2012 Preschool Pilot Study of PBS KIDS Transmedia Mathematics Content

A REPORT TO THE
CPB-PBS *READY TO LEARN INITIATIVE*

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CONTENTS

INTRODUCTION

The 2012 Preschool Pilot Study of PBS KIDS Transmedia Mathematics Content (Preschool Pilot) is an important part of our multiyear *Ready To Learn* (RTL) summative evaluation initiative. Through this initiative funded by the Corporation for Public Broadcasting (CPB) and Public Broadcasting Service (PBS), it was the responsibility of the Education Development Center, Inc. (EDC), and SRI International (SRI) to document and, whenever possible, to measure the impact of transmedia mathematics and literacy resources on learning for children from low-income families across a variety of settings: early childhood classrooms, community settings, and home.

In this phase of the evaluation, we explored the potential of using technology (interactive whiteboards and laptops) and transmedia resources (digital videos and interactive games)—specifically games developed using the CPB-PBS RTL Mathematics framework, guided by the Common Core Standards (CCSSO/NGA, 2010) and created by trusted educational advisors—to enhance preschool mathematics teaching and learning. We used the Preschool Pilot to develop and test curricula supplements and teacher professional development programs and produce research designs and research instrumentation in preparation for a more rigorous study of transmedia use in early childhood classrooms involving a larger sample of children and teachers—the 2013 prekindergarten randomized controlled trial (Preschool RCT). At the same time, we used the study to gather important and useful knowledge about preschool mathematics instruction, and the possibilities and constraints shaping the use of leading-edge technologies and PBS KIDS transmedia resources in present-day preschool classrooms. To best understand the design and findings of this research, it is important to bear in mind the current state of early mathematics research and practice in early childhood settings.

Research and curriculum initiatives in the preschool mathematics field have accelerated in recent years, but are still in an early stage of development compared to other areas of preschool focus such as early literacy (e.g., Opening the World of Learning (OWL); Wilson, Morse, & Dickinson, 2009) or social and emotional development (e.g., Second Step; Frey, Hirschstein, & Guzzo, 2000). In designing the Preschool Pilot, we drew on a number of important resources from the pioneering mathematics work of Herb Ginsberg (Ginsburg, Greenes, & Balfanz, 2003; Ginsburg, Klein, & Starkey, 1997) and Doug Clements and Julie Sarama (2004, 2007, 2009). We also relied on our own findings from our 2011 Ready To Learn context study (Education Development Center & SRI International, 2011). In that study, we observed 32 early-childhood and summer-learning-program classrooms, documenting teachers' typical mathematics instruction, their use of technology, and their hopes for instruction and technology in the future.

Our 2011 CPB-PBS RTL context study confirmed the work of others (e.g., Frede & Barnett, 2011), revealing that preschool teachers in our sample received little formal instruction or support to teach mathematics and, for the most part, had limited access to structured curriculum to guide their instruction. Additionally, the context study highlighted that mathematics instruction in general was limited in preschool classrooms, but that when it did occur, teachers were routinely engaged in basic math teaching and learning such as counting out loud, reviewing the names of basic shapes, reading and writing numbers, and sorting and classifying objects on broad level characteristics. While this suite of skills represents traditional early-childhood mathematics that preschool teachers teach with a degree of comfort, research (Balfanz et al., 2003) has suggested that, on the whole, preschool teachers are less comfortable teaching more advanced (yet developmentally appropriate and educationally important) mathematics such as subitizing and identifying shape angles (corners). Further, even when teachers theoretically had access to curricular materials to support their mathematics instruction (74% of our context study participants), these were most frequently published curriculum "systems" (e.g., *Creative Curriculum,* Dombro, Colker, & Dodge, 1999; *High Scope,* High/Scope Research Educational Foundation,1989) that provide only the frameworks for mathematics instruction, not specific activities, materials, or teacher supports for the everyday teaching and learning of more advanced preschool mathematics. These findings suggested the materials used in our Preschool Pilot should provide more structured supports for preschool teachers to successfully enact a full range of mathematics instruction and a way to integrate this instruction with their everyday teaching strategies and practices both related to mathematics and in general.

RESEARCH APPROACH

For the Preschool Pilot, we used a design-based research approach to develop two mathematics curriculum supplements—one rich in PBS KIDS transmedia, and one using only hands-on materials—that each cover ten weeks of material for preschool teachers and children (this includes two weeks of "ramp up"). This design allowed us to be responsive to the *Ready To Learn* evaluation parameters set by CPB and PBS which included the inclusion of RTL transmedia games and PBS KIDS videos into the supplement design and the use of interactive whiteboard (IWB) units, while contending with the lack of existing supplemental mathematics materials that allow preschool classrooms to address important, developmentally appropriate mathematics concepts and skills. Our approach also allowed us to incorporate technologies and transmedia resources that may become important components in future early-learning environments but are not currently a part of early-learning environments, including those serving children living in lower-income households.

We had four goals in conducting the Preschool Pilot. First, we wanted to explore how the PBS KIDS transmedia materials could help children develop targeted early mathematics skills. For the purpose of this study, transmedia includes the use of familiar characters, settings, and narrative themes or stories across different media formats, such as digital video, interactive online games, and interactive whiteboard (IWB) applications. Second, we wanted to explore how leading-edge classroom technologies—laptop computers, broadband Internet connectivity, and IWBs—could be used synergistically with more typical preschool learning materials (e.g., pattern blocks and dominoes) to support early mathematics learning. Third, we wanted to establish how specialized training and coaching could assist preschool teachers in successfully implementing a mathematics curriculum supplement. Finally, we wanted to create and test technical and logistical systems that will be necessary for the Preschool RCT. These goals drove the preparation work we did throughout Year 2 and shaped the 16-week schedule we followed during core implementation of the Preschool Pilot in Spring 2012. Table 1 outlines the professional development, implementation, research, and technology (transmedia-rich condition only) timelines for both conditions.

Table 1. 16-Week Pilot Schedule

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Preparation			**Study Implementation**										**Post**		
Tech Installation		Ongoing In-Classroom Technology Support											Tech Removal		
Child Pre-Assessments			Ramp Up		Full Implementation of Curriculum Supplement with Teachers and Children								Child Post-Assessments		
	Teacher Professional Developement				Coaching										
		Teacher Survey				Implementation Observations							Teacher Survey		

RESEARCH DESIGN COMPONENTS

APPROACH TO EARLY MATH INSTRUCTION

Following research on early mathematics learning for children from low-income families (Balfanz et al., 2003; Ginsberg et al., 1997), we approached the Preschool Pilot with the theory that young children, including those in low-income communities, already use mathematical thinking and are able to develop new mathematical skills and knowledge. In fact, children's latent mathematical skills, theories, and knowledge can be a useful foundation for formal instruction in mathematics. We also took into account that well-trained preschool teachers able to guide mathematics experiences provide the best support for such learning. Finally, we believed this support is particularly important for children in traditionally underresourced communities, which often do not have access to a stimulating and challenging preschool mathematics learning environment to support their early mathematics learning (Ginsburg, Lee, & Boyd, 2008).

The content and sequencing of the PBS KIDS transmedia-rich and comparison mathematics curriculum supplements used in the Preschool Pilot drew on the work of Herb Ginsberg, Doug Clements, and Julie Sarama. In particular, the Clements and Sarama *Building Blocks* curriculum (Sarama & Clements, 2004) provided strong examples of how to introduce and sequence mathematics skills that preschool teachers are comfortable in addressing and with which they tend to be less experienced. Ginsberg's *Big Math for Little Kids* (Ginsburg et al., 2003) provided evidence-based examples of mathematics topics, skills, and activities.

APPROACH TO TRANSMEDIA AND TECHNOLOGY

Findings from the 2009 CPB-PBS *Ready To Learn* randomized controlled trial—where we engaged in a large-scale evaluation of a media-rich literacy curriculum supplement (Penuel et al., 2009)—provided the theoretical grounding for the approach used in creating the transmedia-rich curriculum supplement for the Preschool Pilot: anchoring activities around weekly video-co-viewing and including a mix of transmedia-rich and hands-on traditional prekindergarten activities throughout the curriculum supplement. As in that study, we began from the understanding that media and technology resources have particular strengths and affordances for learning and are powerful tools for teaching, but are most valuable when thoughtfully sequenced to complement and enrich established routines and activities. Additionally, McManis and Gunnewig (2012) reaffirmed our approach with conclusions that making technology educational in early childhood classrooms settings often means the presence of adults nearby, interacting with children and providing peer-peer interaction. They also noted that, akin to our approach, research suggests that technology use has positive outcomes for children if it (1) is developmentally appropriate, (2) includes tools to help teachers implement the technology successfully, and (3) is integrated into the classroom and the curriculum.

APPROACH TO COACHING

Coaching also played an integral role in the 2009 RCT (Penuel et al., 2009), and findings from that study and others (Ackerman, 2008; Bowman et al., 2001; Chen & Chang, 2006; Poglinco & Bach, 2004) suggested that, in order to successfully implement new practices in the classroom, teachers need professional development, support, and just-in-time guidance. For the Preschool Pilot, we created a similar coaching model where “expert instructors” supported preschool teachers in their efforts throughout implementation of the curriculum supplements. Each teacher in both conditions received coaching prior to enacting the first week of the curriculum supplements and in varying dosages throughout the Preschool Pilot. Coaches worked with one to three teachers (with most working with two teachers) to introduce materials and the curriculum supplement and to provide frequent co-modeling in the early weeks of implementation. Coaches met with teachers at least four times each in the early weeks of implementing the curriculum supplements. Coaches followed a general coaching model, but adjusted implementation support based on teacher need and their own assessment of teacher implementation. For most teachers, visits from coaches decreased from twice a week to once a week over the course of implementing the supplements, with some teachers chosing telephone or e-mail communication in later weeks over in-person visits. A few teachers requested one or two visits a week throughout the entire implementation.

APPROACH TO RESEARCH SYSTEMS AND PROCESSES

Because the summative evaluation team will be responsible for all aspects of the Preschool RCT, it was important during the Preschool Pilot to create and test the important research systems and work processes essential for a successful Preschool RCT, including development and broad distribution of learning materials and teacher guides to classrooms; development and implementation of adequate teacher professional development and support; instrument selection and development; training for data collection; and ensuring that methods were in place to collect, store, and process large quantities of qualitative and quantitative data. All these activities also were informed by the implementation of 2009 CPB-PBS *Ready To Learn* RCT (Penuel et al., 2009).

SYNERGY OF DESIGN COMPONENTS

The above four core research design and implementation components—early math instruction, PBS KIDS transmedia and technology, coaching, research systems and work processes—constituted the basis of our Preschool Pilot study. Independently, they are all crucial parts of a successful mathematics curriculum supplement study; however, it was how they worked together to create not only the supplemental materials and logistical framework for data collection but also a system of support and structure for high-quality early mathematics instruction that was crucial to the design. We describe aspects of this design, and the two math curriculum supplements in particular, in much greater detail in the sections below, but the basic elements that brought the design of the supplements together into a research study included the following:

- A 10-week PBS KIDS transmedia-rich math curriculum supplement (transmedia-rich group)
- A 10-week hands-on math curriculum supplement (comparison group)
- Printed curriculum supplements guides, in-person professional development, and ongoing coaching for participating preschool teachers
- Resources needed to enact the curriculum supplements, including hands-on materials, as well as technology tools and digital resources (PBS KIDS videos and games) for the transmedia-rich condition only
- Installation of technology tools and ongoing technical support for preschool teachers in the transmedia-rich group
- A beliefs-and-attitudes survey for preschool teachers, and an observation protocol focused on implementation of the curricular supplements
- A battery of child assessments before and after implementation of both of the curriculum supplements
- Weekly logs for teachers and coaches to reflect on their experiences with the curriculum supplements

RESEARCH QUESTIONS

In designing the CPB-PBS *Ready To Learn* Preschool Pilot, we wanted to answer two kinds of research questions. The first were questions focused on the content and enactment of the transmedia-rich and comparison mathematics curriculum supplements. In particular, we sought to identify components of each supplement that were strong and ones that might benefit from revision in advance of the Preschool RCT. These research questions were as follows:

- What features of the PBS KIDS transmedia-rich mathematics curriculum supplement and comparison supplement (activities, technology, and coaching) worked well?
- How can the PBS KIDS transmedia-rich mathematics curriculum supplement be improved to make it stronger for the full RCT?

We also focused our attention on potential impacts of the PBS KIDS transmedia-rich mathematics curriculum supplement on the mathematics skills of the children participating in the Preschool Pilot, and on the attitudes and beliefs of the preschool teachers enacting the curriculum supplements. These research questions were as follows:

- Do preschool teachers implementing the PBS KIDS transmedia-rich mathematics curriculum supplement change their views about teaching mathematics, and how does this change compare to that of teachers who implement the comparison supplement?
- Do children in classrooms implementing the PBS KIDS transmedia-rich mathematics curriculum supplement make significantly more gains in math relative to children in classrooms that enact the comparison supplement, which does not use technology or PBS KIDS transmedia content?

PBS KIDS MATH CURRICULUM SUPPLEMENTS

In order to address the Preschool Pilot research questions, we needed to develop a transmedia-rich mathematics curriculum supplement from the ground up, given the evaluation parameters set by the CPB-PBS *Ready To Learn* Initiative, that is, incorporating PBS KIDS videos, transmedia games, addressing math skills included in the RTL mathematics framework, and using interactive whiteboards (IWBs) in classrooms. Also, because no comparable, nonmedia early-childhood mathematics curricular supplement exists, we also elected to develop one to serve as our comparison. Given the narrow mathematics instruction preschool teachers reported implementing in the 2011 *Ready To Learn* context study (Education Development Center & SRI International), we decided that the best comparison condition for the Preschool Pilot Study would be one that provided preschool teachers with comparable mathematics content and professional development, altering only the inclusion of technology. This approach also provided additional opportunity to understand how traditional math activities with manipulatives support learning and can complement transmedia-rich activities.

Several logistical and practical factors, in addition to the theoretical frameworks mentioned above, contributed to our approach in developing both the PBS KIDS transmedia-rich supplement and the comparison supplement for the Preschool Pilot. First and foremost, we strove to develop a 10-week curriculum supplement that would augment what preschool teachers typically do when supporting mathematics learning. Findings from our 2011 Ready To Learn context study (Education Development Center & SRI International, 2011) indicated that, although mathematics instruction in general was limited, the majority of teachers (98% of the sample) taught counting if and when they taught math. Thus, we used counting as an entry point in the curriculum supplements. This approach allowed teachers to begin with a familiar skill as they took up the task of teaching the more advanced mathematics that research suggests children are capable of mastering (Baroody, 2009; Ginsburg et al., 2003; Sarama & Clements, 2009a). For teachers in the PBS KIDS transmedia-rich condition, this approach also was intended to facilitate their integration of transmedia and technology into their classrooms.

We also carefully considered the mathematics skills framework developed by CPB-PBS in their efforts to address relevant and important early-childhood mathematics skills with their PBS KIDS transmedia. For the transmedia-rich condition in particular, we drew on the CPB/PBS *Ready To Learn* properties available as the supplement went into production; beginning with our 2011 RTL context study, we carefully vetted all existing CPB-PBS *Ready To Learn* PBS KIDS online games for age appropriateness and mathematics skills addressed. We then reviewed existing PBS KIDS videos to identify potential mathematics content present in video properties that were developed prior to the RTL initiative, so, although videos related to the transmedia games developed for RTL in story line and character, they were not produced with specific mathematics content in mind (no videos were produced as part of the RTL initiative,[1] only transmedia games and related activities). We then culled all of the videos and games that best addressed the core skills the supplements focused on: counting, recognizing numbers and subitizing, recognizing and composing shapes, and patterning and developed a transmedia-rich supplement that included transmedia content from several different RTL-funded producers along with traditional hands-on materials that we believed would function well within the context of a typical early-childhood classroom's schedule and routines. The comparison supplement addressed the early mathematics skills covered in the transmedia-rich condition and matched the content of the transmedia games where possible, to provide mathematics instruction in hands-on, nontechnology ways.

We used a spiral curriculum design model (Bruner, 1960) for both the transmedia-rich and comparison supplements. In this model, teachers introduce content and skills and then provide repeated and increasingly sophisticated activities for children to understand, practice, refine, and master previously introduced material. The repetition and increasing complexity allotted by the *introduce-practice-review* approach to both curricula supplements was critical to the design. Allowing children time, space, and a variety of different opportunities to learn and practice skills is crucial for their early knowledge and deepening understanding of mathematics skills (Wiggins & McTighe, 1998).

1 Videos were not developed during Years 1 or 2 of RTL, but will be produced in Years 3 and 4.

COMMON COMPONENTS

While the PBS KIDS transmedia-rich and comparison mathematics curriculum supplements represent distinct approaches to supporting mathematics learning, some core design elements were common to both conditions:

- **Theme of being a "mathematics detective."** Throughout the supplements, children were encouraged to be "mathematics detectives" and sleuth out mathematics in a variety of scenarios.
- **Common preschool activity formats: whole-group, small-group, paired and individual activities.** These groupings of instruction were based on the most common arrangements in current prekindergarten classrooms, each with its own affordances for teaching and learning. In particular we took into account the use of early childhood center-time areas—areas in the room that support independent learning and small group interactions—and used them for both hand-on activities and pop-up areas for computer use.
- **Professional development and coaching.** To support teachers in their efforts, each received at least two personalized one-on-one professional development sessions with a coach—an instructor experienced in the implementation of the curriculum supplements—prior to beginning implementation. Coaches then continued to visit or contact teachers via phone or e-mail weekly throughout the duration of the Preschool Pilot, providing support to enact the supplements.
- **Structured experiences.** We designed both supplements for implementation to occur 4 days a week, for no more than 2.5 hours a week over the course of 10 weeks. Full implementation of each curriculum supplement began after an initial introductory or ramp-up period with fewer activities and more support provided for teachers.
- **Teacher guides.** Two-part booklets contained the activities, suggested script, and suggestions for instruction for the first half (Book 1) and the second half (Book 2) of the supplements. The guides began by reviewing preschool mathematics skills covered in the curricula supplements as well as the study plan from pre-assessment to ongoing implementation to post-assessment. In the transmedia-rich condition, the guides also contained tips for introducing technology to children; a review of the RTL properties included in the curriculum supplement; and the delivery, installation, and removal schedule for technology.
- **Comprehensive materials.** Teachers received everything they needed to enact either the transmedia-rich or comparison mathematics curriculum supplements. From technology to manipulatives to dry-erase boards and markers, everything necessary was provided for all teachers based on the mathematics curriculum supplement being implemented.

PBS KIDS TRANSMEDIA-RICH MATHEMATICS CURRICULUM SUPPLEMENT

CONTENT AND TRANSMEDIA SELECTION

We began construction of the PBS KIDS transmedia-rich curriculum supplement by identifying four mathematics topics from the RTL Mathematics framework; we identified topics by using a number of parameters including topics for which a variety of transmedia already existed and topics likely to be most developmentally appropriate for our sample of children at the midyear point (when the supplement was being implemented), as well as a combination of topics that made pedagogical sense to teach together. Using prior research (e.g., Ginsburg et al., 2003; Clements & Sarama, 2009a), including our own 2011 RTL context study, we decided upon the four areas of counting, recognizing numbers and subitizing, recognizing and composing shapes, and patterning as the focus of our curriculum supplements.

Next, members of the summative evaluation team reviewed videos available via PBS KIDS and PBS's Kids Lab websites and identified eight videos that contained the most potential in terms of addressing mathematics skills included in our supplements – keeping in mind these videos were produced prior to the RTL initiative, so they did not contain math content explicitly; however, these videos all represent properties for which the RTL initiative was developing transmedia gaming suites that addressed specific math skills. We then identified between three and four points in each video where a teacher could address one of our targeted math concepts. We evaluated all available RTL games on the PBS KIDS Lab website for age appropriateness, reviewed their content and game mechanisms, and selected those that best supported teaching and learning of our four targeted mathematics skills (For a list of digital assets, see Appendix A: Digital Assets Included in the PBS KIDS Transmedia-rich Mathematics Curriculum Supplement). In addition to identifying which games best addressed the concepts we aimed to cover in our supplements, we also identified which games would be best facilitated in a whole-group situation given their complexity (challenge games) and which games children would likely be able to navigate with less support (easy games) (See Appendix B: Transmedia by Difficulty in the PBS KIDS Transmedia-rich Mathematics Curriculum Supplement for a list of RTL transmedia by difficulty in the transmedia-rich mathematics curriculum supplement).

The selected transmedia was then assembled into a 10-week experience of sequenced progression, covering all four of the targeted mathematics topics in a spiral curriculum design model (See Appendix C: Digital Assets by Week in the PBS KIDS Transmedia-Rich Mathematics Curriculum Supplement). Experiences with the transmedia were supported and enhanced with more traditional hands-on preschool activities.

TECHNOLOGY TOOLS

Although some participating sites had limited technology prior to the Preschool Pilot (usually a desktop computer with Ethernet Internet access), we found it necessary to provide all of the technology required for the transmedia-rich curriculum supplement to ensure full and smooth implementation.

Teachers enacting the PBS KIDS transmedia-rich mathematics curriculum supplement received as follows:

- One interactive whiteboard (IWB) with laptop and projector situated on an IWB cart specially designed for use with young children (For an image of the IWB set-up, see Appendix D: Image of IWB Set-up.)
- Four laptop computers with four external mice and eight headphones for use by the children in the laptop center-time area (splitters were supplied so each laptop could accommodate two headphones)
- Wireless routers and 3G wireless broadband Internet access (when needed)
- Access to all of the featured transmedia via a Drupal site

To support teachers' use of the transmedia, we created a Drupal site that collected and organized by week all of the transmedia (video and games) used in the supplement in one convenient web page. (See Appendix E: Drupal Support Site for a screenshot of the Drupal site). By corralling all required transmedia resources, this "walled garden" helped teachers know right away which video to show and which games were featured each week. Another benefit of the Drupal site was that teachers were able to download a video prior to showing it to children. Downloading allowed for smooth viewing in preschool centers where inconsistent Internet speeds (and suspected "throttling" or intentional slowing of Internet service by providers) hampered streaming speed and ability. All laptops—the one associated with the IWB and those in the laptop center-time area—had the Drupal site as their homepage.

HANDS-ON MATERIALS

By design, hands-on activities played an important role in the PBS KIDS transmedia-rich supplement. In addition to technology tools, teachers also received two boxes of hands-on materials including the following:

- Paper-based classroom materials (e.g., large number lines, shape and pattern signs)
- Paper-based games (e.g., shape concentration cards, number cards)
- Manipulatives (e.g., counting bears, pattern blocks, foam dice)
- Seven children's books about mathematics (see Appendix F: Curriculum Supplement Books for a list of books)
- Mathematics Detective Journals (notebooks) for each child in their class

INSTALLATION/REMOVAL OF TECHNOLOGY

To facilitate proper and immediate use of the supplied technology tools, members of the summative evaluation team assembled, delivered, and installed technology for the transmedia-rich curriculum supplement classrooms. IWB carts and accessories, including the projector and laptop, were assembled prior to installation and all laptops were configured to support the use of the specific transmedia.

All preschool centers participating in the transmedia-rich condition had Internet access; however, most did not have wireless capabilities, and others had classrooms with signals too weak or bandwidth too limited to enable access to transmedia resources. We installed wireless routers in three quarters of the participating classrooms. In half of those classrooms, we also installed a 3G wireless broadband access point. Despite these resources, most classrooms still experienced intermittent difficulties with Internet speed; in some cases the Internet connection was too slow at particular times of the day to stream videos or play digital games without interruption. This "throttling" was especially problematic because we had no way to control or remedy the situation.

At the conclusion of the Preschool Pilot, we uninstalled and removed the IWB, including the cart and associated laptop and projector, as well as two laptop computers and accessories, leaving two laptop computers and accessories (two mice, two headphone splitters, four headphones) as a technology donation. Wireless routers remained installed at locations where removing them would diminish access to online content.

SCHEDULE

In the Teachers' Guide, we provided a recommended implementation schedule for the PBS KIDS transmedia-rich mathematics curriculum supplement (an example is shown in Table 2).

Table 2. Weekly Schedule of PBS KIDS Transmedia-rich Mathematics Curriculum Supplement

Recommended Schedule

Monday	Tuesday	Wednesday	Thursday	Friday
Video Co-Viewing (25 minutes)	Guided Challenge Game Play (25 minutes)	Math Detective Journal with Easy Game Play (15 minutes per group)	Weekly Math Circle Routine with Guided Reading (25 minutes)	
Centers (10+ minutes)	Centers (10+ minutes)	Centers (10+ minutes)	Centers (10+ minutes)	

We designed the supplement so that each week teachers would use PBS KIDS videos and games to introduce early mathematics concepts. In the case of games, teachers would have a place for children's independent practice on the week's activities and skills. We designed the first day of each week to have teachers introduce the concepts and skills for the week through a 12- to15-minute video-co-viewing experience.[2] We provided teachers with a video to actively watch with children on the IWB and invited them to pause at predetermined times during viewing to discuss a mathematics skill or answer a question using mathematics with children. We also provided teachers with games from the PBS KIDS Lab website[3] to be played on the IWB in either whole-class or small-group arrangements on two other days of the week. Before children played independently, teachers were to model game playing, and children had the opportunity to practice the games in front of their peers on the IWB. After the initial ramp-up period, teachers were expected to use the PBS KIDS transmedia-rich curriculum supplement more intensively. To give teachers flexibility in implementation, we provided them with schedules that allowed them to use supplement activities for 3, 4, or 5 days per week.

By design, center-time activities were presented each day of the supplement as well. Paper-based games and manipulatives (such as pattern concentration cards and counting bears, respectively) served as a familiar medium for additional practice with mathematics concepts and skills, while pop-up laptop center-time areas—nonpermanent center-time areas created on the spot as needed and placed where the space existed at the time—allowed children using headphones with a partner to revisit the games they played on the IWB.

Additionally, each week, teachers read a mathematics-related book to the class and repeated a number of circle-time activities, such as counting the number of boys and the number of girls present and comparing numbers. Each week teachers used Mathematics Detective Journals, a notebook for each child, to document something mathematics-related that the "detectives" were working on or to practice a new skill, such as using tally marks to count how many shapes they drew.

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2 Videos were included from the properties *The Cat in the Hat Knows a Lot About That, Sid the Science Kid,* and *Curious George.*

3 Games were included from the properties *The Cat in the Hat Knows a Lot About That, Sid the Science Kid, Curious George*, and *Dinosaur Train*.

TEACHER SUPPORTS

Prior to implementing the PBS KIDS transmedia-rich mathematics curriculum supplement, teachers received at least two professional development sessions with coaches. These one-on-one sessions included training on the technology as well as an overview of early-childhood mathematics concepts and a detailed walk-through of the curriculum supplement and accompanying guide and materials. By design, teachers worked closely with their coaches during the first two ramp-up weeks of the PBS KIDS transmedia-rich supplement; coaches co-taught, modeled, and observed lessons. Coaches continued to support teachers throughout the remaining 8 full implementation weeks of the transmedia-rich supplement, providing regular feedback or targeted problem-solving support and assistance.

Coaches, along with technical staff, provided just-in-time and regular check-in support of technology and helped solve problems as they arose, as teachers did not otherwise have access to technology support.

COMPARISON MATHEMATICS CURRICULUM SUPPLEMENT

CONTENT SELECTION

We modeled the comparison mathematics curriculum supplement after the PBS KIDS transmedia-rich supplement. Specifically, the same four targeted math concepts were addressed: counting, recognizing numbers and subitizing, recognizing and composing shapes, and patterning. Additionally, to mimic the video co-viewing that anchored the week's activities, the comparison classrooms began each week with an "introductory activity with visuals" using large chart paper in a whole-group, teacher-led format. We replaced IWB games with hands-on games that covered the same mathematics content, and in some cases the same game mechanics. For instance, the hands-on game Fruit Party was born out of Curious George's Fair Shares. In both games, the player divides items among participants: in Fair Shares, the player digitally distributes dog bones to dogs; in Fruit Party, the player divides plastic fruit among peers at a party.

No transmedia assets were provided as part of the comparison mathematics curriculum supplement.

HANDS-ON MATERIALS

Teachers in the comparison mathematics curriculum supplement received the same two boxes of hands-on materials as teachers in the PBS KIDS transmedia-rich supplement condition. In addition, teachers in the comparison condition also received another box of materials to enact their supplement, including as follows:

- More classroom materials (e.g., chart paper, markers)
- More paper-based games (e.g., bingo-type cards, game board number paths)
- More manipulatives (e.g., ice cube trays, Oops! Boards made of foamcore board to create number lines with Velcro to attach wooden number tiles)

INSTALLATION/REMOVAL OF TECHNOLOGY

No technology was installed as part of the comparison mathematics curriculum supplement; however, two laptops and accessories (mice, splitters, headphones) were delivered to teachers enacting the comparison supplement as a technology donation at the conclusion of the Preschool Pilot study.

SCHEDULE

In the Teachers' Guide, we provided a recommended implementation schedule for the comparison mathematics curriculum supplement—a schedule similar to the PBS KIDS transmedia-rich condition, shown in the example in Table 3.

Table 3. Weekly Schedule of Comparison Mathematics Curriculum Supplement

Recommended Schedule

Monday	Tuesday	Wednesday	Thursday	Friday
Introductory Activity with Visuals (25 minutes)	Guided Challenge Game Play (25 minutes)	Math Detective Journal with Easy Game Play (15 minutes per group)	Weekly Math Circle Routine with Guided Reading (25 minutes)	
Centers (10+ minutes)	Centers (10+ minutes)	Centers (10+ minutes)	Centers (10+ minutes)	

Each week, teachers began by introducing a mathematics concept using chart paper to discuss and show mathematics ideas to the children, using thoughtful questioning and searches for "math" around the room. These "introductory activity with visuals" experiences served as the anchors for the week's activities and skills. On two other days of the week, teachers played hands-on games in whole groups and in small groups with children, modeling and guiding practice with our targeted mathematics topics.

As with the PBS KIDS transmedia-rich math curriculum supplement, mathematics-based center-time activities were presented each day of the week in the comparison supplement. Paper-based games and manipulatives (such as pattern concentration cards and counting bears, respectively) served as a familiar medium for continued practice with mathematics concepts and skills. Unlike the PBS KIDS transmedia-rich supplement where a pop-up laptop center-time area was present along with hands-on activity center-time areas, the comparison supplement used two different hands-on activity center-time areas each day.

Teachers enacting the comparison supplement read the same books and did the same weekly circle routine as the PBS KIDS transmedia-rich condition. They also completed the same Mathematics Detective Journal activities.

TEACHER SUPPORTS

As with the PBS KIDS transmedia-rich supplement, teachers received at least two professional development sessions with coaches prior to implementing the comparison mathematics curriculum supplement. Their one-on-one sessions included an overview of early-childhood mathematics concepts and a detailed walk-through of the curriculum supplement and accompanying guide, as well as a review and inventory of all of their hands-on materials. Again, teachers worked closely with their coaches during the first two "ramp-up" weeks, having coaches observe, model, or co-lead activities. Coaches continued to support teachers throughout the remaining eight full implementation weeks of the comparison supplement, providing regular feedback or targeted problem-solving support and assistance.

RESEARCH METHODS

This section describes the instruments and procedures we used for collecting qualitative and quantitative data throughout the study. To understand better enactment of the PBS KIDS transmedia-rich and comparison conditions, we conducted a series of structured observations and asked preschool teachers and coaches to describe each week using implementation logs. To gauge possible changes in teacher attitudes and beliefs, we surveyed teachers before and after the experience about their attitudes toward mathematics and mathematics teaching and learning. To detect changes in children's mathematics skills and knowledge over time, we administered both supplement-based and standard mathematics assessments, and also measured children's capacity to self-regulate using another standard measure. The following section describes the data-collection instruments and measures in detail. Subsequently, we describe the sample of teachers and children in the study and the important limitations to this research that provide necessary context for our findings.

DATA COLLECTION AND MEASURES

IMPLEMENTATION

We collected data on the implementation of the math curricular supplements from the participating classrooms using weekly teacher logs, weekly coach logs, and classroom observations. The data from the weekly logs and the classroom observations will inform the upcoming RCT, as revisions to the curriculum supplement will be based on the design team identifying activities in both supplements that worked well and the areas that need strengthening.

Weekly teacher logs. Data from the teacher logs provide an important vantage point from which we can examine classroom enactment of the supplement activities. The teacher log consisted of a number of open-ended questions, designed to garner insights about teachers' experiences—specifically activities that they found exciting or frustrating—and factors particular to each classroom that affected implementation of supplements. Open-ended questions were supplemented by a number of quantitative items, designed to gather information about the frequency of a particular pattern of implementation. The weekly teacher logs provide data to identify and understand the patterns of implementation that characterize the sample of participating classrooms as a whole and to explore differences, if any, between classrooms in the PBS KIDS transmedia-rich and comparison conditions. Because the data were gathered weekly, we were also able to examine the patterns associated with each week of implementation. (See Appendix G: PBS KIDS Transmedia-Rich Math Curriculum Supplement Teacher Log, Weeks 9-10 for a sample copy of teacher logs.)

Topics from the weekly teacher logs related to the classroom enactment of activities, including the amount of time taken for specific activities, teachers' perceptions of how well the activity worked in the classroom, the challenges and successes teachers encountered while using the materials and implementing activities, and the types of coaching assistance they received. We also tracked when and how teachers modified supplement activities. Additionally, teachers implementing the PBS KIDS transmedia-rich math curriculum supplement provided specific information on the challenges related to the use of technology and the technology support they received from coaches.

The teacher logs for implementation week 10 (the last week of implementation) included additional questions that prompted all preschool teachers to reflect on the entire 10-week implementation experience. These questions addressed topics regarding implementation scheduling; the extent to which teachers were satisfied, overall, with the curriculum supplements and the professional development provided by their coach; and teachers' recommendations for improving the supplements and the accompanying professional development and coaching model.

Weekly coach logs. Coach logs complemented the teachers' logs by providing information on implementation, and offered additional insights, from the coaches' perspectives, into teachers' preparedness to implement the PBS KIDS transmedia-rich and comparison supplements. Also, the coach logs helped us understand how the coaching model unfolded in practice and the specific types of assistance that coaches require in order to effectively support participating teachers. (See Appendix H: PBS KIDS Transmedia-Rich Math Curriculum Supplement Coach Paper Log – Week 10 for a sample copy of coach logs.)

Items on the coach logs addressed activities that, in the coaches' opinion, were more successful in the classroom, as well as activities with which they observed children or teachers struggling. The coach logs included questions about the frequency and nature of coaches' contact with teachers, the types of assistance that coaches provided to teachers, implementation successes and challenges, and specific barriers that teachers may have encountered. The coach logs for the transmedia-rich classrooms included questions about the integration of transmedia and technology, the challenges encountered with the use of technology, and the sorts of technology supports teachers may have received.

As with the teacher logs, week 10 of the coach logs invited reflection from coaches regarding the entirety of the 10-week curriculum supplement. It asked coaches to reflect on those activities that required additional support and asked for coaches' recommendations as to how the supplements and the coaching model could be modified and improved for the Preschool RCT.

Classroom observations. Data from the classroom observations provide a "holistic" picture of implementation of both the PBS KIDS transmedia-rich supplement and the comparison supplement in weeks 4 through 8. Conducting parallel observations of transmedia-rich and comparison classrooms, we also had the opportunity to contrast complementary activities in the two conditions and identify important differences, if any, which were associated with implementation. Classroom observation data highlighted both successful supplement features as well as areas for improvement. As a result, they provided useful guidance for revisions to the curriculum supplements—and the design of specific activities—that will be at the core of the Preschool RCT. Finally, the classroom observation data were yet another source of information that pinpointed the specific types of support that teachers require in order to successfully implement the supplements.

To collect classroom observation data, we visited each participating classroom, in both PBS KIDS transmedia-rich and comparison conditions, during a specific week of implementation. Classroom observations targeted the second half of the implementation period, starting with Implementation week 4. For any given implementation week, our goal was (1) to observe four classrooms, two in the PBS KIDS transmedia-rich condition and two in the comparison condition; (2) to complete two to three visits to each classroom; and (3) to observe PBS KIDS transmedia-supported and nonmedia activities during whole-class, teacher-guided small-group, and center-time sessions.

This arrangement provided the best opportunity to understand what each week looked like in any given classroom, to compare PBS KIDS transmedia-rich and comparison classrooms for corresponding activity types, and to identify patterns associated with preschool teachers' enactment and children's engagement/responsiveness for a given week and a given activity. Especially because study teachers had the flexibility to implement activities in a 3-, 4-, or 5-day-per-week schedule, we prepared an activity record for each class observed. The activity records synthesized researchers' observations of a particular activity, targeting the enactment of any given activity, the differences between actual enactment and the description of the activity in the curriculum supplement materials, children's participation in the activity, observed barriers to implementation, and observers' perceptions of how and why activities were successful in a classroom.

TEACHER OUTCOMES

Mathematics attitudes and beliefs questionnaire. To assess teachers' attitudes and beliefs toward mathematics, we asked teachers to complete a questionnaire recently developed by a group of early childhood mathematics researchers led by Drs. Jie-Qi Chen and Jennifer McCray at the Erikson Institute (2012). Teachers in both the PBS KIDS transmedia-rich and comparison conditions were asked to complete the questionnaire prior to implementation, then again at the end of implementation. We asked teachers to complete the questionnaire online, using a unique identifying number. In some cases, owing to technical challenges, teachers completed the survey using paper-and-pencil, with the research team transferring answers to the online system. We followed up with teachers individually to ensure they had no problems filling out the survey and to answer any questions that arose.

The mathematics attitudes and beliefs questionnaire was pilot-tested with over 300 Chicago public school teachers, as part of a study evaluating the implementation and examining the effects of a prekindergarten to a third-grade mathematics professional development program. Although the questionnaire is under development, preliminary evidence suggests that it has high internal consistency, with a Cronbach's alpha of 0.93. To complete the questionnaire, teachers are asked to rate items assessing their attitudes and beliefs regarding mathematics instruction and students' mathematical abilities on a 10-point Likert scale (where 0 = strongly disagree and 10 = strongly agree).

CHILD OUTCOMES

Direct Assessments of Children's Skills. To assess children's mathematics outcomes, we administered two early mathematics assessments: a short version of the Research Based Early Mathematics Assessment (REMA short version; Weiland, Wolfe, Hurwitz, Clements, Sarama & Yoshikawa, in press) which served as a standardized assessment of children's mathematics skills, and a supplement-based assessment (SBA) developed by our team to be closely aligned to the mathematics topics and skills included in the PBS KIDS transmedia-rich and comparison supplements. In addition, to assess children's self-regulation we administered the Head-Toes-Knees-Shoulders (HTKS; Ponitz et al., 2008), a recently developed and validated measure of young children's behavioral self-regulation.

Trained assessors administered the three assessments to children in both the transmedia-rich and comparison conditions prior to implementation and at the end of implementation. Assessors administered pretest assessments during several weeks prior to start of implementation and posttest assessments during several weeks after implementation ended. They administered the REMA on one day and the SBA and HSKT together on a separate day to avoid children becoming fatigued. Each session lasted approximately 20 to 25 minutes. We randomly assigned children to assessment order to avoid unintended order effects.

Standardized mathematics assessment. The short version of the REMA was recently developed by Weiland, Wolfe, Hurwitz, Clements, Sarama and Yoshikawa (in press) as an extension of the full REMA (Clements, Sarama & Lui, 2008), which was designed to assess children's mathematics learning in prekindergarten through second grade. The short version of the REMA measures preschool and kindergarten children's early numeracy and geometry skills. The 19 items selected to be part of the short version of the REMA assess mathematics skills that are considered essential in preschool and kindergarten (CCSO/NGA, 2010; Sarama & Clements, 2009b)—recognition of number and subitizing, composition of number, comparison and sequencing, counting, numeral identification, arithmetic, shape and shape composition, and patterning (Weiland et al., in press). Each item includes a game-like activity that involves the assessor reading a verbal prompt and, at times, demonstrating with manipulatives. Children are required to provide a verbal response, point, or engage with manipulatives.

Rasch analysis conducted on the short version of the REMA provides evidence of high item (approximately 1.00) and person (ranging from 0.68 to 0.76) reliability (Weiland et al., in press). Findings also indicate that the assessment is sensitive to detect differences in young children's mathematics ability levels and has adequate concurrent (correlations of 0.74 were reported with the full version of the REMA and the Woodcock Johnson Applied Problem subtest) and discriminant validity (correlations of 0.64 were reported with the Peabody Picture Vocabulary Test 3rd Edition and the Letter Word Identification subscale of the Oral Language Scale). Finally, differential item functioning (DIF) analysis for gender, home language, and socioeconomic status across different samples indicated that there is no DIF in the short version of the REMA.

Supplement-based mathematics assessment. To assess children's understanding of the concepts and activities included in the PBS KIDS transmedia-rich and comparison supplements, we developed the Preschool Pilot supplement-based assessment (SBA). The SBA assesses children's understanding of counting, number recognition and subitizing, shapes, and patterns. As in the REMA, items involve game-like activities that require assessors to read a verbal prompt and children to provide a verbal response, point, or engage with manipulatives. The 20 items included in the SBA mimic the format of the activities included in the supplement.

To ensure the items on the SBA would function as intended, we piloted the SBA on a small sample of preschool-age children prior to the study. Once data collection was complete, we conducted analyses to examine internal consistency and concurrent validity. Findings from these analyses indicate that the SBA has adequate internal consistency (Cronbach's alpha ranging from .73 to .78) as well as adequate concurrent validity (a correlation of .51 was observed with the short version of the REMA and a correlation of .32 with the HTKS).

Self-regulation assessment. The Head-Toes-Knees-Shoulders (HTKS) was developed as a more complex version of the Head-to-Toes Task that was designed to measure children's behavioral self-regulation. The Head-to-Toes Task involves asking children to follow a command (e.g., "Touch your toes") and then asking them to respond with a conflicting or nonautomatic response (e.g., "When I say 'Touch your toes,' touch your head"). The HTKS starts off with these two commands ("Touch your toes" and "Touch your head") and slowly becomes more complex by introducing two other commands ("Touch your shoulders" and "Touch your knees"). The HTKS requires children to use multiple cognitive skills, such as remembering rules and attending to verbal commands, and then applying them to their behavioral response. "These demands may be similar to those in classrooms, when children need to follow multiple instructions and finish one project before starting another or remember to raise their hand before participating" (Mathews, Ponitz, & Morrison, 2009, p. 693).

Studies using the Head-to-Toes and HTKS have reported high interrater reliability (e.g., Connor et al., 2010; Ponitz, McClelland, Matthews, & Morrison, 2009; Wanless et al., 2011). Studies also have found that higher behavioral-regulation (measured using the HTKS) is predictive of later mathematics and literacy achievement in early childhood (Ponitz et al., 2009; Wanless et al., 2011).

SAMPLE SELECTION

We drew largely on preschool centers and agencies that participated in the 2009 CPB-PBS *Ready To Learn* Literacy RCT or the 2011 context studies for sample classrooms for the Preschool Pilot. These preschool centers and agencies serve primarily 3- to 5-year-old children from low-income families in diverse communities. Eight classrooms (4 in each condition on each coast) implemented the PBS KIDS transmedia-rich and comparison supplements for a total 16 participating classrooms with 24 participating preschool teachers. All 8 classrooms on the east coast were taught by a single lead teacher. Four of the west-coast classrooms were team-taught by 2 teachers (1 transmedia-rich, 3 comparison) while two classrooms were team-taught by 3 teachers (1 transmedia-rich, 1 comparison). Two PBS KIDS transmedia-rich condition classrooms were taught by single teachers, resulting in 16 teachers participating on the west coast.

Classroom size, and thus children exposed to the curriculum supplements, ranged from 12 to 24 children (13 to 22 on the east coast, 12 to 24 on the west coast), with an average of 19 children per classroom. Although we attempted to recruit classrooms containing 4- and 5-year-old children only, some classrooms contained 3-year-old children. However, only 4- or 5-year-old children were assessed at pre- and posttest, with an average of 10 (west-coast) and 11.25 (east-coast) children assessed per classroom.

Eligibility for recruitment into the CPB-PBS *Ready To Learn* Preschool Pilot was based on the following requirements:

- Participants that came from Head Start and early childhood preschool programs in the greater New York City and San Francisco area not affiliated with public schools.
- Programs that were in reasonable proximity to EDC/SRI offices. Accessibility by the research team was key so that team members could provide coaching, troubleshoot, and support technology use in a timely manner.
- Classrooms that were part of preschool centers serving at least 50% for children from low-income families (i.e., children who qualify for subsidized preschool and/or free or reduced-price lunch).
- Classrooms that had at least eight 4- to 5-year-olds enrolled who were proficient enough in English to complete mathematics assessment tasks in English.
- The majority of classroom instruction had to be conducted in English.
- Participants had to be willing to use the mathematics curriculum supplements, receive training and coaching, complete surveys, and keep logs of their mathematics instruction.
- In the transmedia-rich condition only, participants had to be willing to use new classroom technology, even if they did not necessarily have those technologies or supports in place.

The research team contacted a total of 46 preschool centers by phone, 25 in the New York Metro area and 21 in the San Francisco Bay Area. Recruitment was on a rolling basis and, given the additional time and coordination for the transmedia-rich condition, preschool centers that agreed to participate in the study were assigned on a first come, first served basis to the PBS KIDS transmedia-rich condition, and then the comparison condition slots were filled. On the east coast, eight total classrooms, from 8 different preschool centers and 7 different agencies, were recruited into the Preschool Pilot, four in each condition. On the west coast, eight total classrooms, from 8 different preschool centers and 3 different agencies, were recruited into the Preschool Pilot, four in each condition.

All classrooms in the PBS KIDS transmedia-rich condition completed all 10 weeks of the supplement. Seven out of eight classrooms in the comparison condition completed all 10 weeks of the supplement; the eighth classroom completed 7 weeks of the supplement due to external factors. All preschool teachers and preschool centers received a modest stipend upon completion of the Preschool Pilot, along with a technology donation of two laptop computers, two external mice, two headphone splitters, and four pairs of headphones.

LIMITATIONS AND CONSTRAINTS

We devoted careful thought and considerable effort to the development of the research design and materials used in this study. Given the exploratory nature of pilot studies, and the limited early-childhood resources (e.g., supplemental mathematics curricula and scales/ assessments) available to us, we were mindful of the following limitations as important context for understanding the study and its findings.

First, the study sample is not representative of preschool populations in New York and California. We purposely selected classrooms that were interested in implementing mathematics curricular supplements and were willing to integrate technology into their classrooms. In addition, since programs volunteered and we assigned preschool classrooms to condition on a rolling basis (rather than by random assignment), there are potential biases or differences across conditions. We tested for baseline equivalence in child outcomes at the conclusion of the pilot and found that children in the PK Pilot study did not have significantly different scores on any of the three outcomes. Finally, given limited resources, our study included a small sample of classrooms—eight classrooms were recruited and participated in each condition. Therefore, the power to detect effects was low. (See Appendix I: Power Analysis.)

Although the curriculum supplements developed by our team were informed by early mathematics research and evidence-based curricula (e.g., Ginsburg et al., 2003; Sarama & Clements, 2009b), they were early iterations that were being pilot-tested by teachers as part of the design process. As expected, some aspects of the supplements and related lessons and materials were more successful than others, and findings from the analysis of pilot data will inform the revisions to the materials and the professional development and coaching components of the curriculum supplements. Similarly, given the recent focus on early mathematics and the lack of available instruments to assess mathematics in early childhood, the teacher questionnaire and child assessments we selected to measure teacher and child outcomes are recently developed assessments (e.g., the short version of the REMA and the HTKS) or assessments that are currently under development (e.g., the teacher attitude and belief questionnaire and the SBA). Therefore, we have limited psychometric information available. Findings from the analysis we conducted as part of the study will help inform future use of the questionnaire and assessments as well as revisions to the ones that we developed specifically for use in the study (e.g., SBA).

We also navigated a number of constraints in developing the mathematics curriculum supplements, including the limited availability of PBS KIDS transmedia games addressing the targeted math skills at the time of the supplement development, the inclusion of video properties that were not created with mathematical instruction in mind, and the challenges of supporting implementation in poorly equipped classrooms.

DATA ANALYTIC APPROACH

IMPLEMENTATION ANALYSIS

DATA COLLECTION

Teachers and coaches completed the teacher and coach logs, respectively, on a weekly basis. As we mention above, teachers' responses highlighted their experiences with implementing the supplements—successes, difficulties, and modifications—while coaches' responses emphasized the types of support that teachers required, teachers' general comfort with the implementation process, and other contextual factors that influenced implementation. The coach log consisted of two components: (1) a paper-and-pencil scannable log (Teleform) that coaches typically completed while they were on-site, working with teachers and (2) an online component that consisted of open-ended questions about classroom implementation, designed to invite coaches' reflection.

Response rates for both teacher and coach logs were high (> 90%), indicating that the conclusions drawn from these data can be assumed to apply to the study sample as a whole.

Table 4. Teacher Logs Data-Collection and Response Rate

Teacher Log	Total Responses	Response Rate
Both Conditions	151	94.37%
PBS KIDS Transmedia-Rich Group	74	92.5%
Comparison Group	77	96.25%

Table 5. Coach Logs Data-Collection and Response Rates

Coach Log	Teleform Log		Online Log	
	Total Responses	Response Rate	Total Responses	Response Rate
Both Conditions	157	98.12%	159	99.37%
PBS KIDS Transmedia-Rich Group	80	100%	80	100%
Comparison Group	77	96.25%	79	98.75%

Classroom observations, which were conducted during weeks 4 through 8 of implementation, included two to three visits to all participating classrooms, occurring during the same implementation week and designed to capture implementation of activities as they unfolded during the week. The observations also prioritized activities that offered the primary contrast between the PBS KIDS transmedia-rich and comparison supplements (Video Co-viewing/Introductory Activity with Visuals, Guided Challenge Game Play, Math Detective Journal/Easy Game Play, Computer Center-time/Hands-on Center-time) in order to gain an understanding of the enactment and of preschool teachers' and children's responses.

Table 6. Classroom Observation Data Collection

Observations	Classrooms	Individual Activities
Both Conditions	16	67
PBS KIDS Transmedia-Rich Group	8	37
Comparison Group	8	30

ANALYSIS

Following Auerbach and Silverstein (2003), our approach to the analyses of these data was exploratory, designed to uncover aspects of implementation that were successful and to identify other lessons salient for the implementation of the supplements with a larger sample of classrooms, teachers, and children during the Preschool RCT in Year 3.

Given that ours was a pilot study, the analysis focused on gathering information about the implementation of the PBS KIDS transmedia-rich and comparison math curriculum supplements in real-world classrooms. Our analysis involved the review of observation and log data to identify the emergent findings on features of successful and challenging activities and the types of support that teachers required in order to implement the supplements successfully. The analysis also paid special attention to children's participation in PBS KIDS transmedia-rich activities, teachers' and children's reactions to the integration and use of transmedia and technology and other contextual factors that affected the use and smooth functioning of technology, and the general implementation of the supplements.

The goals of the analysis were twofold. The primary emphasis of the analysis was to inform revisions to individual activities and the sequence of activities in the PBS KIDS transmedia-rich math curriculum supplement and modifications to professional development and the coaching model. A secondary goal of the analysis was to assess the performance of data-collection instruments and processes to inform how these could be improved and modified appropriately for use in the Preschool RCT.

The analysis of implementation data, including coach and teacher logs and classroom observation data, helps tell the story of how the two curriculum supplements unfolded in preschool classrooms and provides an empirical basis for conceptualizing what works, in what order, and in what kinds of classrooms. Using qualitative analysis software (Dedoose[4]), the research team aggregated and analyzed the classroom observation and teacher and coach log data to identify the main patterns in the data and organize them into coherent categories. The

4 For more information, go to http://www.dedoose.com.

topics for analysis included the lessons learned about the integration of the transmedia and technology into math learning, the performance of the two curriculum supplements in general, and the coaching and types of support provided to teachers.

We were interested in distinguishing themes that applied more generally to all classrooms in the sample or to all classrooms in the two conditions, from ones that were peculiar to certain classrooms, groups of teachers, and periods of implementation. Wherever appropriate, our analysis contrasted patterns observed among the classrooms and teachers implementing the PBS KIDS transmedia-rich supplement against the classrooms and teachers implementing the comparison supplement. Again, wherever appropriate, our analysis looked at patterns for each week of implementation as well as across all 10 weeks of implementation to detect patterns more typical of certain weeks of implementation (e.g., the start-up period) from patterns that applied more generally. The coach and teacher logs blended open-ended questions with other quantitative items designed to determine the frequency with which a pattern occurred (e.g., type of coach support, type of implementation challenge, etc.). The analysis of frequencies helped ground the qualitative data, distinguishing between more and less frequently observed patterns of activity and behavior.

TEACHER OUTCOMES

Prior to conducting analysis on the data collected using the mathematics attitudes and beliefs questionnaire, our team reviewed all 42 items in the questionnaire to identify items of interest (items that addressed or matched the theoretical rationale and goals of our study). Once data collection was complete, we extracted the data from the online system and used SPSS16 to conduct item-level analysis on the previously selected items. Because data were ordinal (the questionnaire used a 10-point Likert scale with 1 = strongly disagree and 10 = strongly agree), we did not compute means.[5]

Instead, we examined other, more appropriate measures of central tendency, such as the mode (or most frequent response), and graphed the distributions of responses to identify patterns of change in responses from pretest to posttest. Because graphical representations including all 10 responses would be difficult to visually interpret, we collapsed responses into three categories—a group including responses ranging from 1 to 3 (closest to disagree response), a group including

5 When data are ordinal (as the data collected using a Likert scale), one can examine whether one score is higher than another, but not how much higher (as can be done with interval data which tells the distance between two points). When using a Likert scale, one does not know whether the distance between two points is equal to the distance between two other points. Rather than calculating means as one would with interval data, we calculated modes and graphed distribution of responses.

responses ranging from 4 to 7 (closest to neutral response) and a group including responses from 8 to 10 (closet to agree response). We then examined the distributions descriptively to detect patterns of change in teacher's attitudes and beliefs towards mathematics.

CHILD OUTCOMES

We gathered data using the three direct assessments in scannable paper form: the short version of the REMA, SBA, and HTKS. Each assessment was then optically scanned by our research team to create an electronic data file. We cleaned the electronic file and verified the data (e.g., double-checked scanned entries to ensure accuracy and hand-entered any information that had not been recognized via scanning). We then coded item responses as necessary and scored each of the assessments. The short version of the REMA and the HTKS were scored using guidelines provided by the developers. We calculated both raw and Rasch scores for the short version of the REMA and raw scores for the HTKS and SBA. Once the assessments had been scored, we conducted a series of descriptive analyses using SPSS16. For the short version of the REMA and the SBA, we conducted item-level analysis (percentage of correct responses) to obtain a descriptive view of children's performance on different mathematic skills.

For all three assessments, we conducted repeated measures analysis to examine whether posttest scores were significantly different from pretest scores and whether improvements varied by condition. Finally, we conducted a series of multilevel analyses, using HLM6, to examine the effect of condition while accounting for the nested structure of the data (children nested within classrooms; see Appendix J: Multilevel Modeling Analysis for HLM formulas). We first conducted analysis to ensure baseline equivalence (that there were no differences in pretest scores across conditions). We then conducted a series of analyses to examine the effect of condition on children's gains in mathematics. For each of the three assessments, we first calculated an unconditional model to determine the child-level and classroom-level variability in each of the outcomes. Then we included age and pretest scores as covariates/predictors of each outcome at Level 1. Finally, we included condition as a predictor of each outcome at Level 2. To test potential moderation effects, we also examined potential cross-level interactions between age and condition and pretest and condition.

FINDINGS

In keeping with the pilot nature of this research, we placed our assumptions in the foreground. In preparation for the Preschool RCT, we began this pilot wanting to know what it will take to effectively study the learning potential of the CPB-PBS *Ready To Learn* transmedia assets when used in well-equipped preschool classrooms. As a result, the findings of this report are squarely about implementation of the curriculum supplements as well as teacher and child outcomes. Much more than generating desired headlines about teacher and children outcomes, the real work of this pilot was to delve into concrete details. We sought to test instruments, try out specific digital assets on particular platforms quite uncommon in preschool centers serving children from low-income families, learn about teachers implementing new approaches to math learning, and refine what we know about professional development and coaching.

IMPLEMENTATION

This subsection includes findings based on the analysis of implementation data, namely the classroom observations and the coach and teacher logs. Drawing from teachers' self-reported implementation experiences, coaches' observations and reflections on teachers' instructional practice, and researcher-conducted classroom observations, this subsection describes the patterns of implementation that occurred in classrooms implementing the PBS KIDS transmedia-rich and comparison supplements and all of their associated components.

In this analysis, our primary goal was to identify the successful features of both math curriculum supplements and the areas that require further strengthening in order to refine our design of the Preschool RCT. Additionally, our analyses shed light on the factors that shaped the classroom enactment of the two supplements, such as teacher-initiated modifications to the activities (that arose sometimes as a response to site-based constraints) and the resulting consequences for instruction and children's participation in supplement activities.

Our findings fall into three broad categories: (1) the integration of PBS KIDS transmedia-rich activities; (2) curriculum supplement content, including the concepts and skills addressed by the supplements, the design and sequence of activities, and the use of materials, involving both hands-on materials and the integration of PBS KIDS transmedia and technology; and (3) the professional development and coaching components associated with the supplements. In each of these categories, we highlight our starting assumption then describe patterns of implementation we observed. We outline the lessons learned and the implications of specific findings for the design and implementation of the Preschool RCT in Year 3.

INTEGRATION OF TRANSMEDIA-RICH ACTIVITIES AND ROUTINES INTO EARLY MATH INSTRUCTION

ASSUMPTION: VIDEO CO-VIEWING ACTIVITIES PROVIDE A "GENTLE" INTRODUCTION TO THE TARGET MATH SKILLS.

WHAT WE LEARNED: PBS KIDS Videos used in the transmedia-rich supplement were well received by teachers and children in all classrooms that participated in the Preschool Pilot. Teachers reported the successful enactment of the video co-viewing activities in all weeks of implementation, noting children's excitement about, and engagement with, the videos and their requests for repeat viewings. Teachers noted: "Children love to watch the video," "They ask me every day when we were watching another video," "Children enjoy watching the video and answering questions," and "The video co-viewing went really well. It has gone over well all of the weeks."

In addition to calling out the video co-viewing activities as implementation highlights, teachers also commented that some of the videos were "full of valuable science and math information" that complemented other classroom activities. *The Cat in the Hat* and *Curious George* videos were favorites among children and teachers: "It's funny and moves quickly. The kids loved it! We loved it!" However, teachers and coaches noted that children were less familiar with *Sid the Science Kid,* and they expressed some concern that the content in these videos was "too complicated" and "over the heads" of preschoolers.

Classroom observations and teachers' reports suggest that the presence of familiar characters and the presentation of math content through song and story contributed to children's enjoyment of the videos and, arguably, enhanced their participation in video-based math-learning activities. For example, during a video co-viewing activity involving the Termite Towers episode of *The Cat in the Hat,* children in one classroom appeared engrossed in the video, smiling and laughing when the Cat in the Hat appeared on screen, singing along with the series' opening song ("Go on an Adventure"), with which they were familiar, as well as the termite song ("With sand and spit we'll fix the wall…"), even though they were hearing it for the first time.

In spite of the overwhelmingly positive reactions to the video activities, the available videos themselves were not always the ideal vehicles for introducing math skills. In some instances, the content of the video aligned tenuously with the target math skills; for example, one teacher pointed out that Finola's Farm was "a nice lesson on milk and milk products" but that it had "little to do with math." In other instances, the manner in which the video presented the math content did not offer adequate scaffolds to support children's math learning. For example, one coach noted that a Curious George video lacks an explicit explanation for counting backwards and does not provide concrete referents for counting a diminishing number of objects.

Teachers also stressed the importance of combining video co-viewing with hands-on activities that included manipulative materials, in order to ensure that developmentally appropriate resources were available to support children's math learning. The length of the videos and, concurrently, the length of the video co-viewing activities, was another area of concern. Although the pause points facilitated verbal participation, video activities limited opportunities for movement, and teachers worried about children's engagement and participation, especially with video activities that extended beyond twenty minutes.

ASSUMPTION: IWB GAMES, AT THE HEART OF THE SUPPLEMENT'S GUIDED CHALLENGE GAME PLAY, PROVIDE AN ACTIVE INTRODUCTION TO DISCRETE MATH SKILLS, AS WELL AS OPPORTUNITIES FOR ADULT SCAFFOLDING AND GUIDED PRACTICE.

WHAT WE LEARNED: Like the videos, the PBS KIDS IWB transmedia games at the heart of the Guided Challenge Game Play activities in the transmedia-rich condition elicited positive reactions from teachers and children. Teachers reported that children "loved to play new games on the big screen" and found the IWB games "very engaging;" one teacher put it, "[children] know, after the video, the very next day, they will play a new game and they get very excited about it. They can't wait for me to call them and get very upset when I don't." Meatball Launcher, The Huff-Puff-A-Tron, Sketch-a-Mite, and Blast Off were popular among teachers and children. In fact, one teacher labeled Blast Off as a "blockbuster" game, and several teachers reported that this game helped children become more familiar with the skill of counting backwards.

The PBS KIDS IWB games were a powerful context for children's math learning, given the combination of teacher scaffolding, opportunities for children's active participation, the transmedia's affordances for practicing math skills, and the whole-class setting in which the activity was implemented. Because the goal of the Guided Challenge Game Play was to introduce specific math skills through the context of a novel, challenging game and to provide opportunities for guided practice, teacher mediation was a core component of the activity. The presentation of PBS KIDS computer games on the interactive large screen offered important supports for math learning, including unique representations of math concepts, opportunities for tactile manipulation, built-in scaffolds for learning and practicing math skills, and instant feedback. For example, several games incorporate constrained choice, such as not being able to make progress in the game until the correct answer is selected, which provides children with information on their performance and clarifies the objective of the game. Finally, because Guided Challenge Game Play was typically enacted in a whole-class setting, children were able to learn not only from their interactions and transmedia experiences but also by observing their peers' interactions with the transmedia.

In one classroom, for example, after the teacher had provided directions and modeled game play for Counting with Allie, children took turns playing the game. At each turn, the teacher asked the child to identify the "next number" (e.g., "What's the next number after 6?"), click the number on the IWB, and count the objects displayed on the screen. Once touched, the objects on the screen lit up, helping children keep track of objects that had been counted, while the one-to-one correspondence—the act of touching the objects while counting out loud—helped children make the connection between number and quantity. Clicking on "Allie" caused the on-screen character to speak the numbers out loud as objects lit up in time, reinforcing the children's own counting. All children were able to participate successfully in the activity, even though some children appeared to struggle with the larger numbers. In these instances, the teacher intervened with verbal and nonverbal support (pointing to objects while children were counting, counting along with children, prompting for the next number, etc.) and helped children complete counting for "their" number.

Although the PBS KIDS games were popular among children and teachers appreciated their affordances for learning, teachers and coaches also pointed out the design of the game sometimes interfered with children's game play and math-learning experiences. For example, children appreciated "do-over" opportunities to correct their inaccurate responses and became frustrated when games (e.g., Vegetable Harvest, Crystals Rule) announced the answer rather than providing feedback and an opportunity to repeat. Likewise, in Sketch-a-Mite, children struggled to create shapes with a single stroke (without lifting their finger off the screen), as this was at odds with how they had learned to draw shapes in other contexts.

Their representational richness aside, teachers and coaches noted that PBS KIDS IWB games are limited with respect to the tactile and spatial resources that benefit early math learning and emphasized the importance of combining IWB games with hands-on activities in a math curriculum supplement.

ASSUMPTION: COMPUTER CENTER-TIME ACTIVITIES PROVIDE OPPORTUNITIES FOR CHILDREN TO (1) PLAY GAMES AND PRACTICE MATH SKILLS INDEPENDENTLY OF THE TEACHER, (2) PRACTICE AND MASTER TARGET SKILLS, AND (3) TALK AND INTERACT WITH ONE ANOTHER.

WHAT WE LEARNED: In general, teacher and coach reports and observations confirm that children were excited about using the four laptops that made up the Computer Center-time to play PBS KIDS games that had been previously introduced on the IWB: "When the new game is over, they know already they will play it on the small computers and talk among themselves who will play and who will sit and watch the game." Our classroom observations indicate that the most effective implementation of a Computer Center-time activity combined a number of features: (1) a structured introduction to the game, highlighting the math skill; (2) explicit connections between the IWB game and the computer game, including a discussion of how they were different (e.g., use of a mouse as opposed to a touch-screen); (3) the expectation that children would work collaboratively in pairs and the delegation of roles to children; (4) the appropriate audio set-up (e.g., the use of splitters so two children can simultaneously have audio access to attend to the game); and (5) a sustained amount of time spent on the target game(s).

Our observation data suggest that this constellation of factors was present in only a few classrooms; at least one feature was often missing from teachers' enactment of Computer Center-time activities, impeding smooth implementation. First and foremost, teachers rarely highlighted connections between the target PBS KIDS transmedia games and other activities. Teachers rarely emphasized the math skill at the core of the game, often contributing to circumstances where game play overshadowed the math-learning aspect of the activity. For example, observers noticed that a teacher in one classroom did not insist that children count out loud or "check the number inside the bubble" to verify the accuracy of their response while playing Bubble Pop. After the initial turns, the children stopped counting along; since they were not required to count aloud or predict the number, the children were able to pop the bubbles and continue with the game, but the opportunities for math practice were minimized.

On a number of occasions, observers noted that teachers neglected to connect a Computer Center-time game to its Guided Challenge Game Play counterpart. Also, teachers did not always discuss the salient differences between the two game play formats. Because they were introduced to the games through the IWB format, children were accustomed to using the touch screen to interact with the game. The laptops, on the other hand, required the use of a mouse. Some children, especially those who lacked the fine motor skills to control a mouse, were uncertain about how to interact and, in fact, many attempted to participate in the games by touching the laptop screen.

Although they were intended to do so, Computer Center-time activities did not always foster collaborative pair-work among children, and opportunities for math talk and interactions among children were fewer than anticipated. In some classrooms, Computer Center-time was enacted as an individual activity on account of missing splitters and, at other times, because teachers were concerned that children did not have the appropriate turn-taking skills to participate effectively in pair work. Even when the Computer Center-time was enacted as a pair-work activity, the nature of child collaboration and interaction varied widely. In some classrooms, children worked collaboratively and both members of the pair contributed equally to game play progress, taking turns controlling the mouse. Pair work was more lopsided in other classrooms, with one child controlling the mouse and dominating game play, while the other child merely observed. The uneven collaboration was especially pronounced when headphone splitters were not in use, as was observed in some classrooms, and only one child had access to the audio at any given time.

A final challenge arose from navigation issues that children encountered on the PBS KIDS Lab website, which had the unfortunate effect of cutting into the time children spent playing the target PBS KIDS games. The design of the PBS KIDS Lab website is such that it does not "corral" the children into playing only the PBS KIDS games; in fact, it is easy—and common practice—for children to navigate away from the target games to non-PBS KIDS resources or even out of their web browsers entirely. Even when a teacher was present, actively assisting children, children were observed navigating to, and playing with, games other than the PBS KIDS games for a given week.

ASSUMPTION: ADULT MEDIATION IS KEY TO MAXIMIZING CHILDREN'S PBS KIDS TRANSMEDIA-RICH MATH LEARNING. TEACHERS CAN (1) DRAW ATTENTION TO THE SALIENT MATH SKILL, (2) MODEL MATH TALK, AND (3) INVITE OPPORTUNITIES FOR CHILDREN'S ACTIVE, VERBAL PARTICIPATION.

WHAT WE LEARNED: Coaches and members of the research team observed several positive examples of adult-child interactions during the enactment of transmedia-rich activities, especially in whole-class settings. The designated pause points during the video-based activities and the interactions during the PBS KIDS IWB games helped teachers draw children's attention to important math concepts, introduce mathematical vocabulary, ask questions to elicit children's mathematical thinking and check comprehension, and scaffold children's practice of a math skill. For example, while teaching the video co-viewing activity based on the Termite Towers episode of *The Cat in the Hat,* the teacher first polled all students to elicit their predictions about whether the Cat's tower would stay standing; she introduced the term "semicircle," using the visuals in the video (as well as classroom objects) for illustrations; and she extended children's mathematical thinking and talk by asking them to identify, name, and distinguish shapes based on the number of corners and sides. The teacher's "mistakes" (e.g., identifying a triangle as a square) were fruitful opportunities to invite children to elaborate on their mathematical ideas (e.g., explain that the shape was a triangle, and not a square, because it had three sides).

In some classrooms, observers noted that teachers extended interactions beyond what was specified in the teachers' guide. Extending interactions or incorporating new ones allowed teachers to introduce background information (e.g., about unfamiliar characters), explain and illustrate new vocabulary, provide additional opportunities for practicing math skills (e.g., counting the number of children in Sid's classroom), and expand on the connections between the PBS KIDS transmedia-rich activity and other learning activities (e.g., PBS KIDS activities from prior weeks, nonsupplement-based math-learning activities, and other teaching and learning activities in the classroom). In all these instances, the teachers' modifications facilitated more mathematical discourse, enhanced children's participation in the activity, and supported their math learning.

Along with examples of positive modifications, we also observed the opposite in classrooms: teachers omitted one or more of the recommended interactions, greatly reducing opportunities for math talk and learning. One reason why teachers overlooked interaction opportunities during video co-viewing was because the pause point is presented as a red dot that appears on the screen for a fixed period of time. In most instances, teachers skipped the pause point because they had their backs to the screen and were unaware of it. Upon becoming aware of their omission, teachers sometimes stopped and rewound the video to the suggested pause point; in other cases, the teacher simply moved on. In one instance, we observed a teacher who attempted to rewind the video—this move exited the teacher out of the browser by accident, and the teacher had to re-open the video and wait for it to buffer to get it to the right place.

During the Computer Center-time activities, the multitude of factors that required their attention kept teachers tightly focused on the logistical aspects of game play, leaving little time or opportunity to intentionally mediate children's mathematical learning. During the enactment of Computer Center-time activities, teachers were observed playing a tech support role, troubleshooting technical issues and facilitating the mechanical aspects of game play. Helping children with technical and mousing issues required the dedicated attention of an adult, especially given the presence of four computers in most classrooms, making it challenging for teachers to engage more actively in children's transmedia learning experiences. In general, observers and coaches noted that teachers' interactions with children were typically limited to troubleshooting technical problems—at best, providing just-in-time scaffolding to help a child complete a level or address a question—and the elicitation or extension of mathematical thinking during computer game play was rare.

Effective implementation of a transmedia-rich activity requires attention to a number of related, but competing, factors. The implementation of a transmedia-rich activity requires the orchestration of transmedia and technology, and responsiveness to points of entry for promoting interaction. Additionally, teachers also must focus on the math content, the learning goals of the activity, children's engagement, and classroom management. According to coaches, simultaneously managing pause points and students' attention proved to be too much of a challenge for some teachers, but other teachers, especially those who "did not have trouble with the math in general," appeared more at ease juggling the different aspects of the activities.

MATH CONTENT AND CLASSROOM ROUTINES

ASSUMPTION: IF A MATH CURRICULUM SUPPLEMENT IS TO BE SUCCESSFUL, IT HAS TO BE RECOGNIZABLE TO TEACHERS, STEEPED IN EARLY-LEARNING APPROACHES, AND MUST CAPITALIZE ON TEACHERS' EXISTING MATHEMATICAL PEDAGOGICAL KNOWLEDGE, WHILE ACCOUNTING FOR TEACHERS' POTENTIAL UNFAMILIARITY WITH TEACHING MORE COMPLEX MATHEMATICS IN PRESCHOOL.

WHAT WE LEARNED: Supplement activities and materials that hewed to common and well-established preschool instructional formats were well received by teachers in both the PBS KIDS transmedia-rich and comparison conditions. Teachers appreciated how the supplements leveraged developmentally appropriate and engaging preschool practices such as the use of manipulatives, play-based activities, book readings, and songs to create opportunities for practicing target math skills. The activities that teachers in both conditions highlighted as "successful" and "engaging" shared a number of features, including the following.

MANIPULATIVES

In general, teachers felt that manipulative materials that children could touch, feel, and move offered important opportunities for practicing a number of math skills (e.g., patterning, fair shares). For example, activities like Fruit Party, a part of the comparison supplement, and Sort and Count, a part of both supplements, garnered positive reactions from teachers. One teacher said of Fruit Party, "When they had to share their own fruits, they learned how to share with friends. Most students can do the party and share their fruits as they were instructed when they were given two, four, or six fruits evenly." Similarly, another teacher highlighted the Sort and Count activity and said it "worked really well with the class because [children] really like the objects and manipulatives they were using."

PLAY AND PHYSICAL MOVEMENT

In the PBS KIDS transmedia-rich condition, coaches and teachers reported that IWB games captured the interest of children, not least on account of the opportunity for tactile play offered by the technology: "[Children] LOVE touching the screen on the IWB, and keep trying to do so on the computer." In the comparison condition, teachers and coaches noted that skywriting numbers were highly engaging for children. In both conditions, coaches noted that the physical movements involved in Number Act Out and book-reading activities were enjoyable for teachers and children (e.g., acting out the pattern ant dance in *Busy Bugs*, identifying objects in *I-Spy*). Songs that were enacted as part of the circle-time activities also played well in all study classrooms for their use of music and movement to turn attention to math skills.

WELL-ESTABLISHED ACTIVITY TYPES

NUMBO was modeled after BINGO, a popular preschool activity; similarly, a number of the game-based activities designed to help children practice their math skills integrated concentration games (e.g., Shape Concentration, Dot-Number Concentration) that were favorites in several classrooms. As one teacher said, "One of the activities the students were engaged in was singing, 'Head, Shoulder, Knee and Toes.' It was fun, some of the students said, 'I know the song but this one has more things to say.' They noted we were adding and naming more body parts."

ASSUMPTION: MATH CIRCLE-TIME ACTIVITIES CAN OFFER OPPORTUNITIES FOR INTRODUCING AND REINFORCING CONCEPTS, SKILLS, AND IDEAS RELATED TO NUMBER SENSE IF THEY CONTAIN QUALITIES THAT MAKE CIRCLE TIME EFFECTIVE, FOR EXAMPLE, GROUP SINGING, SHARED BOOK READING, FOCUSED CONVERSATION, AND SO ON.

WHAT WE LEARNED: There were challenges associated with the implementation of the Weekly Math Circle Routine and Guided Reading ("Math Circle") in both PBS KIDS transmedia-rich and comparison classrooms. Although the Math Circle activities used traditional preschool formats, the number of activities, the focus on diverse math skills included in the Math Circle, the time taken for enactment, and the time taken for preparation together made this component difficult for teachers to implement.

Teachers and children responded favorably to the individual activities comprising the Math Circle; for example, the books and songs included in the Math Circle were favorites in several classrooms (e.g., "The book reading worked very well. They liked the story and were able to answer the questions and remain engaged and not bored."). However, enacting the activities as an ensemble was a challenge. Teachers expressed frustration with the variety and treatment of math concepts addressed in a Math Circle activity. As one teacher wrote in a log: “Curriculum [supplement] moves too fast! Too many concepts are attempted in a single circle time. It’s better to focus on fewer concepts in a more in-depth way rather than many concepts in a quick way. Preschoolers need time to process.”

Another source of teachers’ concern arose from the time taken to complete this activity, typically several minutes longer than the time specified in the Teachers’ Guide. In some classrooms, teachers reported taking as long as 40 minutes for the Math Circle, which was too long to sustain children’s interest and attention. Teachers worried that the variety of math skills addressed, combined with the time taken to complete the activity, had a negative influence on children’s engagement and math learning: “It was difficult to fit all the activities suggested for circle time into that time of the day. Usually I would do a song and one of the activities (Number Line, die, or book). Having to do four separate activities, even though they were short, was a bit confusing for the children and made it feel like it was taking longer than it really did. There was a lot of information for the children to take in at one time. Many children lost interest or asked, ‘Are we done yet?’”

The Math Circle, especially when the activity was enacted in its entirety, competed for classroom time with other curricula that teachers were required to implement. Preschool classroom schedules are typically busy, with teachers feeling that they “have a lot to cover,” usually in a limited amount of time. Therefore, implementing the Math Circle activities reduced the time available for other lessons and activities, even though the activities themselves were designed to be simple and brief. In some classrooms, teachers divided the Math Circle into its component activities, implementing them separately at different times rather than all together. This increased the number of activities that teachers had to implement per week and, because teachers acutely felt the challenge of “fitting this curriculum [supplement] with a curriculum specified and mandated by [the state],” some of the activities were omitted.

In general, teachers struggled with the complexity that they attributed to multistep, multipart activities. Although it consisted of fewer components, the Math Detective Journal and Easy Game Play also posed challenges similar to the Math Circle. Teachers were hard-pressed to present the activity as specified in the curriculum supplement materials; in several classrooms, teachers reported implementing it in a modified format, splitting a multipart activity into separate activities (e.g., Math Detective Journal and Easy Game Play), or changing the activity structure to a small-group setting that teachers could orchestrate more tightly (e.g. independent center-time activities).

ASSUMPTION: REPEATING ACTIVITIES CREATES OPPORTUNITIES FOR PRACTICE, HELPING CHILDREN MASTER MATH CONCEPTS BY ACTIVELY BUILDING NEW MATHEMATICS KNOWLEDGE THROUGH EXPERIENCE AND PRIOR KNOWLEDGE.

WHAT WE LEARNED: Both the PBS KIDS transmedia-rich and the comparison supplements were designed to "spiral," touching repeatedly on target math skills. There were a number of activities designed to address a specific math skill, and children encountered the same activity more than once in both the transmedia-rich and comparison supplements. Repeating activities were intended to provide children an opportunity to review and practice what they had previously learned, as well as to layer new knowledge (e.g., a more sophisticated articulation of the math skill) onto prior learning.

In practice, repeating opportunities did not elicit a favorable response from teachers and children. Rather than viewing the multiple exposures as opportunities for acquiring new concepts (or approaching concepts with greater sophistication), teachers related that children "did not want to do the same activity again and again" and that "when [there] is too much repetition, children started to get bored." Teachers noticed that "since they played it already, [children] have the tendency to get bored," lose interest in a game or activity, and move on to other center-time areas of the classroom, such as blocks, dramatic play, and such.

PROFESSIONAL DEVELOPMENT AND COACHING

ASSUMPTION: BECAUSE MANY ACTIVITIES FOLLOW FAMILIAR FORMATS AND STRUCTURES, IMPLEMENTATION OF THE SUPPLEMENTS IS MANAGEABLE (LESSON PREPARATION AND ACTIVITY SET-UP TIME IS MINIMAL).

WHAT WE LEARNED: The priority to emphasize recognizable activity formats and classroom routines notwithstanding, both the PBS KIDS transmedia-rich and comparison supplements included unfamiliar materials, used in novel ways, and activities that were new to preschool teachers. The PBS KIDS transmedia-rich supplement included activities that called for the integration of digital technologies (IWBs, laptops, Internet streaming) and transmedia assets (videos and computer games) into early math instruction. The comparison supplement included new activities, games, and forms of representation (e.g., tally marks). Both the PBS KIDS transmedia-rich and the comparison supplements included activities that used materials (e.g., dominoes, pattern manipulatives) as well as activities (e.g., journaling, patterning, transmedia-rich activities) with which teachers typically had little prior experience.

The implementation of both supplements required a significant amount of planning and preparation on the part of teachers. To enact supplement-based instruction in their classrooms, teachers had to acquaint themselves with unfamiliar activities and organize the materials beforehand. Some whole-group activities included three to four distinct components, and some implementation days included a number of individual activities. Even though they were designed to be simple and brief, multiple activities nevertheless added to the time required for lesson preparation and the sorting, assembling, and organizing of materials.

Organizing materials and setting up for activities was one of the recurring challenges reported by teachers and observed by coaches and members of the research team, in both the PBS KIDS transmedia-rich and the comparison groups. Teachers reported difficulties with “the assembling of all the materials to be used” prior to the enactment of activities, although they acknowledged “having it ready is essential.” Coaches reported that teachers found the materials “numerous” and “scattered,” and that “organizing all the materials and managing their use may take too much time.” Coaches also highlighted teachers’ desires for “a more organized way to present hands-on games, and fewer materials to keep track of.”

In both PBS KIDS transmedia-rich and comparison groups, one of the important areas in which coaches supported teachers was with organization of materials. Teachers appreciated the time and effort that coaches put into “arrang[ing] all the materials for the whole week” and “organizing materials by daily activities.” Preparation and assistance with materials accounted for the type of coaching support that teachers reported receiving most frequently; on average, coaches continued to provide this type of support in more than half the study classrooms across all 10 weeks of implementation.

Table 7. Teacher-Reported Frequency of Coach Assistance with Materials by Implementation Week

Prepared or assisted with materials	1	2	3	4	5	6	7	8	9	10	Total
PBS KIDS Transmedia-rich group	7	7	6	6	6	5	3	5	3	2	50
Comparison group	8	7	7	7	7	6	7	6	5	5	65
Combined	15	14	13	13	13	11	10	11	8	7	115

The lack of time for planning activities was a related challenge. Several teachers shared the concern that “if we don’t get to sit down to read [the materials] ahead of time, [we] can’t do it,” and worried that “the curriculum [supplement] moves too fast” and that “it’s very hard to remember for the teachers to do all the activities.” Activities were challenging because there was “no time for the teacher to prepare,” especially given the competing demands on teachers’ time (e.g., other curricular materials, home visits), and some teachers candidly admitted to “winging it,” even though they acknowledged that it was a less-than-ideal practice. Coaches, too, reported that teachers were sometimes enacting activities “on the fly.” On a number of occasions, classroom observers noted that teachers appeared unfamiliar with the structure and steps of an activity while they were implementing it; teachers also acknowledged that, sometimes, they did not have time to read through the activity prior to enacting it in the classroom.

ASSUMPTION: BECAUSE THE SUPPLEMENTS USE RESEARCH-BACKED APPROACHES TO MATH LEARNING, IMPLEMENTATION IS ACHIEVABLE (TEACHERS HAVE THE PEDAGOGICAL KNOW-HOW OR CAN BUILD THE RELEVANT PEDAGOGICAL KNOW-HOW THROUGH SUPPLEMENT IMPLEMENTATION).

WHAT WE LEARNED: While implementing the PBS KIDS transmedia-rich and the comparison supplements, we observed teachers enacting several instructional moves that supported children’s sustained attention to, and engagement with, math learning activities. Teachers exhibited a capacity to maintain focus on the target math skill for the duration of the activity by explicitly stating and sharing the learning goal with children, providing a “hook” to recruit attention (e.g., asking children to make a prediction at the start of the activity), using a variety of instructional strategies to scaffold children’s learning, and asking questions to monitor understanding of the math concept. Building coherence—establishing connections between the current and prior learning—was a key feature, as was the elicitation of mathematical thinking by asking open-ended questions that invited children to share, elaborate, and justify their ideas. Contributions from children, regardless of accuracy, were potential “teachable moments” where the teacher deconstructed the child’s response to identify the algorithm for identifying the correct answer, for example, asking the child to count the sides of the shape when he misidentified a triangle as a square. In these classrooms, teachers also set and managed expectations for the participation of all children involved by directing questions and offering interaction opportunities to the whole group and to individual children.

In contrast, some teachers encountered several instruction-related challenges during the implementation of the supplements. A focus on activity completion—following the steps and procedure of the activity—as well as the need to troubleshoot technical issues—for example, the improper materials set-up, malfunctioning computers—and manage behavior sometimes overshadowed attention to target math skills. Some teachers’ also had a tendency to limit themselves to close-ended questions (Which number is missing? What shape is this?) and did not further explore children’s understanding (How do you know that?), restricting children’s contributions to known answers. Because children's contributions were limited, there also were fewer opportunities for teachers to extend mathematical thinking by recasting children's ideas using math content and vocabulary. In these classrooms, teachers' attention was unevenly distributed, often focusing on one child to the exclusion of the group, causing children to lose interest when it was not their turn. In some instances, teachers did not sustain the interaction with the child, precluding opportunities for eliciting the child's ideas; in other instances, teachers interacted only once with a child (e.g., during a group activity) and did not return to monitor progress, check comprehension, or provide additional scaffolding.

ASSUMPTION: A FLEXIBLE COACHING APPROACH IS MOST APPROPRIATE FOR PROVIDING TEACHERS WITH SUPPORT THAT IS FINE-TUNED TO THEIR PARTICULAR NEEDS.

WHAT WE LEARNED: The absence of a "recipe" for coaching was a deliberate design decision within the Preschool Pilot study, as we wanted to fine-tune the guidance, support, and assistance teachers received as they enacted the supplements. Coaching in all classrooms attended to certain fundamental elements—reviewing the week's activities, target math skills, materials, and, when appropriate, RTL transmedia assets—but because teachers' needs and the contextual factors affecting implementation in classrooms were diverse, coaches adjusted the support they provided to fit the unique features of each teacher's classroom.

In some classrooms, coaches emphasized support with math content and instruction; in others, where teachers reported difficulties with orchestrating the activity or sustaining children's participation, coaches modeled or co-led activities with teachers. In transmedia-rich classrooms, coaches worked with teachers to identify strategies for implementing the whole-class activities and managing the Computer Center-time more effectively. In several classrooms, coaches assisted with materials and activity set-up. Actions associated with coaching included providing guidance on math content and instructional strategies, modeling supplement activities, observing teachers leading supplement activities and providing feedback, troubleshooting technology, and organizing the supplement materials for each week to facilitate the enactment of activities.

The flexible approach also enabled teacher-coach pairs to identify the mode of interaction that was going to be most suitable for their particular situation. Some coaches established a regular rhythm of interaction with the teacher, following a predetermined communication and coaching routine, while a just-in-time pattern was the norm for other pairs. In almost all classrooms and across all weeks of implementation, coaches visited teachers at least once a week; in some classrooms, the frequency of coach visits was higher for some weeks of implementation, the additional visits typically occasioned by a specific implementation problem or at the teacher's request. In some instances, coaches supplemented in-person visits with phone calls and e-mails to teachers, but these modes of communications were rare, other than for the purposes of coordinating classroom visits.

The table below indicates the frequency with which teachers in both the PBS KIDS transmedia-rich and comparison conditions received different types of assistance from the coach during the 10-week implementation period. The most common type of coach assistance involved support with preparing and organizing materials, which might be attributed to the fact that, across both groups, the enactment of activities hinged on the use and organization various materials. However, the comparison condition involved the use of more hands-on materials and manipulatives overall requiring, arguably, more set up and organization than activities in the transmedia-rich condition; this may be one reason why comparison teachers report receiving/requiring more support from the coach as compared to teachers in the PBS KIDS transmedia-rich group.

Table 8. Frequency of Teacher-Reported Assistance from Coach for Both Conditions

Types of Coach Assistance	Transmedia-rich	Comparison	Overall
A. Prepared or assisted with materials	50	65	115
B. Supported with technology use	41	NA	41
C. Supported with math content knowledge or teaching strategies	33	42	75
D. Observed instruction and provided feedback	29	38	67
E. Co-led activities	26	33	59
F. Modeled activities	19	36	55
G. Other	8	13	21
H. Led other classroom activities	6	21	27

Note: N *refers to frequency (number of occasions across the sample of participating teachers) with which a certain type of assistance provided by the coach during the implementation period.*

ASSUMPTION: SUCCESSFUL IMPLEMENTATION OF THE SUPPLEMENTS CALLS FOR JUST-IN-TIME GUIDANCE FROM KNOWLEDGEABLE COACHES.

WHAT WE LEARNED: The coaching model employed in the Preschool Pilot emphasized robust relationships between coaches and teachers. It was an important goal for coaches to get to know the classrooms and the instructional dispositions and practices of the teachers to whom they were assigned in order to understand as much as possible about how teachers were enacting particular activities, the manner in which teachers and children were responding to the supplements, and other contextual factors affecting implementation.

The coaches who supported implementation of either supplement during the Preschool Pilot were drawn from a variety of disciplinary backgrounds and had diverse experiences. Coaches' experiences varied with respect to mathematics instruction, early learning, the integration of transmedia and technology into instruction, and teacher professional development. Although there were definite overlaps in terms of knowledge and skills, only a few coaches were expert in all domains.

Coaches also varied in terms of the extent to which they were familiar with and knowledgeable about the curriculum supplements. Most coaches were knowledgeable about math skills, and some were also proficient in the use of technology more generally for math learning. A few coaches had been closely involved in the design and development process of both supplements, and were knowledgeable about the transmedia and the technologies deployed in the Preschool Pilot. Although the coach training provided guidelines regarding the amount of time dedicated to coaching, the frequency with which coaches should check in with teachers, and what coaches could reasonably expect from teachers in terms of their implementation efforts, time did not allow for coaches to receive a structured training or orientation to supplement materials and teachers' guides to help familiarize them with the materials.

The criteria applied to assess the enactment of a given activity or identify activities as having been "successful" in the classroom, diverged across coaches. Because coaching was, by design, not uniform, it was not uncommon for coaches to view classrooms through the lenses of the particular teacher's needs. Analysis of coach logs reveals that different activities stood out as particularly successful to different coaches, although there were some commonalities, for example, activities that focused on physical movement and tactile play. Some focused on which activities children found engaging and fun; for example, one coach said, "The students very much enjoyed the math detective journal writing, singing, and playing with the dice on the number line." Others defined successful activities as those teachers could implement with high fidelity; for example, a coach noted, "Video co-viewing went as planned, and teacher did a good job of leading the activity." Still others focused on whether children appeared to grasp the target mathematics concepts; one remarked, "The teacher also reported that the children were able to identify patterns and to successfully predict what the next 'element' of a pattern would be."

TEACHER OUTCOMES

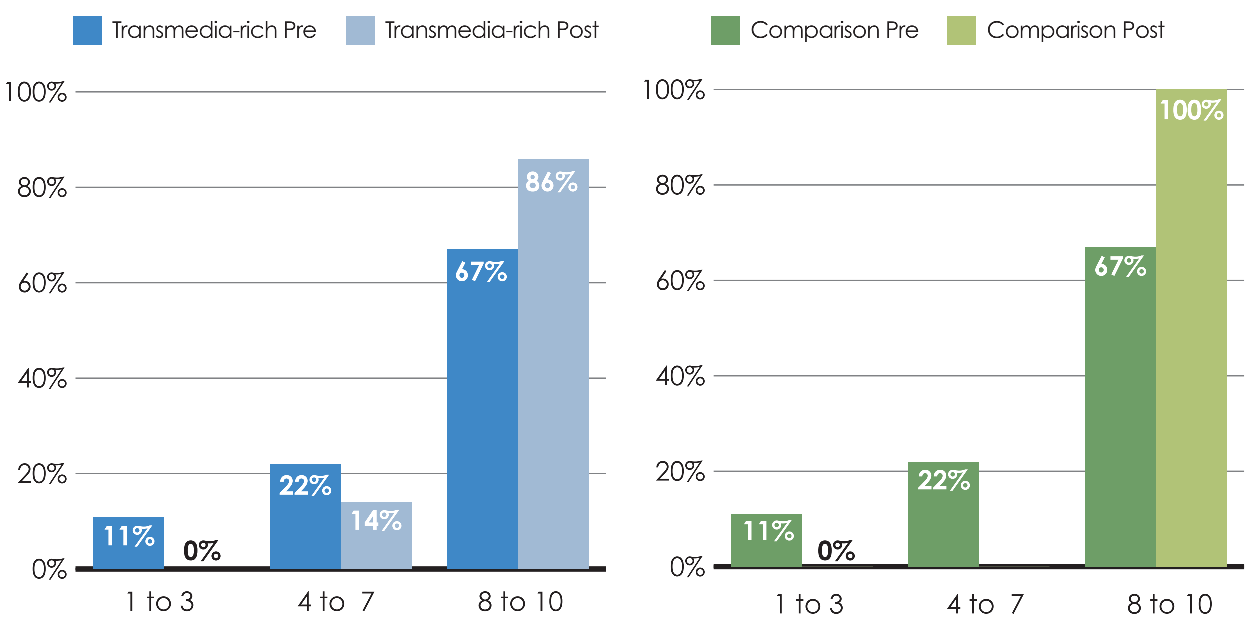
In our analysis of the data from the teacher mathematics attitudes and beliefs questionnaire, we found patterns or trends that were similar for all teachers regardless of supplement condition and trends that differed between the two. Although we cannot make causal claims about changes in teacher's attitude and beliefs and we acknowledge that some variation may be due to random error, we examined patterns that we think were worth considering in relation to our curricular activities and professional development.

After implementing the supplements, some teachers in both conditions reported higher levels of agreement with following statements:

- "Young children like math and are generally interested in it" (see Figure 1).
- "I believe...the inadequacy of a student's mathematics background can be overcome by good teaching" (see Figure 2).

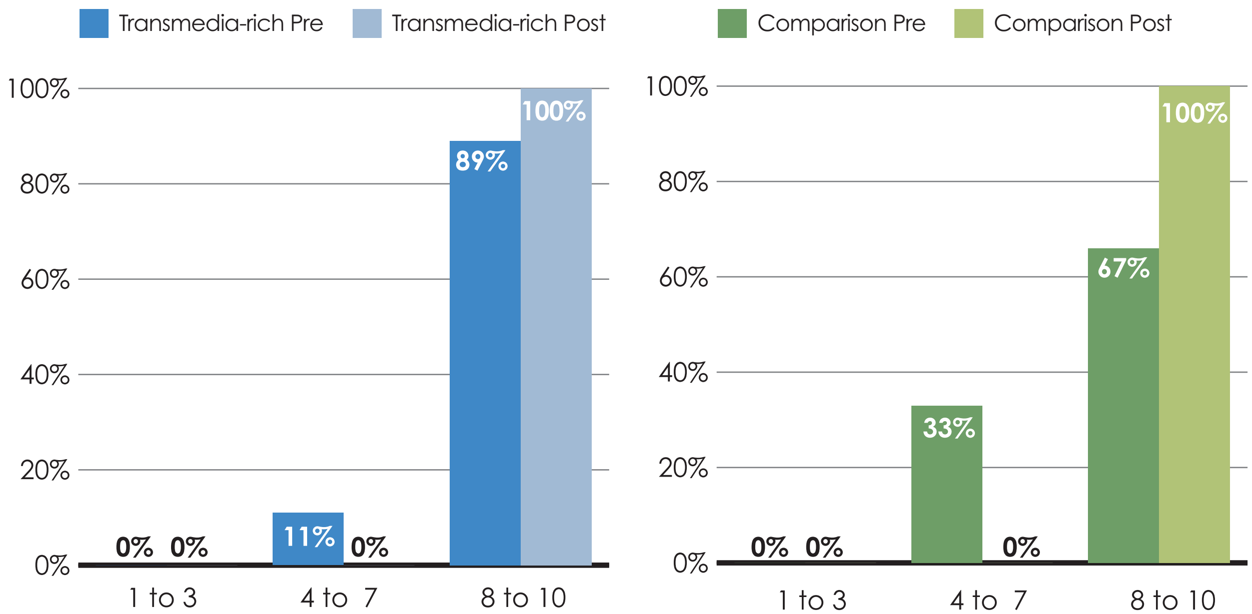
These findings suggest that for teachers in both conditions, beliefs about mathematics teaching and children's interest in mathematics improved over time. While we may not draw a causal connection, it is important to note that our design sought to (1) provide guidance and scripts to model instructional strategies that can lead to learning, and this approach may have led teachers to believe that good instruction could yield learning, and (2) develop engaging activities, and this characteristic may have led teachers to believe that children are interested in mathematics.

Figure 1. "I believe young children like mathematics and are interested in it."



1 = Strongly Disagree, 10 = Strongly Agree. Scores collapsed 1 to 3, 4 to 7, and 8 to 10.

Figure 2. "I believe the inadequacy of a student's mathematics background could be overcome by good teaching."



1 = Strongly Disagree, 10 = Strongly Agree. Scores collapsed 1 to 3, 4 to 7, and 8 to 10.

Findings relating to teacher attitudes and beliefs were not entirely positive, however. After implementing the transmedia-rich and comparison supplements, some teachers in both conditions endorsed lower agreement with the following statements:

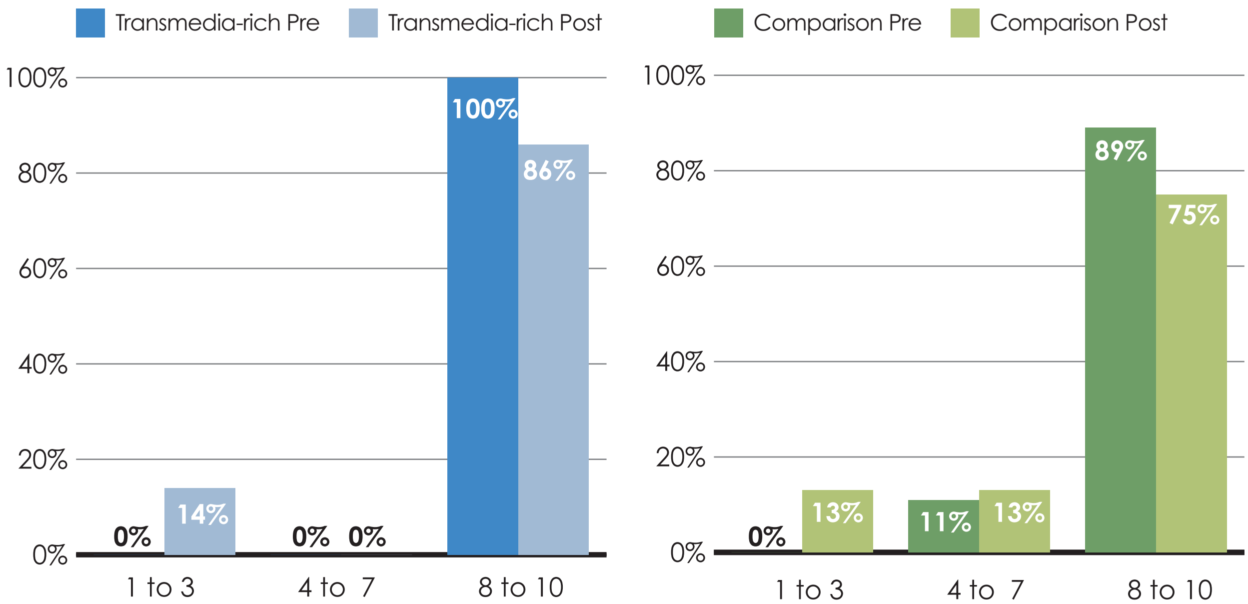
- "I understand the concepts of number/operation and geometry well" (see Figure 3).
- "I understand the concepts of geometry well" (see Figure 4).

In addition, after implementing the PBS KIDS transmedia-rich and comparison supplements, some teachers in both conditions endorsed higher agreement with the following statement:

- "Mathematics is too difficult for young children to understand" (see Figure 5).

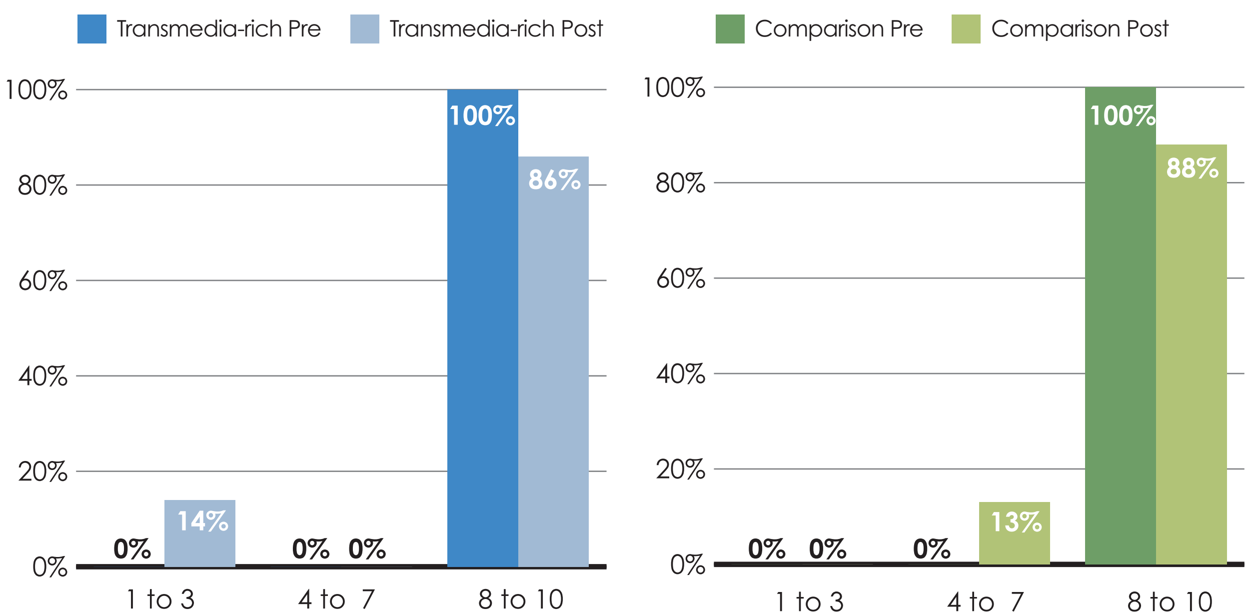
Research suggests that preschool teachers spend less time teaching mathematics relative to other domains like language and literacy (Early et al., 2010). Perhaps as a result of the small amount of time teaching mathematics and the basic way in which mathematics is often introduced in preschool, prior to using the supplements teachers may have been overconfident in their own understanding of mathematics. For instance, when almost all teachers stated that "I understand the concepts of geometry," they may have meant that they know the names of geometric shapes. Our materials have teachers engage much more deeply with mathematical topics and thus may have exposed them to more complex mathematics than they typically teach. This factor may have caused some teachers to feel less confident about their own mathematics content knowledge.

Figure 3. "I understand the concepts of number and operation."



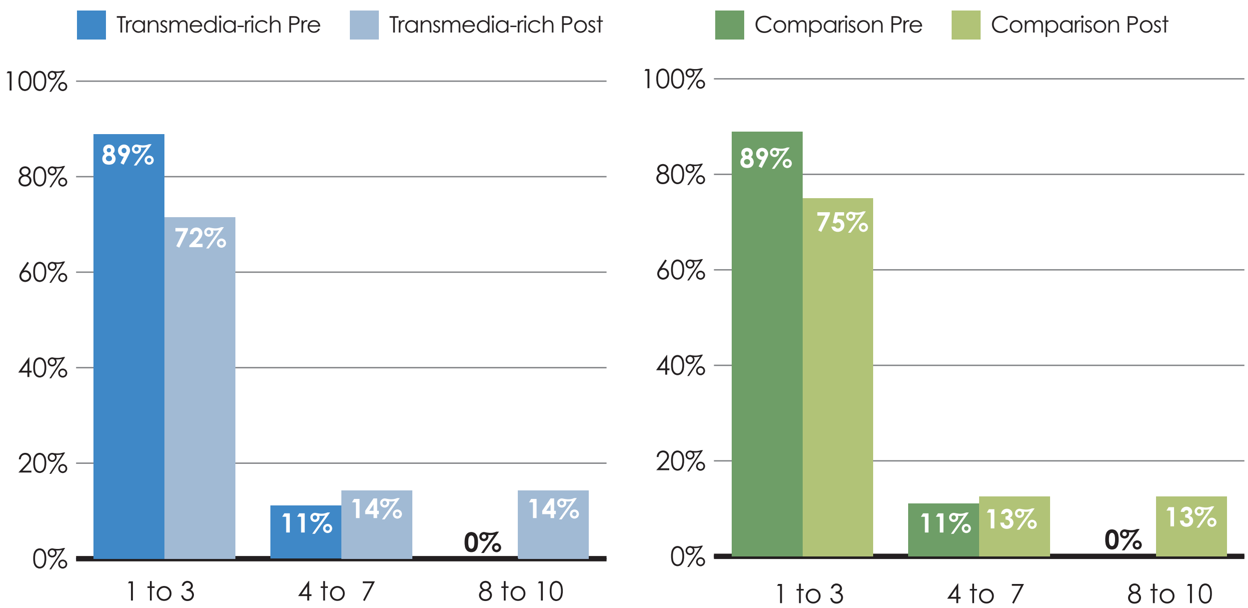
1 = Strongly Disagree, 10 = Strongly Agree. Scores collapsed 1 to 3, 4 to 7, and 8 to 10.

Figure 4. "I understand the concepts of geometry."



1 = Strongly Disagree, 10 = Strongly Agree. Scores collapsed 1 to 3, 4 to 7, and 8 to 10.

Figure 5. "Mathematics is too difficult for young children to understand."

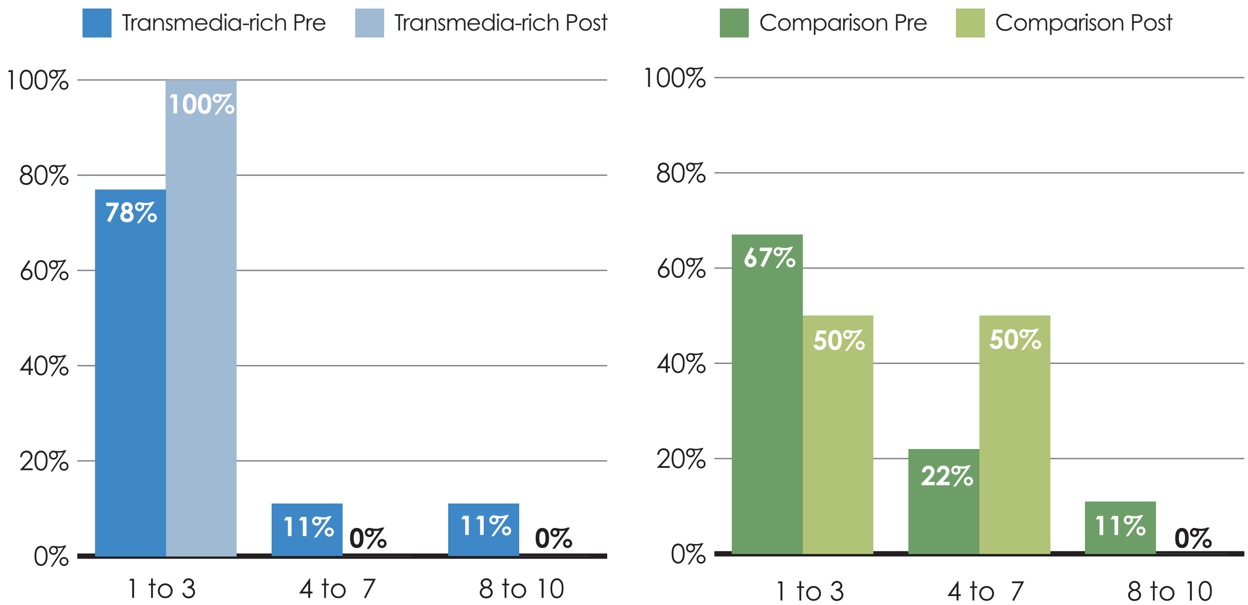


1 = Strongly Disagree, 10 = Strongly Agree. Scores collapsed 1 to 3, 4 to 7, and 8 to 10.

For three items, we found patterns of response that indicate a difference between teachers in the RTL transmedia-rich condition compared to teachers in the comparison condition. After implementing the PBS KIDS transmedia-rich supplement, more teachers reported feeling like a "mathematics person" (see Figure 6) and feeling like they taught mathematics as well as other subjects (Figure 7). These patterns were not as evident in the comparison condition.

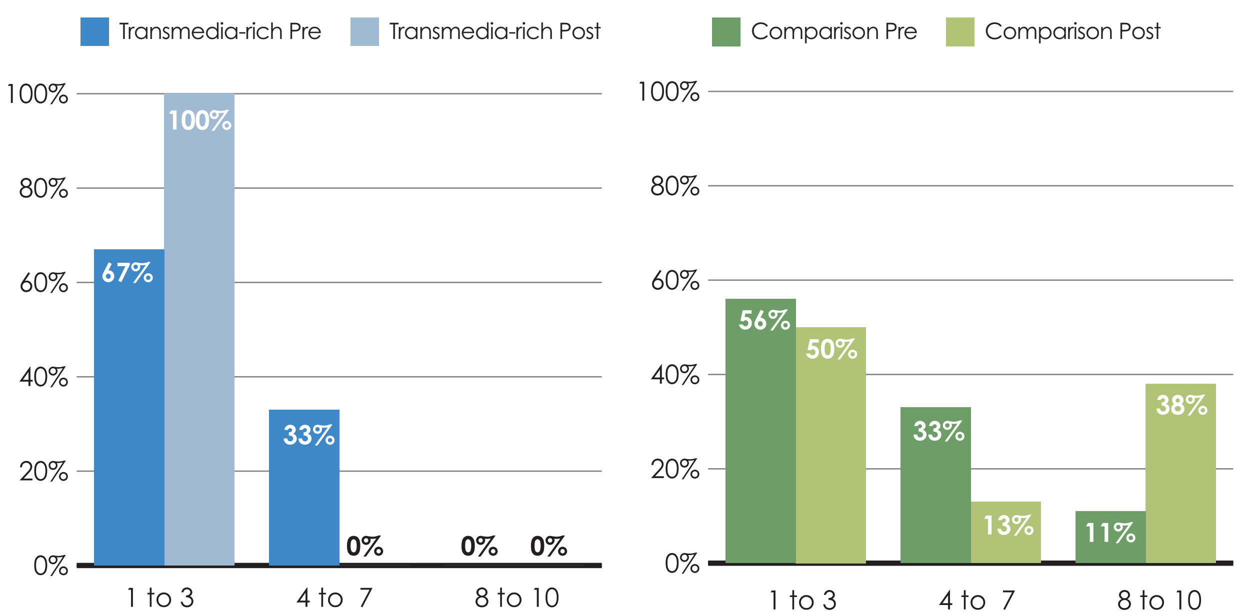
Again while the same caveat about causality applies to this finding, it is worth noting that some teachers in the PBS KIDS transmedia-rich condition seemed to believe that using the IWB to share PBS videos and play PBS KIDS games with groups of children provided them support that helped them enact mathematics lessons they felt were beneficial for the children.

Figure 6. "I am not a 'mathematics person.' "



1 = Strongly Disagree, 10 = Strongly Agree. Scores collapsed 1 to 3, 4 to 7, and 8 to 10.

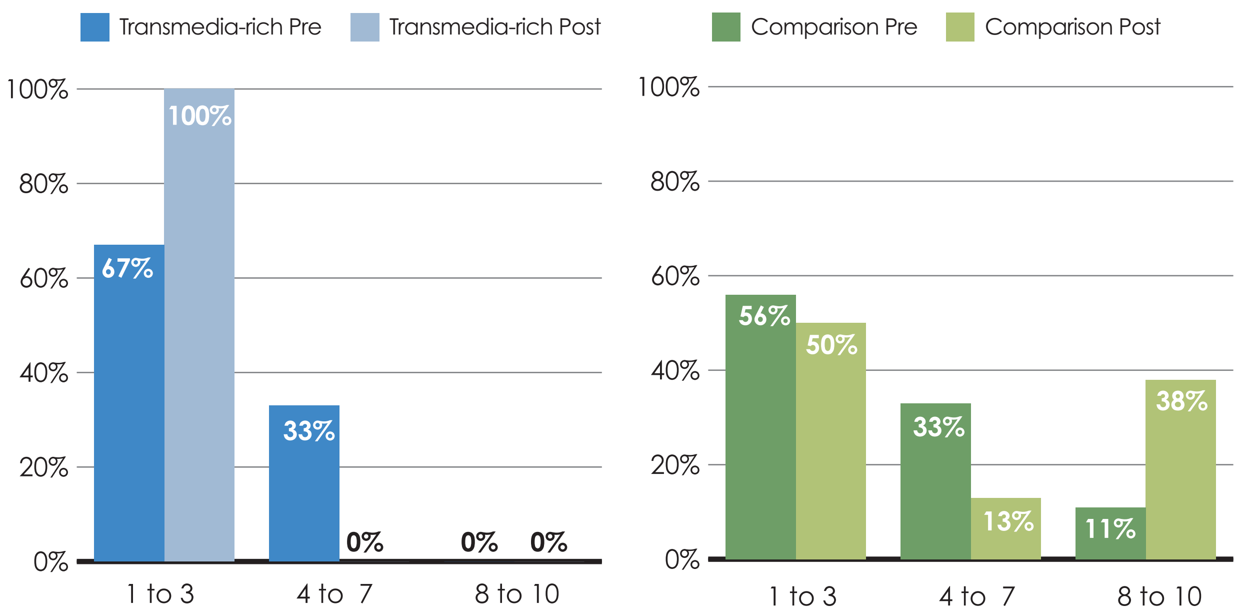
Figure 7. "Even when I try, I am not able to teach mathematics as well as many other subjects."



1 = Strongly Disagree, 10 = Strongly Agree. Scores collapsed 1 to 3, 4 to 7, and 8 to 10.

In addition, in the transmedia-rich group, some teachers reported feeling more confident and some teachers reported feeling less "confident in their ability to facilitate students' communication about mathematics (for example, discussions, questions, and journals)" after completing the transmedia-rich curriculum supplement (see Figure 8). This pattern was not as evident in the comparison condition, where we only observed more teachers reporting feeling less confident.

Figure 8. "I feel confident in my ability to facilitate students' communication about mathematics (for example, discussions, questions, and journals)."



1 = Strongly Disagree, 10 = Strongly Agree. Scores collapsed 1 to 3, 4 to 7, and 8 to 10.

Our approach involved some initial training and support during implementation. This method may have helped some teachers gain confidence in their ability to facilitate children's math learning. However, our approach may not have offered enough professional development opportunities to ensure all teachers understood and felt comfortable adopting instructional strategies to foster young children's math learning. In order to ensure teachers feel well-equipped to teach mathematics, it will be important for the curricular supplements to include a strong professional development component that allows teachers to gain understanding of mathematics concepts and skills and hence confidence in their practice.

CHILD OUTCOMES

Review of the SBA item scores provided useful information about the difficulty level of the concepts and skills targeted in supplement activities, and thus the supplement-based assessment. For example, results from descriptive analysis of the SBA item-level data suggests that most children were able to successfully engage in counting, especially counting up to 5. On the other hand, many children seemed to struggle with sorting and patterning activities. This information will be useful as we revise the curriculum supplements for the Preschool RCT, helping us ensure that our activities, and the aligned curriculum supplement-based assessment, target appropriate levels of difficulty.

Descriptive analysis of the mathematics child outcome data (both REMA short version and SBA) provided useful information regarding children's mathematics knowledge and skills, both prior and after implementation of the supplements. (See Table 9 for descriptive statistics for the short version of the REMA and the SBA.)

Table 9. Short Version of the REMA and SBA Means and Standard Deviations

	Full Sample		Transmedia-rich		Comparison	
	Pretest	Posttest	Pretest	Posttest	Pretest	Posttest
REMA short version	8.26 (2.50)	9.36 (2.24)	8.54 (2.54)	9.58 (2.33)	7.99 (2.45)	9.13 (2.15)
SBA	15.41 (3.65)	17.36 (2.65)	15.96 (3.26)	17.82 (1.99)	14.90 (3.92)	16.90 (3.12)

Note: Scores represent raw scores.

Descriptive analysis of the HTKS data provides useful information regarding children's self-regulatory skills, both prior to and after implementation of the supplements. (See Table 10 for descriptive statistics for the HTKS.)

Table 10. HSKT Means and Standard Deviations

	Full Sample		Transmedia-rich		Comparison	
	Pretest	Posttest	Pretest	Posttest	Pretest	Posttest
HTKS	11.71 (15.82)	17.36 (19.19)	12.54 (15.59)	18.04 (18.35)	10.94 (16.10)	17.84 (20.10)

Note: Scores represent raw scores.

Repeated measures analyses of the child outcome data indicated that there was a significant effect of time; in other words, children made significant improvements in both mathematics ($F(1, 143) = 31.57$, $p < .001$ and $F(1, 149) = 62.64$, $p < .001$, for the short version of the REMA and the SBA, respectively) and self-regulation skills ($F(1, 144) = 31.08$, $p < .001$). These improvements, however, did not differ across conditions. Findings from multilevel analysis of the child outcome data also indicated that there were no main effects of condition. Although we had limited power to detect effects (due to our small sample size), these findings indicate no differences in children's learning across conditions.

FUTURE CONSIDERATIONS

The CPB-PBS *Ready To Learn* Preschool Pilot Study, as a test-run before the larger Preschool RCT, provided the intended information to inform the RCT: it confirmed many of our core assumptions about early math learning with transmedia as well as our general approach to conducting the research. It also indicated areas in which we should focus our RCT efforts. Specifically, we found as follows:

- Young children from traditionally underserved communities were deeply engaged with the mathematics learning environments created as part of the transmedia-rich and comparison supplements. Both conditions provided new experiences for many preschool teachers—a focus on mathematics and concrete activities to do so—while many teachers in the PBS KIDS transmedia-rich condition experienced a double innovation: the first due to the changes in their physical classroom with the influx of technology, the second as a result of teaching new material in sometimes unfamiliar ways.
- Preschool teachers in general seem to experience a new "awareness" and knowledge about their ability to teach mathematics and their children's ability to engage and comprehend more complex mathematical concepts, suggesting continued support both in the form of professional development and high-quality curriculum supplements have the potential to impact general preschool mathematics instructional practices.
- Preschool teachers and preschool center directors are willing and able to endure the disruption of a large-scale technology deployment, especially when it also brings the promise of powerful new learning tools well suited to existing routines.
- The general systems and processes we put in place—from data collection and storage to technology installation and support to classroom materials development and distribution—worked well.
- Professional development and coaching are integral components to successful curriculum supplement enactment. In particular, a flexible and responsive coaching model, as was implemented in the Preschool Pilot, is promising; however, more

structured and consistent preschool teacher professional development and coach training will be necessary to support both teachers and coaches at scale during the Preschool RCT.

- The instruments, especially those intended to capture child and teacher outcomes, were well matched to the implementation. In particular, the REMA and SBA that we used with participating 4-year-olds were sensitive enough to capture change over time and were in line with children from low-income families' math learning in the spring, the time when the Preschool RCT will take place. The datasets we have in-hand leave us strongly positioned to make refinements, such as adjusting the difficulty levels of the math skills we will target. Likewise, the teacher measure captured change in attitudes and beliefs for some teachers, and the enactment and implementation measures used provided valuable formative and summative findings, and prepare us well for studying implementation during the RCT.

While the Preschool Pilot leaves us with a solid foundation, it also makes clear the work still to be done. Below are the lessons learned we plan to integrate into the design and implementation of the Preschool RCT.

TRANSMEDIA INTEGRATION

The PBS KIDS transmedia-rich curriculum supplement should carefully curate transmedia properties (videos) to (1) more directly address the specific concepts and skills that are at the heart of the supplement and (2) align with the sequence and gradation of skills outlined in the scope and sequence of the curriculum supplement.

- The curriculum supplement should include a combination of PBS KIDS transmedia-rich and hands-on activities that include manipulative materials, in order to ensure that developmentally appropriate resources are available to support children's early math learning.
- The design of the PBS KIDS transmedia-rich curriculum supplement should provide audio and visual cues at selected video pause points and other resources to help teachers identify and take full advantage of opportunities for interaction.
- In order to take full advantage of joint engagements with transmedia for learning, curricular activities should assume realistic expectations for the role and actions of the teacher and children. Professional development should do as follows:

– Stress the importance of adult mediation, and adult-child interaction, during the implementation of a transmedia-rich activity.

– Provide guidance to teachers about using the transmedia and a point of departure for catalyzing math talk and eliciting children's mathematical ideas.

– Support teachers in developing the appropriate instructional tools and strategies to scaffold pair work and collaboration among children during Computer Center-time activities.

MATH CONTENT AND CLASSROOM ROUTINES

- The PBS KIDS transmedia math curriculum supplement should include a combination of transmedia-rich and nonmedia activities.
- The design of activities should consider factors such as the incorporation of manipulatives, the use of familiar preschool routines, and the need for play and physical movement. The transmedia-rich activities should, when possible, incorporate opportunities for physical movement; the nonmedia activities should incorporate hands-on manipulatives and other materials as well as routines, such as book reading, physical play and movement, and music, that are recognizable to preschool teachers as their instructional mainstays.
- Each activity should explicitly focus on a single math skill. Activities should be simple and brief so as to facilitate the learning and practice of math skills without extending beyond the typical threshold attention spans of preschool-aged children.
- The number of activities specified for a given week in the curriculum supplement should take into consideration the various factors affecting instruction in a preschool classroom (e.g., schedule constraints, competing demands from other activities).
- The sequence of activities for a given week should be tightly orchestrated to attend to specific skills, as dictated by the scope and sequence of the curriculum supplement.

COACHING AND PROFESSIONAL DEVELOPMENT MODEL

- The design of individual activities and the sequence of activities, including the materials and set up that is required, should take into consideration the amount of time that preschool teachers have available for lesson preparation. Expectations regarding lesson preparation should be communicated clearly to teachers during professional development and coaching.
- Because preschool teachers have varying degrees of familiarity and experience with teaching math, the professional development and coaching approach may benefit from the addition of an in-person training session with teachers prior to implementation. Coaching then could build on this introductory work.
- Now that we have captured those coaching activities that were most used and most valued, we will create a more explicit coaching model that will focus coaches on the highest-value activities and also ensure consistency in coaching. In order to be well positioned to support teachers, all coaches must receive training in the curriculum supplements; the training should include hands-on experiences with the materials and activities. Coaches also should receive access to the curriculum supplement materials ahead of time.

REFERENCES

Ackerman, D. J. (2008). Continuity of care, professional community, and the policy context: Potential benefits for infant and toddler teachers' professional development. *Early Education and Development, 19*(5), 753-772. doi: 10.1080/10409280801960505

Auerbach, C. F., & Silverstein, L. B. (2003). *Qualitative data: An introduction to coding and analysis.* New York, NY: New York University Press. Retrieved from http://search.proquest.com/docview/620221036?accountid=25350

Balfanz, R., Ginsburg, H. P., & Greenes, C. (2003). The Big Math for Little Kids early childhood mathematics program. *Teaching Children Mathematics, 9*(5), 264-268.

Baroody, A. J. (2009). Fostering early numeracy in preschool and kindergarten. In *Encyclopedia of language and literacy development* (pp. 1-10). London, ON: Canadian Language and Literacy Research Network. Retrieved from http://literacyencyclopedia.ca/pdfs/topic.php?topId=271

Bowman, B. T., Donovan, M. S., & Burns, M. S. (2001). *Eager to learn: Educating our preschoolers.* Washington, DC: The National Academies Press.

Bruner, J. (1960). *The process of education.* New York, NY: Vintage Books.

CCSSO/NGA. (2010). *Common core state standards for mathematics* (Vol. 2010). Washington, DC: Council of Chief State School Officers and the National Governors Association Center for Best Practices.

Chen, J., & Chang, C. (2006). A comprehensive approach to technology training for early childhood teachers. *Early Education and Development, 17*(3), 443-465. doi: 10.1207/s15566935eed1703_6

Clements, D. H., & Sarama, J. H. (2007). Effects of a preschool mathematics curriculum: Summative research on the Building Blocks project. Journal for Research in Mathematics Education, 38(2), 136-163.

Clements, D. H., & Sarama, J. H. (2009). *Learning and teaching early math: The learning trajectories approach.* New York, NY: Routledge.

Clements, D. H., Sarama, J. H., & Liu, X. H. (2008). Development of a measure of early mathematics achievement using the Rasch model: The Research-Based Early Maths Assessment. *Educational Psychology, 28*(4), 457-482. doi: 10.1080/01443410701777272

Connor, C. M., Ponitz, C. C., Phillips, B. M., Travis, Q. M., Glasney, S., & Morrison, F. J. (2010). First graders' literacy and self-regulation gains: The effect of individualizing student instruction. *Journal of School Psychology, 48,* 433-455.

Dombro, A. L., Colker, L. J., & Dodge, D. T. (1999). *The Creative Curriculum for infants & toddlers.* (Rev. ed.). Washington, DC: Teaching Strategies.

Early, D. M., Iruka, I. U., Ritchie, S., Barbarin, O. A., Winn, D. C., Crawford, G. M., . . . Pianta, R. C. (2010). How do pre-kindergarteners spend their time? Gender, ethnicity, and income as predictors of experiences in pre-kindergarten classrooms. *Early Childhood Research Quarterly, 25*(2), 177-193. doi: 10.1016/j.ecresq.2009.10.003

Education Development Center & SRI International (2011). *Year one context studies: A report to the CPB-PBS Ready To Learn Initiative.* Retrieved from http://cct.edc.org/rtl/index.asp

Frede, E. C., & Barnett, W. S. (2011). *New Jersey's Abbott prekindergarten program: A model for the nation.* Baltimore, MD, US: Paul H Brookes Publishing, Baltimore, MD. Retrieved from http://search.proquest.com/docview/1039035431?accountid=25350

Frey, K. S., Hirschstein, M. K., & Guzzo, B. (2000). Second Step: Preventing aggression by promoting social competence. *Journal of Emotional and Behavioral Disorders, 8,* 102–112.

Ginsburg, H. P., Greenes, C., & Balfanz, R. (2003). *Big Math for Little Kids: Teacher resource binder pre-kindergarten.* New Jersey: Dale Seymour Publications.

Ginsburg, H. P., Klein, A., & Starkey, P. (1997). The Development of children's mathematical thinking: Connecting research with practice. *Handbook of Child Psychology*, (5th ed., Vol. 4), 401-476.

Ginsburg, H. P., Lee, J. S., & Boyd, J. S. (2008). Mathematics education for young children: What it is and how to promote it. *Social Policy Report: Giving Child and Youth Development Knowledge Away, 22(*1), 3-22.

High/Scope Research Educational Foundation (1989). *Program Implementation Profile (PIP) manual.* Ypsilanti, MI: High/Scope Press

Matthews, J. S., Ponitz, C. C., & Morrison, F. J. (2009). Early gender differences in self-regulation and academic achievement. *Journal of Educational Psychology, 101*(3), 689-704. doi: 10.1037/a0014240

McCray, J. S. & Chen, J. (2012). Pedagogical content knowledge for preschool mathematics: Construct validity of a new teacher interview. *Journal of Research in Childhood Education, 26*(3), 291-307. doi: 10.1080/02568543.2012.685123

McManis, L. D. & Gunnewig, S. B. (2012). Finding the education in educational technology with early learners. *Young Children, 67*(3), 14-24.

Penuel, W. R., Pasnik, S., Bates, L., Townsend, E., Gallagher, L. P., Llorente, C., & Hupert, N. (2009). *Preschool teachers can use a media rich curriculum to prepare low-income children for school success: Results of a randomized controlled trial.* New York, NY: Education Development Center and Menlo Park, CA: SRI International.

Poglinco, S. & Bach, A. (2004, January). *The heart of the matter: Coaching as a vehicle for professional development.* Phi Delta Kappan, 85(5), 398-400.

Ponitz, C. E. C., McClelland, M. M., Jewkes, A. M., Connor, C. M., Farris, C. L., & Morrison, F. J. (2008). Touch your toes! Developing a direct measure of behavioral regulation in early childhood. *Early Childhood Research Quarterly, 23*(2), 141-158.

Ponitz, C. C., McClelland, M. M., Matthews, J. S., & Morrison, F. J. (2009). A structured observation of behavioral self-regulation and its contribution to kindergarten outcomes. *Developmental Psychology, 45*(3), 605-619.

Raudenbush, S. A., Bryk, Y. F., Cheong, R. C., & du Toit, M. (2004). *HLM 6: Hierarchical linear and nonlinear modeling.* Lincolnwood, IL: Scientific Software International.

Sarama, J. H., & Clements D. H. (2004). Building Blocks for early childhood mathematics. *Early Childhood Research Quarterly, 19*(1), 181–189. doi: 10.1016/j.ecresq.2004.01.014

Sarama, J. H., & Clements, D. H. (2009a). Building blocks and cognitive building blocks: Playing to know the world mathematically. *American Journal of Play, 1*, 313-337.

Sarama, J. H., & Clements, D. H. (2009b). Early childhood mathematics education research: Learning trajectories for young children. New York, NY: Routledge.

Spybrook, J., Raudenbush, S. W., Congdon, R., & Martinez, A. (2009). O*ptimal design for longitudinal and multilevel research: documentation for the optimal design software v.2.0.* Retrieved from http://www.wtgrantfoundation.org

Wanless, S. B., McClelland, M. M., Acock, A. C., Ponitz, C. C. Son, S. H, Lan, X.,. . . Li, S. (2011). Measuring behavioral regulation in four societies. Psychological Assessment, 23(2), 364-378.

Weiland, C., Wolfe, C. B., Hurwitz, M. D., Clements, D. H., Sarama, J. H., & Yoshikawa, H. (2012). Early mathematics assessment: Validation of the short form of a prekindergarten and kindergarten mathematics measure. *Educational Psychology, 32*(3), 311-333. doi: 10.1080/01443410.2011.654190

Wiggins, G., & McTighe, J. (1998) *Understanding by design.* Alexandria, VA: ASCD.

Wilson, S. J, Morse, A. B., & Dickinson, D. K. (2009). *Examining the effectiveness of OWL as used in ERF projects: Final report of results from the OWL Consortium Project.* Center for Evaluation Research and Methodology: Vanderbilt Institute for Public Policy Studies.

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