

REPORT TO THE READY TO LEARN INITIATIVE

Review of Research on Media and Young Children's Literacy

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Introduction

Since 1994, when Congress allocated significant resources to support the development of the Ready to Learn initiative, policymakers, educators, and many adults who care for children have had an abiding belief that publicly funded media can support young children's learning. Following the release of Ernest I. Boyer's report *Ready to Learn: A Mandate for the Nation*, which described how many preschool-age children were arriving at school ill prepared to learn in a formal educational setting, television was seen as a fundamental part of their most influential learning environment, namely, their homes. The report popularized the idea that early education by parents is the crucial element in children's success in learning and provided recommendations for improving the conditions where this learning took place. Ubiquitous and well liked, television in the home, it was believed, could help ameliorate inadequate preparation for school.

A decade later, the Ready to Learn initiative is in its third phase, and the notion that electronic and now digital media can be effective tools for teaching the skills children need to succeed as students and, ultimately, as citizens has persisted. The belief that media, with the support of outreach efforts, can improve young children's school readiness by arming them with literacy skills has held particular potency. And while the mandate has remained the same—to create high-quality, noncommercial programming that serves low-income children and their families—the current Ready to Learn phase places considerable emphasis on evidence of effectiveness. When issuing its latest Request for Proposals (RFP) in the *Federal Register*, the Department of Education's Office of Innovation and Improvement made clear the importance of scientifically based research. In general, the initiative aimed to support projects designed to develop, produce, and distribute age-appropriate educational video programming and curricula that are based on scientific reading research for children ages 2 to 8 years old and their parents and educators. Specifically, the Ready to Learn programming had to target low-income children and families; scientifically based research had to inform the development of these programs; and new technologies had to be used to ensure that Ready to Learn programs would reach as wide an audience as efficiently and cost-effectively as possible. There was a similar expectation of the evaluation component. Twenty of 100 points on the grant application were based on the quality of the evaluation. The RFP specified a priority for projects proposing an evaluation plan that was based on rigorous, scientifically based research methods to assess the effectiveness of a particular intervention. In addition, the evaluation was expected to inform the development of the project and monitor progress toward objectives throughout the life of the project.

The Corporation for Public Broadcasting and PBS were awarded joint programming and outreach grants through the Department of Education. As a result, the current Ready to Learn initiative has multiple grantees conducting original research on individual television shows, online materials, and curricula.¹ The project as a whole is investigating the hypothesis that *media synergy* can be effective for improving young children's literacy. Media synergy is a

¹ The Department of Education awarded a second programming grant to the Ready to Learn (RTL) Partnership led by the Chicago-based station WTTW. The Michael Cohen Group is overseeing the RTL Partnership's research efforts, including formative and summative studies of *Word World*, one of four new productions.

theory of how people learn from different media (Neuman, 1995). It refers to the idea that different media can complement one another, in terms of what people learn from them. Learning is complementary because there are important qualitative differences in the messages from different media, and skills acquired in one medium can act synergistically to help students make meaning and apply what they have learned to another context or medium.

Current Ready to Learn grantees are each engaged in tests of media synergy in that the resources they are developing all rely on multiple media (e.g., television, print curricula, and computers) and seek to achieve impacts on traditional measures of print literacy.

As the Corporation for Public Broadcasting's summative evaluation partner from 2006 to 2010, the Education Development Center, Inc., in collaboration with SRI International, will undertake research to determine the effectiveness of the Ready to Learn intervention currently in development. As a necessary step before beginning this new study, we thought it beneficial to review research that has investigated media's effects on young children's prereading and reading skills. This report is the result of our efforts. The aim was to look for clues from past interventions and research designs that may inform how we approach our study. We wanted to ground our work in the lessons that Ready to Learn and media focused on literacy have taught us and to identify gaps in the current knowledge base.

Context for the Review

The Ready to Learn initiative is unique in the large number of studies that are planned or under way that are intended to judge its effectiveness. In many federally funded projects, the evaluation is the only systematic study of project impact. But with the Ready to Learn initiative, the summative evaluation is only one of several scientifically based research efforts funded by the Initiative (see Exhibit 1). Currently under way are formative research studies aimed at understanding how individual children and families in low-income communities respond to television shows. There are also planned studies of individual television shows and of curricula being developed through the project. Some of these studies will be experimental studies that use random assignment.

Exhibit 1: Ready to Learn Initiative's Research Efforts

Research Partner	Purpose	Anticipated Evidence of Program Effectiveness
School of Education, University of Michigan	Evaluation of Ready to Learn school instructional materials	Summative data on students' achievement and teachers' instructional practice
Annenberg School for Communication, University of Pennsylvania	Research to support the development of television and online content	Formative data from observational studies and efficacy trials related to each show. Focus on children's attention, content comprehension, and usability
EDC, Inc. / SRI International	Evaluation of Ready to Learn initiative	Summative data on young children's literacy gains
Out of the Blue Productions	Research on <i>Super Why</i>	Formative data on the likelihood the show will reach its literacy goals
Sesame Workshop	Research on <i>The New Electric Company</i>	Formative data on the likelihood the show will reach its literacy goals
WGBH	Research on <i>Between the Lions</i> and <i>Martha Speaks</i>	Formative data on the likelihood the show will reach its literacy goals

The summative evaluator's roles are to synthesize the evidence from studies undertaken as part of the project and to conduct an independent study of program impact. In preparation for undertaking an independent study of impact, we prepared this literature review. This review is a complement to a review conducted by Deborah L. Linebarger and her colleagues at the Annenberg School for Communication at the University of Pennsylvania (Linebarger, 2006b, 2006c; Linebarger, Taylor-Piotrowski, & Vaala, 2007). Their three-part series on television and

television-enhanced interventions summarized well the qualities that make for effective productions. Its key purpose was to inform development of new interventions, especially with respect to content that could enhance literacy outcomes. As a complement to the literature review produced by the University of Pennsylvania, this review takes up the question of what makes for good research and asks where gaps in our understanding of media's influence on children's literacy exist. It seeks to inform both the implementation of the Ready to Learn intervention and the implementation of the multiple research efforts under way.

Purpose of the Review

This review has three specific goals:

- To inform the Ready to Learn community about effective uses of electronic media in addition to television.
- To identify the characteristics and settings of the studies reviewed that can inform the Ready to Learn community about the likely challenges of implementing interventions in field settings.
- To inform the design of a randomized control trial by identifying the range of measures, contexts, and likely sizes of effects for specific measures and outcomes.

As the community begins to develop content for new media, including online and computer-based offerings, answers to the question of what has been shown to be effective in these media can guide development. For example, there is a research base on different kinds of computer-based applications for improving literacy that has explored the impact of these kinds of applications. Understanding what uses of computers and what interventions that use computers can be effective can inform the design of specific content and interaction with content intended to help young children learn.

The focus of our review on study characteristics, especially on implementation, settings, and measures, is intended also to benefit both the evaluation team and the team designing the intervention. An enduring challenge for large-scale trials or field studies is achieving implementation fidelity. Implementation fidelity refers to the degree to which research participants (e.g., teachers, parents, children) implement an intervention as planned. High fidelity can hardly ever be assumed to be easy, and low fidelity can reduce the strength of the intervention (Cordray & Pion, 2006). The evaluation team has analyzed what settings yield greater implementation fidelity, in the hope that such settings could be identified for the summative field trial. The team designing the intervention needs information about implementation fidelity so that it can design the supports (e.g., professional development, equipment) necessary to promote high levels of implementation.

Achieving the third goal will benefit both the evaluation team and the broader Ready to Learn initiative. At present, the Ready to Learn initiative is developing a comprehensive, multimedia intervention that brings together television, curricular, and computer-based content into a coherent whole. This content will be further supported by a social marketing campaign and local public television stations' efforts. The intervention that the Corporation for Public Broadcasting is developing under the current initiative, in cooperation with its production, outreach, and research partners (PBS, American Institutes for Research, Out of the Blue Productions, Sesame Workshop, WGBH, University of Michigan, and University of Pennsylvania), will focus on three skills essential to young children's literacy: letter recognition, phonological awareness, and vocabulary. This review can aid the initiative's efforts in developing the intervention by providing a clearer sense of the literacy domains on which different media are likely to have impacts. It also can help the initiative anticipate how large those impacts may be in different types of settings.

Overview of Research on Media and Young Children’s Literacy

The role of media in young children’s learning has been a subject of considerable debate in recent years (Rideout, Vandewater, & Wartella, 2003). Much of that debate centers on infants, toddlers, and television, but controversy over the value of electronic media in learning extends into the school years. Media, in these debates, typically refers to television shows and to computer applications. Print is also a medium, as are other modes of human expression that are widely believed to have positive impacts on children’s development.

This particular debate is not the subject of our review, but it is an important background to it. We ask, “What do we know about the impacts of media on literacy outcomes for young children?” Our assumption is that an answer to this question can inform discussions about how best to promote children’s literacy learning through different media. Whether or not the media per se cause these impacts is of less central importance in this review, however. Rather, our goal was to understand for different forms of media what impacts are possible when targeted interventions designed to enhance literacy use those media. By interventions, we mean an organized set of media-supported activities for children that are designed to build skills and knowledge.

We included four different types of media-based interventions as part of this review:

Television: Studies that examined the effects of television, with a focus on educational shows developed for children ages 2 to 8. These shows included some for which enhancing literacy was the primary purpose and some for which it was a secondary goal.

Computers: Studies that examined the effects of computers, with a focus on software applications designed to provide instruction and practice in basic prereading and reading skills.

Talking Books: Studies that examined the effects of talking books, with a focus on technology that enables young children to read books that ‘talk’ to them, that is, by speaking words on a printed screen or page to them.

Multimedia/Media Synergy: Studies that examined the effects of combining different media (e.g., computers + television, television + print curricula).

For each of these types of interventions, this review analyzed effects of different interventions for the following domains of literacy measured in individual studies:

- Print awareness and concepts of print
- Aural story comprehension
- Phonological awareness
- Phonics
- Vocabulary
- Fluency

- Comprehension
- General reading skills as measured by broad tests of reading

The studies included in this review vary widely by several characteristics that we summarize for each medium. For example, the particular literacy domains targeted by interventions are different both across and within particular media. Some interventions took place in classrooms, and others took place in laboratory settings where researchers controlled many aspects of children's exposure to media. Additionally, in the studies we reviewed, both researcher-developed and standardized measures were used to measure impacts. This variability of study characteristics is a key focus of our review. By examining the study characteristics in greater detail, we hoped to make better predictions about the settings where interventions might be implemented well, the measures that might show effects for different media, and the level of exposure necessary to achieve meaningful effects on literacy.

This review is organized by medium, and for each medium we answer the following four questions:

- What are the characteristics of the studies?
- What were the intervention goals and measures used in the studies?
- In what settings did the studies take place?
- What were the outcomes of the studies?

We conclude with a consideration of implications of the review and with recommendations for the Ready to Learn initiative and for the summative evaluation.

Methodology

In this review, we sought to identify high-quality research studies published in English-language journals that analyzed interventions that used television, computers, talking books, or other digital technologies (singly or in combination) to support literacy development of young children. To summarize and synthesize the results of the studies reviewed, we used both narrative and meta-analytic approaches to presenting findings. In this section, we describe in detail our approach to identifying, selecting, and analyzing studies.

Process for Finding and Selecting Articles

In December 2006, researchers used EBSCOhost, limiting parameters, and a common set of key words (see Appendix 1) to search a range of research publication databases. Education and developmental psychology research databases included in the EBSCOhost search were:

- ERIC
- Academic Search Premier
- Child Development and Adolescent Studies
- Psychological and Behavioral Sciences Collection
- PsycINFO
- PsycARTICLES
- SocINDEX

In addition, researchers examined studies that appeared in other recent literature reviews, and conducted hand searches of several education and developmental psychology journals. The journals, from 1995 to the present, hand-searched by researchers were:

- Journal of Computer Assisted Learning
- Educational Technology Research and Development
- Child Development
- Early Childhood Research Quarterly
- Developmental Psychology
- Journal of Early Childhood Literacy
- Journal of Communication

To complement these targeted searches, researchers used limiting parameters and the same common set of key words in the Google Scholar search engine to ensure we did not overlook research published on the Web. Researchers downloaded abstracts from all reports or articles found into EndNote, along with relevant bibliographic information. This initial search yielded

113 unique articles. An initial review of abstracts eliminated 42 articles. Researchers obtained full text copies of the remaining 71 articles.

Criteria for Inclusion

Researchers reviewed the complete articles and included in the review only those studies that met the following criteria:

- Research design was either experimental (using random assignment) or quasi-experimental (purposive assignment) with pre- and posttest data on both treatment and control groups.
- Studies had to be published or reported in or after 1996.
- Studies had to be published in English-language journals.
- Studies must have focused on the literacy learning of children ages 2 to 8.
- Studies provided detailed information about the outcomes measured.
- Studies contained detailed information about the intervention.
- Studies provided detailed information about research design and methodology.

The most common reasons for an article to be excluded were: study design did not include a comparison or control group; study was published outside the date ranges; study did not report on outcomes; study was not published in English. Forty-three articles met all criteria and were included in the review.

Coding of Studies

Researchers coded each study for information related to the following:

- Structure of the intervention
- Context where the intervention took place
- Number of and any demographic information about study participants
- Goals of the intervention
- Technology or technologies used in the intervention
- Guidance or support that was provided to parents or teachers of participating children
- Information about any incentives that were offered to participants
- Implementation fidelity
- Standardized and researcher-developed assessments used to measure children's literacy development
- Significant findings reported by study authors

Research on Educational Television and Young Children

Reading and literacy skills are understood to be critical elements that young children must acquire and master early on in order to be successful academically. Watching educational television programs in the early years has been shown to have positive impacts on students' reading abilities in subsequent school years (Linebarger, 2000). As a myriad of programs have emerged targeting various reading, literacy, and other early developmental skills, researchers have examined the different ways in which these programs affect and supplement children's learning processes.

Our review included 13 studies that focused on the impacts of educational television programs on literacy skills in young children. The majority of studies used control group designs measuring the ways in which the television programs affect target literacy skills. Studies looked at the effects of the content of the shows, as well as effects of duration and viewing patterns.

Key Findings

Although there were many high-quality studies of television and literacy, only a few studies compared literacy gains of students watching educational television shows with those of a comparison group that did not watch shows. In these studies, students most often attended scheduled viewing sessions over a multiweek period. The strongest positive effects were for word recognition, phonological awareness, and vocabulary.

What were the characteristics of these studies?

The majority of the children involved in these studies were generally from 4 to 6 years old, although there was significant total range in ages across the studies, from 2 to 8 years old. Sample sizes in these studies ranged as well. All the studies except one used experimental or quasi-experimental designs; the remaining study used a longitudinal-correlational design.

Age Ranges of Students

The 13 studies varied in terms of the age range of the children studied from early age to second and third grades, though the majority focused on children of younger ages. In 6 of the studies, participants were 2 to 4 years old. Five studies were of children between 4 and 7 years old; in the remaining two studies participants were 7 and 8 years old.

Sample Sizes and Backgrounds of Students

Sample sizes ranged in these studies from a small within-group experimental study of 35 subjects up to a multilocation controlled trial with 474 subjects. The median number of participants across all the studies was 108. The Singer and Singer (1998) study with 474 subjects was large: it was conducted in five sites across five cities.

With regard to the demographic makeup of the children in these studies, the numbers of boys and girls were generally balanced across the studies; however, one study focused exclusively on children diagnosed with ADHD, which produced more boys than girls in that sample.

There was a range in terms of the ethnic background of children in these studies. In the studies that reported demographics, 4 had samples that were predominantly white, and 2 studies

looked specifically at Hispanic children who are English Language Learners, and one study. Three studies reported samples with a range of ethnic backgrounds, though they were primarily white, African American, and Hispanic.

Most studies did not report on participants' socioeconomic backgrounds; however, one of the studies in Singer and Singer (1998) focused on a population identified as middle class, while the other study involved populations identified as inner-city and poor. Linebarger and Walker (2004) reported a population with evenly distributed household incomes: below \$30,000 per year, \$30,000 to 45,000 per year, and above \$45,000 per year.

Research Designs

Of the 13 studies, 8 were experimental studies with random assignment to the control group while 4 were quasi-experimental. Additionally, one study was a longitudinal study that examined correlations between toddlers viewing patterns of programs (parent reported) and vocabulary skills.

The vast majority of researchers controlled the viewing of the television shows within classroom, day care, or laboratory settings. Two studies (Bryant et al., 1999; Linebarger & Walker, 2004) used parent logs of children's viewing patterns, because the studies did not control home viewing at all.

Attrition did not appear to be a problem for most of these studies; most of them either reported attrition rates at 10% or less, or did not report attrition at all. One study (Crawley, Anderson, Wilder, Williams, & Santomero, 1999) had significant attrition over 20% due to both equipment failure and student absence, resulting in students' exclusion for not completing all five days of the study protocol.

What were the intervention goals and measures used in the studies?

The 13 studies on television-based interventions focused on a variety of literacy goals ranging from phonemic awareness and letter knowledge to oral language, fluency, and comprehension skills. The studies used well-known programs such as *Blue's Clues* (6 studies), *Arthur* (3 studies), *Barney and Friends* (3 studies), *Sesame Street* (2 studies), *Between the Lions* (1 study), and *Pinwheel* (1 study). *Dora the Explorer*, *Zoom*, *Kratt's Creatures*, and *Magic School Bus* were also part of studies (each appearing once in the studies reviewed here), typically those comparing across programs. The measures used to assess skills included a range of both standardized and researcher-developed tests.

Intervention Goals

The goals of television-based interventions were fairly wide-ranging in terms of target skills. Some studies focused on children's attention; others focused on literacy skills, such as vocabulary, phonological awareness, spoken language, and comprehension skills.

Key Features of Interventions

It is important to note that much of the research focused on how different features of individual television programs contributed to better literacy outcomes of interest to

researchers and producers. Linebarger et al (2004) is one of the few studies included in this review that examined whether the viewing of a show (*Between the Lions*) improved particular emergent literacy skills that the show itself was developed around. Other studies examined aspects of the television shows in relation to nuanced literacy components, such as the varied correlations between children's viewing attention and comprehension (Lorch & Castle, 1997) or the ways in which caption use effects reading skills and comprehension (Linebarger, 2001).

The shows themselves varied widely with respect to intended goals, and some included television shows for which improving literacy is one of several goals. In addition to promoting literacy development, many programs focus on promoting self-esteem and positive interactions with others, such as *Barney* and *Sesame Street*. Conflict resolution skills are targeted in *Sesame Street* and *Arthur*. *Blue's Clues* focuses on problem solving with viewers and promotes repetition of shows as a critical strategy in their delivery of content. Thus, the shows themselves cover a range of viewing goals and strategies, many of which are not directly linked to specific literacy goals.

Intervention Duration and Intensity

The studies varied somewhat in terms of the duration and intensity of the delivery of the intervention, depending on the goals measured. The studies that focused primarily on attention measures had much shorter durations, generally a single session with viewing times around 20 to 30 minutes. The other studies generally delivered the television intervention over a period of time and focused on broader literacy goals. Durations ranged from 10 viewing sessions conducted over 10 weeks, to 54 viewing sessions, to 1 session each school day for a 3 month period. Additionally, two of the studies that investigated the effect of captioning on literacy skills used short duration and intensity of program viewing, with two 15-minute viewing sessions in one study and five 5-minute sessions in the other study.

Measures Used

Researchers developed their own measures to assess a variety of literacy-related skills. Researchers focusing on children's attention developed their own measures capturing eyes-on-screen and percentage of time looking (five studies). They typically used their own measures for comprehension tests, story understanding, program content knowledge and recall, and far transfer tasks (five studies). Researchers also developed measures for word building, word meaning, letter knowledge, concepts of print, and speech-to-print matching tests.

Researchers also used a variety of standardized measures of literacy. They used the measures in Exhibit 2 to assess phonological awareness, word recognition, vocabulary, and general reading ability. Additionally, a few studies used standardized measures of general developmental tasks.

Exhibit 2: Standardized Measures of Literacy Used in Television Studies

Literacy Domain	Measure	Number of Studies Using Measure
Phonological awareness	Comprehensive Test of Phonological Processing	1
	Dynamic Indicators of Basic Early Literacy Skills	1
Vocabulary	Early Childhood Indicator – Expressive Vocabulary	1
	Peabody Picture Vocabulary Test	2
	Minnesota Child Development Inventory—Vocabulary	1
General reading ability	Woodcock Language Proficiency Battery	1
	School-Home Early Language and Literacy Battery	1
	Test of Early Reading Ability	1

In what settings did the studies take place?

These 13 studies took place within a variety of settings, including kindergarten/ elementary school classrooms or programs (4 studies), laboratory settings (3 studies), children’s homes (3 studies), preschools/nursery schools (2 studies), and a day care center (1 study).

Typically, the laboratory studies provided the greatest detail about the settings and about children’s viewing of the programs, probably because they focus on measuring children’s attention. The school-based studies (preschool through elementary school) varied with respect to how interventions were delivered. Although some studies appeared to integrate the viewing of shows within classroom time, others delivered the intervention in free sessions, or not directly linked to actual instruction. Day care settings showed a similar pattern. The studies in home settings tended to entail a somewhat different intervention delivery, as researchers used parental logs to examine the level of viewing and how this correlated with the outcome measures that were tested after a given time period.

What were the outcomes of the studies?

We combined the results from several studies with a technique called meta-analysis. Meta-analysis allows researchers to compare the findings of studies that are similar to one another. The process allows researchers to estimate how big the effect of an intervention or family of interventions may be, not just whether there were statistically significant results. Exhibit 3 shows the results of the analysis for different reading skills measured in the research studies. An effect size is a number that represents the difference between the treatment mean and control mean. So that results can be compared across studies, we standardize the differences by dividing the difference by the standard deviation, a measure of how much variability there is in scores.

Using this approach, we combined results from two studies conducted by Linebarger (2001 and 2004) that analyzed the effects of television interventions on word recognition and comprehension. These two were the only studies to provide information that enabled us to calculate effect sizes. Using researcher-developed measures, Linebarger studied interventions in which children were able to complete successfully speech-to-print word recognition tasks and correctly use words in their own speech after exposure in the intervention. We found that both studies' effects were positive and significant. In addition, the size of the effect across the studies was quite large for educational interventions.

Exhibit 3: Average Effects of Television Interventions on Different Reading Skills

Reading Skill	Number of Studies	Average Effect Size	Confidence Interval (Lower Bound)	Confidence Interval (Upper Bound)
Word recognition and comprehension	2	+0.43	+0.27	+0.58
Phonological Awareness	1	+0.46	+0.29	+0.63
Vocabulary	1	+0.25	+0.11	+0.40
General Reading Ability	1	+0.23	-0.02	+0.49
Story Understanding	1	+0.47	+0.12	+0.82
Concepts of Print	1	+0.46	+0.20	+0.71

Confidence intervals indicate how much uncertainty there is in the average effect. In meta-analysis, when the confidence interval includes zero, the effect is considered nonsignificant.

Effects of the interventions on phonological awareness, vocabulary, general reading ability, story understanding, and concepts of print were analyzed, using one study for each. The effects of each variable were all positive and significant, except the effect on general reading ability, which approached significance. The same study reported on phonological awareness, vocabulary, general reading ability, and concepts of print.

The measures used to calculate the effect on word recognition were a battery of researcher-designed and standardized test measures. The phonological awareness, letter knowledge, vocabulary, story understanding, and concepts of print measures were researcher-designed. The measure for general reading ability was a previously standardized measure.

Research on Talking Books and Young Children

Interactive CD ROMs that provide children with a multimedia experience of stories and literature have come to be known as “talking books.” These books may include oral translation of text, interactive pictures, word games and activities, and speech feedback designed to help children read and understand story components (Ricci & Beal, 2002; Lewin, 2000; Littleton, Wood, & Chera, 2006). Talking books are becoming widespread, with many parents using them at home and research showing potential benefits for incorporating their use in the classroom (Verhallen, Bus, & de Jong, 2006; Chera & Wood, 2003; Ricci & Beal, 2002).

The value of using talking books for children, in or out of the classroom, however, is still being debated (Wood, Littleton, & Chera, 2005; Underwood, 2002). Relatively few studies have examined the impacts using such software may have on children. Some have even argued that much of this software does not coincide with literature curricula, which brings into question its educational utility (Fox, 2002). Research has found that children engage well and enjoy this software (Wood, et al., 2005; Lewin, 2000), but how interventions using this software could help literacy abilities has not been fully investigated.

Key Findings

There were seven studies that focused on “talking books” as a strategy for teaching literacy. In these studies, a researcher closely monitored students’ interactions to ensure implementation. There were typically only a few sessions, and outcomes measured were closely linked to the specific aims of the interventions. The strongest positive effects were for story comprehension.

Our review included seven studies that focused on the impact of interventions using talking books to teach literacy skills to young children. The interventions were based mainly in an experimental room set up in children’s schools and consisted of both single and multiple uses of talking book software. Each of the studies used a control group design and focused on a wide variety of literacy outcomes.

What were the characteristics of the studies?

The studies used participants from 4 to 7 years old from preschool, kindergarten, and early elementary school. The sample sizes were generally small and not described in great detail. There was a mix of experimental and quasi-experimental designs, but researchers controlled children’s exposure to the interventions well.

Age Ranges of Students

Children in the reviewed studies had a range of ages from 4 to 7 years old. Two studies focused on children with a mean age less than 5. Three studies had children who were 5 years old. Two studies used children ages 6 and 7.

Sample Sizes and Backgrounds of Students

Studies reviewed had small to medium sample sizes of children from a single school, classroom, or grade. The median number of students per study was 32. The median number of

children in the intervention groups (those using talking books) was 16, as was the median number of children in the comparison groups.

Researchers in these studies generally did not report on the ethnic or socioeconomic backgrounds of students they studied. One study reported participants being “mostly white”; another, which took place in the Netherlands, reported having Dutch as a second language. Four studies reported the gender of participants, with one having a perfect balance in number and three having only slight differences. One study reported that participants were from predominantly low-income families, and one reported using participants from mostly affluent families with no children from low-income families.

Research Designs

Of the seven control group studies included in the review, three were experimental studies. In each of these studies, researchers randomly assigned individual students to a condition, with one study first matching participants on reading age. The other four studies used a quasi-experimental design or did not discuss how participants were separated into groups. Two of the quasi-experimental studies formed low- and high-performing groups of students, based on a given pretest.

The researchers did not let instructors choose when to use the talking books. Instead, most researchers either controlled the amount of time students used the software ($n = 5$) or recommended how long students should be exposed to it ($n = 2$). For example, Verhallen and colleagues (2006) created a special room within the participants’ school for them to receive the treatment. These students spent one or four sessions, approximately 6 minutes each, interacting with a multimedia story presentation or observing a static story presentation. Similarly, Ricci and Beal (2002) created a room within the school and had students perform one session with a storytelling program, where students’ activity duration varied in length but ended immediately upon story completion.

Attrition was reported by four of the seven studies. Two studies reported no participants being lost, and two reported only one or two students as not completing the study (<10%). These students did not complete the posttest for unreported reasons.

What were the intervention goals and measures used in the studies?

The interventions were aimed at a variety of goals, with improving phonological awareness, story comprehension, and vocabulary being most common. The talking books software shares many attributes, such as placing pictures and text of stories on a computer with children being able to hear and read the text and interact with story components by using their mouse and keyboard. The length of intervention sessions was similar, with the number of sessions varying. The measures used to assess students’ success included a range of standardized and researcher-developed tests.

Intervention Goals

The goals of computer-based interventions focused on a variety of basic literacy skills. Improving phonological awareness was the most common target of the interventions, being

the primary focus of two studies and a secondary goal of another. Improving story comprehension and related skills were the primary focus of two interventions and a secondary focus of a third study. Vocabulary was also targeted by two studies, one as a secondary goal.

Key Features of Interventions

For this younger age group that is just beginning to read, interactive talking books aim to scaffold the reading process through multimedia interaction. The programs typically involve showing story images on a computer screen with corresponding text. The programs will read the words on the screen and sometimes highlight them for nonreaders. Sometimes, beginning readers can also click on a word or sentence to have vocabulary or story segments read aloud. Some activities and challenges also go along with these programs, such as a review of key words from the story and picture sequencing tasks involving the story. In the interventions reviewed, the students typically worked alone, with the program with the experimenter in the room if a student needed help. Occasionally students worked together in pairs.

One intervention, designed by Chera and Wood (2003), had the goal of increasing children's vocabulary and phonological awareness. The intervention used animated multimedia talking books derived from six texts of a UK reading series, *Bangers and Mash*, published by Longman. Children saw the pictures from the book on a computer screen and could control how the story was read to them with their mouse. They could go back and forth from page to page and could click on words or scroll their mouse over text to have it read aloud. The text also would move into a text bubble when being read. The program also contained a built-in activity that explored rhyming words for key words in the story.

Intervention Duration and Intensity

The intervention sessions were similar with respect to their intended duration, but the number of sessions varied. The shortest study used only one 15-minute intervention session. The longest study used twenty 15-minute intervention sessions, with one session per day over 4 weeks. The median number of intervention sessions was 6.

Nearly all the studies required children to interact with talking books in 10 to 15 minute sessions. Only one study varied, using six 6-minute intervention sessions. The actual length of sessions implemented matched the intended length for each study. Children's engagement with the programs was measured by videotape during one session in two studies, and observations were made in two other studies. Three studies did not measure children's engagement.

Measures Used

Researchers used a combination of measures they developed on their own and standardized measures of reading processes (see Exhibit 4). The measures researcher-developed targeted a variety of literacy skills, including expressive vocabulary in one study; however, the main targets of these measures were phonological awareness (two studies) and aspects of story understanding (three studies). Researcher-developed measures of phonological awareness tested auditory onset awareness, visual and auditory letter sound awareness, verbal onset awareness, visual onset awareness, rhyme awareness, and some unnamed components. Researcher-developed measures of story understanding tested or included narrative retelling

ability with various prompts, understanding of action and implied elements, free recall of story facts, inference questions, and picture sequencing tasks.

Of the standardized measures researchers used, the most common ones were intended to measure intervention impacts on phonological awareness, word recognition and analysis, and the general reading ability of students. Researchers also used standardized measures of vocabulary and reading fluency.

Exhibit 4: Standardized Measures of Literacy Used in Talking Books Studies

Literacy Domain	Measure	Number of Studies Using Measure
Phonological Awareness	Phonological Assessment Battery	2
	Rhyme Awareness	1
Word recognition and analysis	British Ability Scales Word Reading Test	1
	Burt Word Reading Test	1
Fluency	Salford Sentence Reading Test	1
Vocabulary	British Picture Vocabulary Scales II	1
General reading ability	Neale Analysis of Reading Ability: Revised	2
	Cito Language Test	1

In what settings did the studies take place?

All seven of the studies took place in school settings at the preschool, kindergarten, and elementary levels. Two of the studies ran interventions in the classrooms themselves, while five studies used laboratory settings in the school set up by researchers for children to participate in the intervention.

Because all seven studies were about computer-based talking books, students received the interventions independently, similar to the computer studies described in the next section. In only one study did students receive the intervention in pairs; the rest of the students were pulled out individually from the classroom.

What were the outcomes of the studies?

Meta-analysis was used to estimate how big an effect this type of intervention may have on the measured child outcomes (see Exhibit 5). Using this approach, we combined the effects from two studies that analyzed the effects of talking books on phonological awareness. These two were the only studies to provide information that enabled us to calculate effect sizes. We found

mixed results. Only one study had a positive significant effect, but because of sample size weighting, the combined result for both studies also showed a positive significant effect.

Effects on story understanding were more conclusive, with both studies showing positive significant effects. The effects on syntax were also significant, although only one study was used in this analysis. Effects on word recognition and analysis, vocabulary, fluency, and general reading ability, however, did not reach significance.

The measures used to calculate the effect on phonological awareness and word recognition were a battery of researcher-designed and standardized test measures. The story understanding, vocabulary, and syntax measures used for the effect size analysis were researcher-designed. The measures for general reading ability and fluency were previously standardized measures.

Exhibit 5: Average Effects of Talking Books Interventions on Different Reading Skills

Reading Skill	Number of Studies	Average Effect Size	Confidence Interval (Lower Bound)	Confidence Interval (Upper Bound)
Phonological Awareness	2	+0.32	+0.05	+0.59
Word decoding, recognition, and analysis	1	+0.12	-0.28	+0.52
Vocabulary	1	+0.46	-0.43	+1.34
Story Comprehension	2	+0.86	+0.57	+1.15
Syntax	1	+1.056	+0.12	+1.99
Fluency	1	+0.02	-0.67	+0.72
General Reading Ability	1	+0.10	-0.62	+0.81

Confidence intervals indicate how much uncertainty there is in the average effect. In meta-analysis, when the confidence interval includes zero, the effect is considered nonsignificant.

Research on Computers and Young Children

Computers and Internet access are increasingly available to young children in a variety of settings. American families with household incomes of less than \$30,000 per year remain less likely to have Internet access in the home than Americans with higher incomes, but over half (53%) of these households had access as of 2006 (Madden, 2006). Computers with Internet connections are also accessible to young children in formal school settings, including Head Start Centers (Li, Atkins, & Stanton, 2006) and in most kindergarten and elementary classrooms (National Center for Education Statistics, 2005).

The value of computers for supporting young children is a subject of considerable debate (Plowman & Stephen, 2003). Critics have expressed concern that technology enthusiasts believe computers can replace teachers; they also argue that time on computers takes away from interactive play, an essential aid to development (Cordes & Miller, 2000). However, others point to correlational evidence of the potential effects of computers on literacy as a reason to believe that computers could be beneficial for young children, especially for those most at risk (Judge, Puckett, & Bell, 2006; Stephen & Plowman, 2003).

Our review included 17 studies that focused on the impact of interventions using computers to teach literacy to young children. Each of these studies used control group designs, which allow for more internally valid inferences about the impacts of computers on literacy outcomes. In these studies, the computer was the primary medium of instruction, though a teacher was often present and computer programs did not replace the regular curriculum.

Key Findings

There were 17 studies that examined the impact of computer-based interventions on literacy. Most were small, but one was a large, multisite experimental study. The primary goals of interventions were to increase phonological awareness and build vocabulary. For the smaller studies, there were positive effects on phonological awareness and word recognition. However, for the large field trial, there were no positive effects on any literacy skills.

What were the characteristics of the studies?

The majority of the studies of computer interventions focused on children who were in kindergarten. They had small samples and did not describe those samples in great detail. The majority of studies used quasi-experimental rather than experimental designs, but researchers tried to control children's exposure to interventions.

Age Ranges of Students

Although the reviewed studies targeted students when they were in kindergarten, the actual ages of students at the time of the study were older than the 2 to 8 range targeted by our review and by the Ready to Learn Initiative. Six studies were of children who were 5-year-olds. Seven studies' participants were 6 to 7 years old. Participants in four studies (all follow-up studies) were over 8 years old.

Sample Sizes and Backgrounds of Students

For the most part, the reviewed studies had small samples consisting of children from a single school. The median number of students per study was 67.5. The median number of children in the intervention groups (those using computers) was 26, compared with 31 for comparison students. The very large experiment included in the review (Dynarski et al., 2007) had 2,619 first-grade students as participants.

Researchers in most of these studies did not report on the ethnic or socioeconomic backgrounds of students they studied. However, they did report on the numbers of boys and girls in the studies, and the numbers were balanced across studies. Three studies were conducted with young children from predominantly low-income families.

Research Designs

Of the 17 control group studies included in the review, 7 were experimental studies in which children were randomly assigned to condition. In all but one of these studies, researchers assigned individual students, rather than whole classrooms or schools, to a condition. In the large experiment, randomization took place within schools at the classroom level. Ten of the studies used quasi-experimental designs; that is, researchers assigned children to a treatment or comparison group, but the process was not random. In two of these studies, researchers assigned whole classrooms, rather than individuals, to a condition.

Most of the researchers did not let instructors choose when to use computers. Instead, most researchers either controlled the exposure to computer software (8 studies) or recommended how long students should use it (4 studies). For example, Barker and Torgesen (1995) created a schedule for students to come to the psychologist's office in the school, where students worked on computers three and four at a time for 25-minute sessions four times a week. Similarly, Segers and Verhoeven (2003) checked to make sure that students played computer reading games at least once for 30 minutes every 2 weeks throughout their 30-week intervention study.

Attrition, the loss of participants from the beginning of the study to the end of the study, was a problem for some of the studies. Three studies lost 15% or more of their sample over the course of the study. Two of these studies spanned multiple years, and attrition was caused by student mobility. In one of the studies, the primary problem was that too many students got perfect scores on some of the pretest measures. These students had to be removed from the sample because they could not improve on the outcome measures used in the study. For the remainder of the studies that reported attrition, the primary cause was student mobility.

What were the intervention goals and measures used in the studies?

The majority of the reviewed studies focused on a narrow range of reading skills, namely, phonological awareness and vocabulary. The computer programs used share some common features: they are game-based and provide extensive opportunities to practice phoneme segmentation, deletion, and blending to make words. The interventions vary widely, however, with respect to expected duration. The measures used to measure their success included a range of standardized and researcher-developed tests.

Intervention Goals

The goals of computer-based interventions tended to be focused on just a few basic literacy skills. Half of the interventions studied (8 studies) had as a primary goal developing children's phonological awareness. Phonological awareness refers to children's understanding that language is composed of words, which are composed of syllables, onsets and rimes, and phonemes. Five of the interventions taught vocabulary, and four aimed to increase children's ability to name letters in the alphabet. Four had as a goal building students' reading comprehension skills, but in only one of these studies was it the primary goal.

Key Features of Interventions

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. Typically, the computer presents a task, such as asking a child to click to select a letter that is being spoken by the computer. The computer then provides some feedback to the child as to the correctness of the answer. The feedback is instant, and some programs are designed to give students additional practice with tasks that prove difficult for them. In all of the interventions studied, children worked solo on a computer, even though they may have worked in groups as part of whole-class instruction that did not involve work on the computer.

The intervention designed to increase phonological awareness described by Olson and colleagues (Olson, Wise, Ring, & Johnson, 1997) is fairly typical of the programs studied. 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. A third set of tasks asks students to choose one of four nonwords presented on the screen that matches a nonword that the computer pronounces.

Intervention Duration and Intensity

The studies varied widely with respect to their intended duration. One program designed to teach phonological awareness provided just 5 hours of instruction to children over a 4-week period. Another called for an 11-week study. Most of the rest, however, intended children to use the computer programs for an entire school year.

Nearly all the studies required children to use the computer for at least 10 minutes per session. Three of the studies scheduled sessions that were 30 minutes or longer for children, and data from these programs indicate that children were able to meet this requirement. Actual engagement figures for students were not provided, however, for these three studies or any other study of computers we included in the review.

Measures Used

Researchers used a combination of measures they developed on their own and standardized measures of reading processes. The researcher-developed measures they used most researcher-developed included measures of letter naming (four studies); for this domain at

least, the face validity of most measures would not likely be in question, provided researchers asked children to name as many letters as they knew. Researchers also tended to use their own measures, however, for more complex domains, such as nonword reading, in which students are asked to pronounce or recognize spoken nonwords as a measure of their phonological awareness (three studies). They also used their own measures for phoneme blending, segmenting, and deletion.

Of the standardized measures researchers used, the most common ones were intended to measure intervention impacts on phonological awareness and on word recognition and analysis skills of students (see Exhibit 6). Researchers also used standardized measures of vocabulary, fluency, and comprehension in some studies.

Exhibit 6: Standardized Measures of Literacy Used in Computer Studies

Literacy Domain	Measure	Number of Studies Using Measure
Phonological awareness	Lindamood-Bell Auditory Conceptualization Test	3
	Phonological Awareness Test	3
	Comprehensive Test of Phonological Processing	1
	SAT-9 Sounds and Letters Subtest	1
Word decoding, recognition, and analysis	Woodcock-Johnson	3
	Wide Ranging Achievement Test (Decoding)	3
	Peabody Individual Achievement Test - Word Reading	2
	British Ability Scales - Word Reading	1
	Wechsler Objective Reading Dimension	1
	Comprehensive Test of Basic Skills - Word Recognition	1
	Test of Word Reading Efficiency	1
	SAT-9 Word Reading Subtest	1
Vocabulary	Peabody Picture Vocabulary Test	1
	Comprehensive Test of Basic Skills - Vocabulary	1
Fluency	Woodcock-Johnson Reading Fluency LUKILASSE (Dutch)	1
		1
Comprehension	Comprehensive Test of Basic Skills - Reading Comprehension	1
	Peabody Individual Achievement Test – Reading Comprehension	1
	Oral Written Language Scales (Listening)	1

In what settings did the studies take place?

The vast majority of studies (15 studies) took place in school settings at the kindergarten and elementary levels. Two studies took place in laboratory settings.

A closer look at the settings of the studies, however, reveals some unusual characteristics of these studies. Computer interventions were often pull-out programs from classrooms, which in some cases also facilitated random assignment of students to condition. Where computer use was integrated into regular instruction, it tended to take place in a separate computer lab, rather than in the children’s classrooms. The large experiment took place in both real classrooms and computer labs.

What were the outcomes of the studies?

Meta-analysis was used to estimate the magnitude of computer-based interventions on children’s literacy in the studies for which we could calculate effect sizes (see Exhibit 7). Using this approach, we combined results from four studies that analyzed the effects of computers on phonological awareness. We found that all four studies’ effects were positive and significant. In addition, the average size of the effect across studies was quite large for educational interventions. Effects on word recognition were more mixed, but results across studies were positive and significant.

Exhibit 7: Average Effects of Computer Studies on Different Reading Skills

Reading Skill	Number of Studies	Average Effect Size	Confidence Interval (Lower Bound)	Confidence Interval (Upper Bound)
Phonological awareness	4	+0.72	+0.35	+1.08
Word decoding, recognition and analysis	3	+0.30	+0.12	+0.47
Letter knowledge	2	+0.09	-0.17	+0.36
Aural comprehension	1	+0.32	+0.09	+0.54
Fluency	1	+0.45	+0.14	+0.76
Spelling	1	+0.65	+0.33	+0.96

Confidence intervals indicate how much uncertainty there is in the average effect. In meta-analysis, when the confidence interval includes zero, the effect is considered nonsignificant.

We computed effect sizes from two studies that examined effects of computers on students’ letter knowledge. The average effect size was not significant.

One study each examined effects of computers on aural comprehension, fluency, and spelling. The effects for aural comprehension, fluency, and spelling were positive and significant. The same study that reported effects on fluency also reported effects on spelling.

Although we did not calculate confidence intervals for effect sizes from the large field experiment, the outcomes are important to report, especially since they are not consistent with

the results presented above. The effect sizes for this study ranged from -0.01 to +0.06. None of the effects was significant for any measure.

Research on Media Synergy

Although some educators, parents, and policymakers advocate for the inherent educational value of media technologies, others have questioned whether television and, more recently, digital multimedia technologies are appropriate learning tools for young children. Some researchers have claimed that television displaces other activities that might have a greater impact on children's literacy skills and their cognitive and emotional development in general (Corteen & Williams, 1986; Gadberry, 1980; Hornik, 1978). Others have claimed that multimedia experiences are inherently more passive and therefore stunt the imaginative capacities of children (Singer & Singer, 1983).

Rejecting the idea that television and other electronic media have a unidirectional effect, Neuman (1995) argues that environmental circumstances (family norms about information and media, other adult interactions with children involving media, etc.) act to condition children's experiences. That is, what children are able to learn depends on how use of these technologies is mediated by parents, teachers, siblings, and significant others. She further posits that with some thoughtful effort on the part of adults, a positive synergy may develop as children interact with different information formats (pictures, text, video, etc.), particularly while they are learning to read.

This idea is based on two assumptions. First, conventions and physical features of different media, which may include sounds, images, moving images, text, symbols, or all of these, shape the way material is represented and conveyed in qualitatively unique ways. Second, interacting with different media requires children to develop sets of skills for navigating, constructing understanding, and generating inferences.

Neuman hypothesizes that a child's countless experiences across media represent a connected set of learning opportunities that encourage children's developmental skills for attaining new knowledge, creating meaning, and achieving greater facility to process information across media. With the support of parents and teachers, experiences with visual media may be able to directly support and enhance children's emergent literacy.

In the years since this theory was first formulated, various interventions and programs have been developed that incorporate media experiences to strengthen and complement literacy programs and curricula. The studies reviewed in this section provide some evidence about the effectiveness of some of these interventions and the media synergy hypothesis on which they are based.

Our review included six studies that focused on the impact of interventions that combined television or video elements with other instructional strategies. Three of these studies were conducted by evaluation researchers affiliated with the earlier phase of the PBS Ready to Learn project (2000-2004). Each of these studies used control group

Key Findings

There were six large multisite studies of media synergy. Two relied on parent co-viewing and reading with children; four integrated television with print curricula. The effects of synergy studies involving parent co-viewing and prior Ready to Learn activities were not significant. There were small positive effects for word recognition and conventions of print in the studies that combined television viewing with literacy curriculum activities.

designs, which allow for more internally valid inferences about the impacts of media synergy on literacy outcomes. In these studies, television programs or segments were the primary multimedia material parents and/or teachers used in concert with other instructional activities.

What were the characteristics of the studies?

All studies of media synergy interventions focused on children who were enrolled in preschool, kindergarten, or first grade. Sample sizes in these studies ranged from 200 to 2,500 students. Researchers provided varying degrees of information about students in the samples. Four of the studies used quasi-experimental rather than experimental designs. Half the studies were able to precisely control the amount of exposure to media during the intervention, while the other half were not.

Age Ranges of Students

In all six media synergy studies, children were from 3 to 6 years old. In four of these studies, participants spanned this age range. One study included only 6-year-olds; the remaining study included only preschool students enrolled in Head Start programs.

Sample Sizes and Backgrounds of Students

Evaluation research studies conducted for the PBS Ready to Learn project by WestEd (Horowitz, et al., 2005) and Mathematica (Boller, et al., 2004) included samples comprising children from sites in multiple regions of the country. The other media synergy studies were conducted within particular states: Mississippi, New Mexico, and Connecticut, respectively. The median number of students per study was 812. The median number of children in the intervention or treatment groups was 423, compared with 389 for comparison groups.

Ready to Learn studies did not describe the ethnic or socioeconomic backgrounds of the students they studied, nor their gender. Among the other studies, these features were described in detail. In Prince's Mississippi study, one sample, from the Delta region, was 97% African American, while the other was made up entirely of students from the Choctaw Indian Reservation. The New Mexico study sample consisted entirely of students from Native American tribal communities in the state, while the sample in the Connecticut study was mostly Latino (62%) and African American (35%). Students in each of these studies came from predominantly low-income families and the numbers of boys and girls in the studies were balanced.

Research Designs

Of the six studies included in the review that focused on media synergy, two were experimental with individuals randomly assigned to treatment or control conditions. Four of the studies used quasi-experimental designs where local considerations precluded random assignment. For example, some participants in the Mississippi study had been promised that they would receive the intervention being studied if they agreed to take part. As a result, researchers identified a purposive comparison group and elected to proceed with a quasi-experimental design.

Although all media synergy interventions sought to influence or control children's exposure to media content, researchers reported uneven success in achieving dosage targets. Some, like Chambers et al. (2006) and Prince et al. (2002), were able to control the amount of multimedia content. Chambers and her colleagues were able to incorporate brief (up to 3 minutes long) multimedia segments into teachers' daily 90-minute Success for All reading lessons, while the teachers in Prince's study used two episodes of *Between the Lions* and related print resources provided by the researchers on a weekly basis. By contrast, past Ready to Learn studies had relatively little influence on the amount of media that parents and teachers provided to students. Horowitz et al. (2005) reported that while the recommended dosage for the study was 2.5 hours of either *Sesame Street* (for the youngest children) or *Between the Lions* (for older children), researchers reported that fewer than 3% of teachers provided that much exposure to students.

Attrition, the loss of participants from the beginning of the study to the end of the study, was an issue for half the studies. These researchers reported attrition rates of greater than 20% over the course of the studies. However, because study designs anticipated these relatively high attrition rates, the final samples provided sufficient power to maintain internal validity. The main causes of attrition were failure to obtain parent consent, student mobility, and student absenteeism during treatment or assessment.

What were the intervention goals and measures used in the studies?

The majority of the reviewed studies focused on a narrow range of reading skills: vocabulary, letter and word knowledge, phonological awareness, print awareness, and reading comprehension. Interventions commonly used programs or segments that showed characters modeling these emergent literacy skills and provided children an opportunity to actively practice them. Interventions did vary widely, however, with respect to expected duration. The measures used to measure their success included a range of standardized and researcher-developed tests.

Intervention Goals

The goals of media synergy interventions tended to focus on just a few basic literacy skills. All interventions studied had as a primary goal increasing children's vocabularies. A majority of studies reported that interventions also had the goal of increasing children's phonological awareness, knowledge of the letters of the alphabet and how they combine to form words, print awareness, and book knowledge. Half the studies reported the goal of increasing children's reading comprehension skills.

Key Features of Interventions

Each of the media synergy interventions reviewed involved children viewing segments or whole television programs as part of a treatment condition. For past Ready to Learn studies, co-viewing (watching and interacting with the television program with a peer, parent, or teacher), as opposed to solo viewing, was strongly encouraged. Media experiences in these interventions were closely coordinated 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 the information or skill covered in the program.

The intervention described by Prince and colleagues (Prince et al, 2002) provides a representative example of a media synergy intervention in practice. Teachers in the 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, these preschool, kindergarten, and first grade children would view 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.

Intervention Duration and Intensity

The intended duration of the intervention in all media synergies was an entire school year. There was less consistency about the recommended or controlled amount of media exposure or the amount of total instructional exposure (an element of which would involve multimedia). One study included only a single short media segment (30 seconds to 3 minutes in length) each day as part of a 90-minute literacy block. Another recommended two 30-minute episodes per week plus supplementary activities in addition to the regular literacy curriculum. Lastly, another recommended 2.5 hours media co-viewing with an unspecified additional amount of co-reading and hands-on activities.

Measures Used

With one exception, researchers used standardized measures of reading processes (see Exhibit 8). The one study that also used researcher-developed measures adapted questionnaires that gathered information about the preschool classroom literacy environment and preschool educator demographics. As with other studies in this review, the researcher also developed measures of letter naming, environmental print awareness, and phonemic awareness, particularly related to sound isolation, phoneme blending, rhyming, and alliteration.

Of the standardized measures researchers used, the most common ones were intended to measure intervention impacts on phonological awareness and on word recognition and analysis skills of students. Researchers also used standardized measures of vocabulary, fluency, and comprehension in some studies.

Exhibit 8: Standardized Measures of Literacy Used in Media Synergy Studies

Literacy Domain	Measure	Number of Studies Using Measure
Vocabulary	Peabody Picture Vocabulary Test	2
	Picture Naming Task	1
	Woodcock-Muñoz Picture Vocabulary Test	1
	Woodcock-Muñoz Language Survey	1
	Woodcock Reading Mastery Tests-Revised	1
Letter Identification	Test of Early Reading Ability – 3	1
	Woodcock-Munoz Language Survey	1
Phonological Awareness	Dynamic Indicators of Basic Early Literacy Skills	2
Comprehension	Narrative Comprehension of Picture Books	1
	Test of Early Reading Ability - 3	1
	Woodcock Reading Mastery Tests-Revised	1
	Woodcock-Muñoz Language Survey	1
Print knowledge	Test of Early Reading Ability - 3	1
	Story and Print Concepts task in the CAP Early Childhood Diagnostic Instrument	1
Fluency	Dynamic Indicators of Basic Early Literacy Skills	2

In what settings did the studies take place?

A majority of studies took place in school settings at the preschool, kindergarten and elementary levels. Both the WestEd and Mathematica studies expected interactions to take place in home and school settings as parents and teachers applied the techniques they had learned at project workshops to support literacy learning of children in their care.

With the exception of the Chambers study, where researchers replaced a nonmedia activity with a multimedia one, all studies presumed that the media synergy intervention would augment, rather than replace, other literacy instruction or enrichment students were already receiving.

What were the outcomes of the studies?

The outcomes for the two groups of studies included as evaluations of interventions that attempt to incorporate learning from different media were different for each group. Past studies of Ready to Learn’s outreach activities to parents and teachers saw limited or no positive effects on literacy outcomes. By contrast, studies that integrated television viewing with curriculum materials implemented by teachers saw some small effects in a few literacy domains.

In both the WestEd and Mathematica experiments, the researchers concluded that there were no significant impacts on students’ literacy outcomes as measured by the Woodcock-Muñoz Language Survey. On the three scores derived from these measures—Picture Vocabulary, Attention Sustained, and Letter-Word Identification—there were no significant overall impacts of Ready to Learn outreach activities. In field tests of the “View-Read-Do” cycle, there were challenges to both parents’ and teachers’ implementation, leading to less than faithful implementation level. On the basis of difficulties with teachers, the WestEd researchers concluded that the skills of staff in child care centers may be too variable to expect them to be able to implement this cycle of multimedia literacy activities successfully.

There were other challenges in conducting this research that limit the generalizability of findings from these two studies. First, the WestEd researchers noted that there were major differences among participants with respect to demographics. However, even when controlling for these differences, there were no significant differences between the treatment and comparison groups on either the Picture Vocabulary subtest or Letter-Word Identification subtest of the Woodcock-Muñoz Language Survey. A more significant limitation was the fact that there may have been floor effects on the measures used, leading the researchers to conclude that the measure—used in both studies—is inappropriate for evaluating the impact of Ready to Learn. The Mathematica report authors did not raise similar concerns about the measures in their analysis, however.

Studies of media synergy that involved more intensive curricular interventions that took place in structured educational settings showed more positive, if small, benefits. The benefits reported were in the domains of conventions of print (Prince, Grace, Linebarger, Atkinson, & Huffman, 2002), letter knowledge (Linebarger, 2006a), phonological awareness (Linebarger, 2006a), word recognition (Chambers, Cheung, Madden, Slavin, & Gifford, 2006), and oral language and vocabulary (Linebarger, 2006a). These results were not consistent across studies, however, and positive impacts were not found for some measures used in the studies. Below, we review the findings from each study in greater detail.

In the Chambers et al. (2006) study, we calculated four separate effect sizes. The average size of the two effects calculated for word recognition was small but positive and significant. By contrast, the confidence intervals of the effect sizes for fluency and comprehension included zero, an indicator that these effects were not statistically significant (see Exhibit 9).

Exhibit 9: Average Effects of Chambers et al. (2006) Substudies on Different Reading Skills

Reading Skill	Number of Sub-studies	Average Effect Size	Confidence Interval (Lower Bound)	Confidence Interval (Upper Bound)
Word recognition	2	+0.24	+0.04	+0.43
Fluency	1	+0.12	-0.08	+0.32
Comprehension	1	+0.08	-0.12	+0.28

Confidence intervals indicate how much uncertainty there is in the average effect. In meta-analysis, when the confidence interval includes zero, the effect is considered nonsignificant.

We were able to calculate several effect sizes from reviewing the Prince et al. (2002) study in five different literacy domains. In the report, several positive effects were reported. When effects are combined for particular measures, however, the pattern of results suggests more modest overall effects. The only average effect that was positive and significant of those measured was for print conventions (see Exhibit 10).

Exhibit 10: Average Effects of Prince et al. (2002) Substudies on Different Reading Skills

Reading Skill	Number of Substudies	Average Effect Size	Confidence Interval (Lower Bound)	Confidence Interval (Upper Bound)
Alphabet	6	+0.11	-0.09	+0.31
Word meaning	6	-0.10	-0.35	+0.14
Print conventions	6	+0.24	+0.08	+0.41
TERA	6	+0.01	-0.16	+0.17
Vocabulary	6	+0.04	-0.13	+0.20

Confidence intervals indicate how much uncertainty there is in the average effect. In meta-analysis, when the confidence interval includes zero, the effect is considered nonsignificant.

The complete results of the New Mexico study, which built on the Mississippi study conducted by Prince et al. (2002), are not yet available; however, analyses of student growth showed some positive and significant results in some literacy domains in comparison with national norms, principally in the areas of oral language, vocabulary, and overall literacy. There was growth in students' knowledge of letter names and phonological awareness, but national norms were not reported in the study for these measures. There was no significant improvement in environmental print awareness, alliteration, or rhyming skills of students.

Despite variability in results across studies, for both sets of studies, researchers *were* able to establish a clear connection between implementation of the intended models and outcomes. A correlational analysis by Mathematica researchers (Vogel & Dadgar, 2005) found that children who watched more hours of PBS Kids programming were more likely to write or draw and be able to write their first name. At the same time, there were negative associations between watching more PBS Kids and measures of behavior. Furthermore, although co-viewing was

unrelated to child outcomes, there was a strong, consistent pattern of small positive effects for children whose parents engaged in the full range of View-Read-Do activities at least three to five times a month, compared with those who engaged in this cycle of activities less frequently. These children had higher book knowledge and were more likely to be able to read or pretend to read, write, or draw. In addition, they were more likely to be able to identify 10 written numbers and have higher scores on positive behavior measures. Likewise, in WestEd's study of Ready to Learn, children who were exposed more to View-Read-Do activities outperformed those who were exposed less often on the Picture Vocabulary and Letter-Word Identification subtests of the Woodcock-Muñoz. Finally, in the New Mexico study, level of classroom implementation was positively associated with literacy outcomes.

Taken together, these studies, which took place in diverse field settings, suggest that field trials that test the impacts of interventions that combine television with print curricula led by teachers are likely to have small effects on a limited number of literacy outcomes. These effects, moreover, are likely to be mediated by how well the interventions are implemented. For this reason, extensive professional development may be necessary to ensure better curriculum implementation, if Ready to Learn is to be effective in a field trial. Mathematica's correlational study suggests that one of the features of effective professional development is the modeling of desired behaviors by workshop leaders (Vogel & Dadgar, 2005). Still, these correlational results linking implementation to outcomes and professional development to implementation should be treated with caution. In the context of a randomized control trial, "intent to treat" analyses are likely to show diminished overall effects comparable to the ones found in these studies, compared with laboratory studies where implementation is more tightly controlled.

Summary and Implications

A key finding from the review is that interventions using different media show effects on literacy, but the effects are not the same across studies. Positive effects were found for interventions that used television, computers, and talking books as media of instruction. At the same time, there were examples of interventions in each of these categories in which children did not show greater improvement than children in comparison groups. The sizes of effects varied with respect to the type of outcome measured as well.

The review also found that using several different media in the same intervention can produce small effects when led by an instructor who receives extensive professional development. The effects of media synergy were small but significant in several literacy domains, and they were evident in studies where television was coupled with print curriculum implemented by teachers in preschools or day care centers. The teachers in the studies with positive results had extensive professional development, and print and television elements reinforced each other.

The literacy skills for which studies showed consistent positive effects were letter knowledge, phonological awareness, word recognition, and aural story comprehension. Students could use media effectively to learn to recognize more letters presented to them. Children learning with media showed better ability to blend and segment phonemes, to recognize onset and rimes in words, and to recognize nonwords. In addition, they could recognize printed words shown to them better with the help of media. Finally, young children were able to recall and understand elements of stories—such as setting, plot, main characters, and complicating action—better with the help of media.

Smaller studies in which researchers controlled implementation had larger effects on average than larger, multisite field trials in which implementation was supported or monitored but not controlled. This finding, represented in Exhibit 11, was true for different types of media-based interventions studied. We cannot distinguish which of the two study characteristics—sample size or degree of researcher control over implementation—explains the differences in effect sizes, because there were few large-scale studies in which implementation was tightly monitored and few small-scale studies that allowed implementation to vary naturally. However, we conjecture that the reason for this relationship is that in large-scale studies, standardized measures are often used that are less sensitive to the effects of intervention. In addition, implementation varies widely in large-scale studies, reducing the strength of the intervention.

An alternative explanation for the results is that they were affected by “publication bias.” Publication bias refers to the fact that journals rarely accept manuscripts from studies that find no significant effects. Therefore, most fields have many more studies of “positive” effects that can be analyzed than studies that show no effects. Significantly, all but one of the larger studies were part of external evaluations that were not published in peer-reviewed journals.

There remain several gaps in the existing knowledge base, both in terms of the focus of past studies and in terms of their quality. With respect to the focus, we found few studies that examined the effects of interventions on low-income children. With respect to quality, we found few large-scale random assignment studies, and only one such study of the media

synergy hypothesis that was focused on analyzing the effects of print curricula and television together. That study took place in an elementary rather than preschool setting. Also missing from many studies were consistently reported data on how much exposure students had to media and whether exposure was related to literacy outcomes.

Another limitation of the existing knowledge base is detailed information about the local settings in which studies took place. Student composition of schools or day care centers in the studies is one element of settings not consistently reported. The details of the roles that adults in settings were expected to play were also absent from most studies.

Recommendations

On the basis of this review, we make the following recommendations regarding the design of the current Ready to Learn intervention and of the summative evaluation study.

As the Corporation for Public Broadcasting works with its partners to develop the media synergy intervention, create a map that shows the team’s ideas or hypotheses about how the media will be integrated and lead to literacy learning. As much as the individual shows are working from a broad literacy framework, the intervention design team needs to map how specific intervention features are likely to lead to improved literacy. The map should focus on specific ways children will interact with television shows and curricular experiences, such as how opportunities for learning letters or for learning how to blend or segment phonemes are organized.

Emphasize a few skills in the intervention rather than a broad range of skills, and measure progress on those skills. The more diffuse the focus, the less likely the intervention is to have positive and significant effects in the field. The best candidates for the intervention are outcomes for which the review found consistent, positive effects. Those are letter knowledge, phonological awareness, word recognition, and story comprehension. This is a somewhat different list of outcomes than the initiative has considered to date. That list included vocabulary, but effects were inconsistent across a range of studies for that outcome. Also, that list did not include story comprehension, but some of the largest effects found in these studies were in this literacy skill.

The intervention should be undertaken in an educational setting. The media synergy studies that took place in educational settings and that targeted teachers were generally more successful than interventions that targeted parents and that focused on media use in the home. Although home viewing is the main way children are exposed to television, educational settings are the primary place where they are exposed to structured curriculum. In educational settings, it is more likely that teachers can facilitate transfer of learning from one medium to another. Therefore, it may be most productive if children can watch television shows in educational settings as well.

Provide ongoing professional development to teachers throughout the implementation period. Implementing a multicomponent intervention will require professional development. To be effective in supporting implementation, it will need to be ongoing, involve participants as active learners, and provide feedback to teachers on their practice (Desimone, Porter, Garet, Yoon, & Birman, 2002; Garet, Porter, Desimone, Birman, & Yoon, 2001). An interdisciplinary team, supported with funding from the project, may need to design and implement professional development. Plans for the professional development should be developed in conjunction with the intervention and should be seen as an integral part of the intervention itself.

Vocabulary effects may be extraordinarily difficult to detect in an evaluation study. There is likely to be a mismatch between the words and word types tested on standardized measures of vocabulary and those to which children are specifically exposed in media-based interventions. This mismatch poses a measurement problem, because children may be learning new words targeted by television shows or in curricula, but the tests will not be sensitive to

that learning. A measure that focuses on whether children learned the words targeted in the shows and curricula might be more sensitive to what students learned, but it would hardly be a fair test for children assigned to a control group.

Redesign the summative evaluation of the intervention as an efficacy study in a few sites, instead of relying on a multisite field trial. It is risky to undertake a field trial immediately after completing the design of an intervention. A better approach would be to design a series of two or three experimental studies, each conducted in a single site, to test the efficacy of one or more approaches to integrating media. In these studies, children could be randomly assigned to condition, yielding sufficient power to detect potential effects.

The final summative evaluation report should present the results of the experimental studies of the intervention and synthesize findings from other randomized control trials conducted as part of the initiative. This recommendation flows from the observation that the summative evaluation is not the only scientifically based research being conducted for the project. It recognizes that evidence of impact is best supported through multiple studies, rather than a single study (National Research Council, 2002). The evaluators are in a good position to synthesize that evidence and present that synthesis to the Corporation for Public Broadcasting and the U.S. Department of Education at the end of the project.

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Appendix 1: Key Word Search Terms

Online Learning

- ONLINE + (LITERACY OR "EARLY LITERACY" OR READING)
- ONLINE + (CHILDHOOD OR "EARLY CHILDHOOD" OR PREK OR KINDERGARTEN OR TODDLER OR K-3)
- WEB + (LITERACY OR "EARLY LITERACY" OR READING)
- WEB + (CHILDHOOD OR "EARLY CHILDHOOD" OR PREK OR KINDERGARTEN OR TODDLER OR K-3)
- INTERNET + (LITERACY OR "EARLY LITERACY" OR READING)
- INTERNET + (CHILDHOOD OR "EARLY CHILDHOOD" OR PREK OR KINDERGARTEN OR TODDLER OR K-3)
- ONLINE + PRESCHOOL + (READING OR LITERACY)
- ONLINE + PREK + (READING OR LITERACY)

Reading Software for Students pre-K to Age 8

- SOFTWARE + (LITERACY OR "EARLY LITERACY" OR READING)
- SOFTWARE + (CHILDHOOD OR "EARLY CHILDHOOD" OR PREK OR KINDERGARTEN OR TODDLER OR K-3)
- GAMES + (LITERACY OR "EARLY LITERACY" OR READING) + COMPUTER
- GAMES + (CHILDHOOD OR "EARLY CHILDHOOD" OR PREK OR KINDERGARTEN OR TODDLER OR K-3) + COMPUTER
- COMPUTER + (LITERACY OR "EARLY LITERACY" OR READING)
- COMPUTER + (CHILDHOOD OR "EARLY CHILDHOOD" OR PREK OR KINDERGARTEN OR TODDLER OR K-3)

Early Television Viewing

- (SYNTHESIS OR REVIEW) + RESEARCH + (TELEVISION OR MEDIA OR ONLINE OR COMPUTERS) + CHILDHOOD

Appendix 2: Studies Included in the Review

Television Studies

- Bryant, J., Mullikin, L., Maxwell, M., Mundorf, N., Mundorf, J., & Wilson, B. (1999). *Effects of two years' viewing of Blue's Clues. A report submitted to Nick Jr.* .Tuscaloosa, AL: Institute for Communication Research, University of Alabama.
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