* anchored the curriculum activities. Teachers showed entire episodes of *Sid the Science Kid* to introduce a weekly in-class investigation, periodically interrupting the video to highlight key science vocabulary and ideas. Students also viewed self-contained segments from *Peep and the Big Wide World* that engaged target content, vocabulary, and skills. Online games created by the producers provided additional support for the curriculum by targeting the same instructional strands. Both programs are intended to develop the early scientific knowledge of preschool children, the target age for the study. Researchers also adapted the hands-on activities suggested on the programs' websites for inclusion in the curriculum. Teachers led hands-on activities in whole group, small group, and individual settings.

Focal Skills

The curriculum addressed the development of four instructional strands in early science: science content, vocabulary, skills, and scientific thinking. In conjunction with students' prior knowledge, hands-on exploration, and observations, each strand is essential for later scientific development. These strands align with three of the National Research Council's recommended strands for science learning in informal environments: 1) Experience excitement, interest, and motivation to learn about phenomena in the natural and physical world; 3) Manipulate, test, explore, predict, question, observe, and make sense of the natural and physical world; and 5) Participate in scientific activities and learning practices with others, using scientific language and tools (National Research Council, 2009). Teachers guided children in exploring *science content* that was conceptually linked to "Transformation and Change," the topic of the 5 *Sid* episodes selected for the study. Instructional content addressed freezing, melting, growth, decay, reversible change, and irreversible change. Activities were based on everyday experiences easily observable with the five senses. Teachers taught preschoolers *science vocabulary* words related to these science concepts. They also learned vocabulary for science skills, such as observing, collecting, sorting, and investigating. Teachers supported children in learning the *science skills* needed to make observations using their senses, and record them in drawings. Long-term investigations allowed children to make predictions and check them over time. Children practiced *scientific thinking* by comparing their observations with those of their classmates, as well as by participated in memory games.

Teacher-Led Viewing

The curriculum called for early childhood educators to engage children in active viewing of segments and episodes. When showing video to the children, teachers introduced the key content and vocabulary, paused the video to encourage active processing of information, and reflected on areas of learning embedded in the video. After viewing each week's *Sid* episode, teachers supported children in repeating the hands-on investigations performed by the characters, such as planting a seed to watch it grow.

Opportunities for Repeated Practice

The curriculum sequence gave children multiple opportunities to develop and practice focal skills. They watched whole episodes and focused viewing segments several times and participated in repetitive teacher-led, small-group, and individual activities. Review and repeated focused viewings occurred on consecutive days and over the course of the 10-week curriculum so that content, vocabulary, and skills introduced in earlier weeks were revisited in following weeks.

Intensive Support for Implementing Early Childhood Educators

Preschools participating in the science curriculum received teachers' guides containing daily scripts and 10 weeks of activities, as well as materials such as potting soil, science journals, and a stipend for perishable items used during investigations. To increase the depth and quality of implementation, teachers received ongoing professional development from an instructional coach. This training began with two two-hour orientations to familiarize teachers with the curriculum and materials. Coaches subsequently provided on-site support that included modeling examples of good teaching practice, observation, and constructive feedback, as well as general assistance with implementation. Coaches made an average of eight visits to each class during implementation. The average visit was about two hours long. Between visits, coaches provided support by telephone and e-mail.

The Current Study

The research question investigated was: *Can a media-rich science intervention implemented by teachers in early childhood centers positively impact low-income children's talk about science with their caregivers?*

The researchers conducted a randomized experiment to test the impact of the curriculum. They randomly assigned preschool teachers in each participating center to either a treatment or comparison group. The treatment group of educators implemented the science curriculum, while the comparison group implemented a literacy curriculum of the same duration and with rich media components. The use of the literacy curriculum was to facilitate clear interpretation of findings; evaluators wanted to avoid the possibility that results could be explained by children's excitement about media use.

Sample

Eighty classes at 47 different early childhood education centers participated in the study. Some of these centers were some part of large-scale programs like Head Start, some were run by school districts, others were small, privately run facilities, some of which were home based. More than two-thirds of the early childhood educators (69%) had a postsecondary degree.

A total of 398 children (mean age at pretest, 4 years, 9 months) participated in the study. Fifty-three percent of the children were Hispanic, and 28 percent were African American. A majority (60%) of these children spoke English at home, and a third (31%) spoke Spanish at home. Some (8%) spoke both languages at home. Over all the children in the sample, 20 different languages were spoken at home. Seventy-nine percent were low-income, as indicated by the fact that their families were eligible for a subsidy to help them pay for tuition costs.

Outcome Measure

A key challenge in measuring outcomes of preschool curricula in science is the paucity of measures of student learning (Greenfield et al., 2009). Given the resources of this study, it was not feasible to directly measure the impacts of the science curriculum by individually assessing children. Instead, the study team relied on a single measure of caregiver reports of children's talk about science. More intensive analyses of children's science talk in the home indicate the home is a site where children's interests are expressed and, in some cases, developed with the help of caregivers (e.g., Tenenbaum, Snow, Roach, & Kurland, 2005). Our measure aligned with Strand 1 of the NRC's (2009) informal science learning guidelines and sought to capture children's excitement, interest, and motivation to learn about science topics. Caregiver reports are a less precise way to learn about children's expressed interests, but they are more readily collected than discourse data for large-scale studies such as this one.

The measure used was a single index comprised of the sum of caregivers' response to 8 items. The study team asked caregivers to report on whether or not children reported in recent weeks that they had: pretended to be a scientist or science teacher, talked about doing investigations or experiments, expressed curiosity about the natural world, expressed an interest in why things change, expressed an interest in how things work, talked about freezing and melting, talked about decay, and talked about heat and change.

Procedure

After random assignment had been completed, the study team provided training to coaches. The training for coaches included a review of the curriculum's goals and activities, as well as guidance regarding how to support teachers in learning how to implement the curriculum. The training also included a review of a weekly log form that coaches were to complete and that provided information on teachers' implementation of the curriculum. The team supported coaches' work by providing weekly opportunities to review progress and challenges with a coach coordinator, one in New York and one in California.

After coach training had been conducted, coaches established contact with classroom teachers to set up an orientation session to the curriculum. During the orientation session, coaches reviewed the curriculum goals, activities, and strategies, as well as expectations for implementation. In addition, the coaches reviewed materials that had been shipped to teachers and that included all the digital and print content needed to implement the curriculum. In the first 4 to 5 weeks, coaches led activities that had been scheduled that day, co-led them with teachers, or observed as teachers implemented the activities. In subsequent weeks, the study team gave coaches discretion as to how many times to visit sites, though they continued to make weekly contact with sites to complete implementation logs.

Within four weeks of completing the 10-week curriculum, the study team began contacting caregivers to conduct the survey. The team made up to 20 attempts to reach parents, caregivers, or guardians who had given consent for their children to participate in the study. Response rate for the parent survey was 56 percent, which was high for parent surveys in general and for this population in particular.

Approach to Analysis

In the study, children were nested within classrooms; classrooms were the unit of treatment assignment for the study. Because of the multilevel nature of the data, and because a significant proportion of the variance for each of the four outcomes was associated with classrooms, the study team employed hierarchical linear modeling (Raudenbush & Bryk, 2002) to estimate treatment effects. After fitting a fully unconditional model to the data to estimate variance at each level (96% at Level 1, 4% at Level 2), two models were fit: one that included only the treatment indicator as a predictor and a second that examined the impact of the parent respondent on outcomes (whether the respondent was the father or another caregiver).

Prior to modeling, the study team conducted a factor analysis and analyzed the reliability of the outcome measure. These analyses suggested a single-factor structure, and together, the items had a modest internal reliability of $\alpha = 0.75$. Since scores were skewed, the team used a bootstrap resampling method to calculate the standard deviation of parameter estimates and transformed the outcome data (using the square of the measure). Squaring the outcome measure did not produce different model results, so outcome measure for all subsequent analyses was the mean score for the 8 items, to facilitate interpretation.

Because there were missing data, the study team used data for all children in the study, namely their gender, ethnicity, and family income level, to determine whether the students' caregivers with missing data differed in any way from those for whom their caregivers did complete surveys. The results of this analysis indicated that there were no differences between the group for whom complete data were available and the group for whom data were missing on any background characteristics. The science and comparison curriculum groups were also equivalent on these background measures and a measure of early literacy.

Results

There was a statistically significant treatment effect of the science curriculum on science talk for both models fit to the data ($p < .05$). In Model 1 (Table 1), the mean outcome score of the science curriculum children was 0.712, compared with 0.634 for the comparison group children. The magnitude of the effect was 0.30 standard deviations. There was no statistically significant relationship between child gender and scores on the outcome measure.

Table 1: Impacts of the Curriculum on Science Talk: Model Results.

	Model 1	Model 2
Intercept	0.634	0.614
Treatment is Science	0.078* (0.0335)	0.111** (0.0332)
Respondent is Father		0.161** (0.0545)
Respondent is Other		0.000 (0.171)
Treatment X Father		-0.281* (0.1199)
Treatment X Other		-0.101 (0.23484)
r^2	0.022	0.052
Adjusted r^2	0.018	0.014

* $p < .05$, ** $p < .01$

Model 2 in Table 1 presents a slightly different picture of the results and shows that when the mother was the caregiver responding to the survey, the average score for children in the science condition was 0.725 and for comparison children it was 0.614. When the father was the caregiver responding to the survey, scores were higher for both treatment and comparison groups. Moreover, when fathers are respondents, scores of children in the literacy classrooms are significantly higher than scores of children participating in the science curriculum. The data do not permit the research team to analyze why the effect is different for fathers, but this could be a topic for future research.

Discussion and Conclusion

This study provides preliminary evidence that preschool teachers can implement a media-rich science curriculum that can impact caregiver reports of children's talk about science. Caregiver reports of children's talk reveal something of what children find interesting and memorable enough to relay about their experiences in preschool. Preschoolers' reports of recent events are not easily recalled, so the finding that children in the study talked about topics in the curriculum is especially significant.

A key limitation of the study is the outcome measure, which is only an indirect measure of children's interest in science and not a good measure of what they may have learned from the curriculum. Future studies will require additional resources to implement testing of children individually, as well as better measures of learning aligned to the curriculum's goals. Although some measures are now under development, published results of validation studies are not yet available.

One conclusion that can be drawn is that the potential of this and other curricula merit further investigation. Such studies should focus not only on the outcomes or impacts of curricula but also on the processes by which students learn from them. Studies that can identify ways that hands-on activities and interactions with video and online games complement one another would be of particular interest. Differences among learners are likely to arise, and in the context of field-based studies, so, too, will differences in preschool teachers' ability to implement the curriculum under varying levels of coaching support. In addition to understanding impacts of curricula on student learning, developing an understanding about who learns what, and under what circumstances, are important goals for learning sciences research.

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